सुलभप्रतिवेदन/ Open file report
वर्ग बी/Category–B

भारत सरकार
भारतीय भूवैज्ञानिक सर्वेक्षण

GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA

कर्नाटक राज्य के उडुपी और शिमोगा जिले में भूआकृति संख्या 48K/13, 48N/03और48N/04 के कुछ हिस्सों में वृहद पैमाने पर (१: ५०,०००) भूस्खलन संवेदनशीलता का मानचित्रण

(कार्य सत्र कोड संख्या:एम4एलएसएसएम/एनसी/एसआर/एसयू-केजी/२०१९/२५१७८)

(कार्य सत्र: २०१९-२०)

MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NOS. 48K/13, 48N/03AND 48N/04, UDUPI AND SHIMOGA DISTRICTS, KARNATAKA

(FSP CODE NO: M4LSSM/NC/SR/SU-KG/2019/25178)
FIELD SEASON: 2019-20

By

कपिल सिंह, भूवैज्ञानिक
कमल कुमार,भूवैज्ञानिक

Kapil Singh, Geologist
Kamal Kumar, Geologist

मिशन-IV
MISSION-IV

PROJECT: NLSM / परियोजना: एनएलएसएम्
STATE UNIT: KARNATAKA & GOA/ राज्य इकाई: कर्नाटक एवं गोवा

November, 2020

इस प्रतिवेदन का कोई हिस्सा महानिदेशक, भारतीय भूवैज्ञानिक सर्वेक्षण की पूर्वलिखित अनुमति के बिना प्रतिलिपित नहीं किया जाना चाहिए

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भारतीय भूवैज्ञानिक सर्वेक्षण
GEOLOGICAL SURVEY OF INDIA
सत्यमेव जयते
1851

सुलभप्रतिवेदन/ Open file report
वर्ग बी/Category–B

भारत सरकार
भारतीय भूवैज्ञानिक सर्वेक्षण

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GEOLOGICAL SURVEY OF INDIA
सत्यमेव जयते
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(FSP CODE NO: M4LSSM/NC/SR/SU-KG/2019/25178)

Field Season: 2019-20

By

Kapil Singh, Geologist
Kamal Kumar, Geologist

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कर्नाटक राज्य के उडुपी और शिमोगा जिले में भूआकृति संख्या 48K/13, 48N/03और48N/04 के कुछ हिस्सों में वृहद पैमाने पर (१: ५०,०००) भूस्खलन संवेदनशीलता का मानचित्रण

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(**कार्यसत्र**: **२०१९-२०**)

सारांश

१४५६ वर्ग किलोमीटर के क्षेत्र के लिए उडुपी और कर्नाटक के शिमोगा जिलों के कुछ हिस्सों में उच्च संकल्प रिमोट सेंसिंग डेटा और फील्ड इनपुट का उपयोग करके एक सहज भूस्खलन संवेदनशीलता मानचित्र तैयार करने के उद्देश्य से मैक्रो स्केल लैंडस्लाइड सुस्पेक्टिबिलिटी मैपिंग किया गया था। अध्ययन क्षेत्र में भूस्खलन की घटनाओं की कम संख्या के कारण , विश्लेषणात्मक पदानुक्रम प्रक्रिया (AHP) की परिकल्पना की गई थी।

भूस्खलन और कारण कारकों के बीच स्थानिक संघटन का विश्लेषण करने के लिए कुछ भू-कारकों को मूलभूत धारणा के आधार पर चित्रित किया गया था कि वर्तमान और पिछले भूस्खलन के कारण होने वाले स्थानिक कारक भविष्य में इसी तरह के भूस्खलन का कारण बन सकते हैं। पूर्व-क्षेत्र के नक्शे, अर्थात, भूमि उपयोग भूमि कवर (LULC) मानचित्र, भू-आकृति विज्ञान मानचित्र, सामग्री बनाने का ढलान और Regolith मोटाई का नक्शा आर्क-जीआईएस सॉफ्टवेयरपर मल्टी-टेम्पोरल गूगल ेअर्थ इमेजरी (ओपन सोर्स) से इनपुट के साथ तैयार किया गया था।

क्षेत्रवार (उच्च से निम्न) LULC को विभाजित किया गया है: मोटी वनस्पति , खेती, मध्यम वनस्पति, बंजर, विरल वनस्पति, उच्च ऊँचाई वृक्षारोपण (HHP), कम ऊँचाई वृक्षारोपण (LHP), परती भूमि, खदान, बस्तियाँ, संशोधित पर बस्ती ढलान, व्यापक कट ढलान और जल निकाय। अध्ययन के क्षेत्र में शहरीकरण की गड़बड़ी मुख्य रूप से घाटियों में देखी जाती है। अध्ययन क्षेत्र में मुख्य रूप से धारा के प्राकृतिक प्रवाह का अतिक्रमण करने के बाद ही कृषि भूमि को ज्यादातर घाटियों में देखा गया है।

अध्ययन क्षेत्र में देखी गई प्रमुख लिथोलॉजी इकाइयाँ ग्रेनाइट नीस , क्वार्ट्ज-क्लोराइट सिस्ट,argillite, मेटाबेसाल्ट और हॉर्नब्लेंडे-एक्टिनोलाइट-क्लोराइट विद्वान हैं। नीस एवं सिस्ट चट्टानों और argillite की उपस्थिति मध्यम कोण ढलान में कम योगदान दे रही है , जबकि मेटाबासाल्ट और बांडेड मैग्नेटाइट क्वार्टजाइट के रूप में उच्च प्रतिरोधी चट्टान , अध्ययन क्षेत्र में कम उच्च स्वर्गीय ढलान में योगदान दे रही है।

फील्ड कार्य के दौरान कुल 117 भूस्खलन की पहचान की गई और भूस्खलन सूची के लिए 42-बिंदु भू-पैरामीट्रिक शीट में प्रलेखित किया गया। इनमें 71% Debris स्लाइड, 25% Earth स्लाइड, 3% debris प्रवाह और 1% प्रत्येक Earth प्रवाह और subsidence शामिल हैं। अधिकतम स्लाइड (82 no's) को सड़क के खंडों के साथ संशोधित ढलान पर दर्ज किया गया है।मलबे / मिट्टी और मेटा-बेसाल्ट के बीच इंटरफेस , सड़क निर्माण जैसे मानवजनित गतिविधियों के

लिए अत्यधिक कटाव, ढलान के आधार पर उचित जल निकासी की कमी और ढलानों पर जॉइंट्स और फ्रैक्चर जैसे कमजोर प्लेन में पानी का रिसाव होता है। ढलान अस्थिरता के लिए अध्ययन क्षेत्र। भूस्खलन, अध्ययन क्षेत्र में बड़े पैमाने पर एक्शन के लिए वर्षा प्रमुख कारक है।

बढ़ते कृषि क्षेत्र के लिए प्राकृतिक प्रवाह मार्ग (घाटी भाग) का अतिक्रमण और साथ ही साथ पहाड़ी क्षेत्र की ओर धाराओं का मोड़ अक्सर अध्ययन क्षेत्र में अभ्यास कर रहा है। भारी वर्षा के दौरान पानी की बड़ी मात्रा संशोधित धारा घाटी में समायोजित नहीं हो पाती है और इस तरह से पैर की अंगुली का क्षरण बढ़ जाता है। धारा कटाव के कारण लगभग 22% स्लाइड्स हो रही हैं, जो अंडरकटिंग के कारण ढलान का कारण बनता है और इस प्रकार ओवरलोडिंग और शियर शक्ति कम होने के कारण विफल रहता है।रिकॉर्ड की गई स्लाइडों में से लगभग 36%, 25 ° से 35 ° ढाल के बीच, 32% स्लाइड 15 ° - 25 ° ढाल के बीच और 15% , 35° - 45° में निहित हैं, जबकि 11% स्लाइड 15 ° से कम वाले एवं 6% , 45° से अधिकता वाले ढलान में मौजूद है।

AHP गणना के साथ संयुक्त मल्टी-क्लास इंडेक्स ओवरले पद्धति का उपयोग करके तैयार किए गए कच्चे संवेदनशीलता स्कोर मैप। अंतिम रॉ अतिसंवेदनशीलता स्कोर मानचित्र को क्रमशः "उच्च" और "मॉडरेट" के लिए 50% और "मॉडरेट" और "निम्न" श्रेणियों के लिए 30% के कट-ऑफ मार्जिन के आधार पर तीन संवेदनशीलता क्षेत्रों में पुनर्वर्गीकृत किया गया है। कुल 76.32% कम संवेदनशीलता क्षेत्र में , 21.89% और 1.79% क्रमशः मॉडरेट और उच्च संवेदनशीलता क्षेत्रों में आते हैं।

अध्ययन क्षेत्र में किए गए सुस्पेक्टिबिलिटी मैपिंग के आधार पर , जोखिम को कम करने के लिए कई सामान्य सिफारिशें दी जाती हैं। यह भी ध्यान दिया जाना चाहिए कि मैक्रो लेवल पर सुसाइडेबिलिटी मैपिंग की कुछ सीमाएं और बाधाएं होती हैं। , इलाके की विशिष्ट परिस्थितियां, मैपिंग का पैमाना, घने जंगल वाले क्षेत्र आदि। इस तरह के सुसाइडेबिलिटी मैप को डायनेमिक मैप के रूप में माना जा सकता है और अलग-अलग स्टेटिक मापदंडों में संभावित बदलावों को देखते हुए समय-समय पर इसकी जांच और संशोधन किया जाना चाहिए।

यदि कुछ क्षेत्रों में, ऐसे मैक्रो-स्केल मैपिंग के आधार पर खतरनाक क्षेत्रों में पहले से पहचाने जाने वाले विकास गतिविधियों के लिए अपरिहार्य हैं, तो मेसो-स्केल अतिसंवेदनशीलता मैपिंग (बड़े पैमाने पर) और / या साइट विशिष्ट अध्ययन को विकासात्मक गतिविधियों के लिए वास्तविक योजना के तहत किया जाना चाहिए।

MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NOS. 48K/13, 48N/3AND 48N/4, UDUPI AND SHIMOGA DISTRICTS, KARNATAKA

(FSP CODE NO: M4LSSM/NC/SR/SU-KG/2019/25178)

Field Season: 2019-20

By

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ABSTRACT

In compliance with the Annual programme of GSI for FS:2019-20, macro scale Landslide Susceptibility Mapping was carried out with an aim to produce a seamless landslide susceptibility map using high resolution remote sensing data and field inputs in parts of Udupi and Shimoga districts of Karnataka for an area of 1456 sq.km. Owing to the less number of landslide incidences in the study area, use of Analytical Hierarchy Process (AHP) was envisaged.

For analyzing the spatial association between the landslides and causative factors somegeo-factors were delineated based on the fundamental assumption that the spatial factors that caused present and past landslides are likely to cause similar landslides in future. Pre-field maps, viz., Land Use Land Cover (LULC) map, Geomorphology map, Slope Forming Material map and Regolith thickness map were prepared on Arc-GIS platform with inputs from multi-temporal Google earth imageries (open source). Whereas DEM-derived maps, viz., Slope Aspect map, Slope Gradient map, Slope Curvature map and Drainage map were extracted from CARTO DEM (30m resolution).

The area wise (High to low) LULC is divided into: Thick vegetation, Cultivation, Moderate vegetation, Barren, Sparse vegetation, High Height Plantation (HHP), Low Height Plantation (LHP), Fallow land, Quarry, Settlements, Settlement on modified slope, Extensive Cut Slope and Water Body. Urbanization agglomerations in the study area are mainly observed in valleys. The agriculture land in the study area is mostly seen in the valleys; mainly after encroaching the natural flow of stream.

The major lithological units observed in the study area are Granite gneiss, Quartz-chlorite schist, Argillite, Metabasalt and Hornblende-actinolite-chlorite schist. Presence of gneissic, schistose rocks and argillite are contributing low to moderate slope angle, while high resistant rock as Metabasalt and Banded magnetite quartzite, less in study area contributing to high angle of slope.

A total of 117 landslides were identified during field work and documented in 42-point Geo-parametric sheet for landslide inventory. These include 71% debris slides, 25% Earth slide, 3% Debris flow and 1% each earth flow and subsidence. Maximum slides (82 nos.) are recorded on modified slope along road sections. Interface between debris/soil and meta-basalt, excessive cutting due to anthropogenic activities such as road construction, lack of proper drainage at toe part and on the slopes causing seepage of water into the weaker plane like joints and fractures are some of the important parameters in the study area for slope instability. Rainfall is the principal triggering factor for landslides, mass movements in the study area.

Encroachment of natural flow path of stream (valley part) for increasing agriculture area and simultaneously diversion of streams towards hill side is often practiced in the study area. The large volume of water during heavy rain is unable to accommodate in the modified stream valley and thus aggravated the toe erosion. Around 22% slides are occurring due to stream erosion that caused steepening of slope due to undercutting and thus failed due to overloading and reduced shear strength. Around36% of the recorded slides corresponds to slope gradient class between 25°to 35°, 32% slides are lies in between 15°- 25° gradient and 15% in 35°- 45° gradient followed by 11% in less than 15° and6% in greater than 45°gradients.

The raw susceptibility score map prepared by using multi-class index overlay method combined with AHP calculation. The final raw susceptibility score map has been reclassified into three susceptibility zones based on the cut-off margin of 50% for “High” and “Moderate” and30% for “Moderate” and “Low” categories respectively. Total76.32% falls in Low Susceptibility zone, 21.89% and 1.79% falls in Moderate and High Susceptibility zones respectively.

Based on Susceptibility mapping carried out in the study area, several general recommendations are given with a view to reduce the landslide risk. It must also be noted that the Susceptibility mapping on Macro level has some limitations and constraints viz., the terrain specific conditions, scale of mapping, thick forested areas, etc. This kind of Susceptibility map may be treated as a Dynamic Map and should be checked and modified from time to time considering the likely changes in different thematic parameters. If certain areas are preliminarily identified in hazardous zones, meso-scale susceptibility mapping (large scale) and/ or site specific studies should be carried out before actual planning for developmental activities.

1. INTRODUCTION

1.1 Background Information:

India has a colossal and significant record of the disastrous landslides causing damage to property, loss of life and economic losses. One of the most significant and disastrous landslide events in the recent past is one that occurred on 15-17 June 2013 in hilly region of Uttarakhand. Triggered by continuous heavy rainfall in higher reaches of Himalayas, it took thousands of lives and destroyed properties incurring heavy losses and shock to the nation. As fallout of the Uttarakhand disaster, GSI, the National Nodal Agency for landslides studies, took up a National Landslide Susceptibility Mapping programme, aimed at preparing seamless landslide susceptibility map for the landslide prone areas of the country on macro scale.

India has 0.42 million sq. km landslide prone area distributed in the Himalayan belt, North-Eastern states and Western &South-Western parts of the country covering the Western Ghat ranges and adjoining coastal belt to its west. Thus a systematic approach is required to map these areas for landslide susceptibility. A thrust in this activity is imminent to match the pace of infrastructural development in these areas. Accordingly, Geological Survey of India, being the Nodal Agency in the country for landslide studies launched National Landslide Susceptibility Mapping (NLSM) programme with an aim to produce a seamless landslide susceptibility map of the country. To foster better progress rate and to improve the quality of landslide susceptibility mapping, along with requisite amount of field inputs, NLSM programme proposes to use very high-resolution Remote Sensing data for preparation of its landslide inventory & geo-factor database and GIS based landslide-dependent empirical techniques as well as knowledge based techniques (AHP) for data integration & landslide susceptibility modelling. The main purpose of this national programme is to prepare a nation-wide landslide inventory and susceptibility database for easy retrieval, prognostication, use and updating in future whenever new events and large-scale changes in geo-environmental parameters are encountered.

Udupi and Shimoga Districts of Karnataka state lie in the central part of Western Ghats with high hills and undulating topography. These districts with their distinctive geomorphology, geology, hydrology and meteorology characteristics have long been known for landslides in selected areas during certain months of a year. The topography of the region is sensitive and any changes in the land use/land cover pattern causes landslides or slope

failures affecting the population. Thus, the district along with its scenic beauty and pleasant climatic conditions is also becoming known for natural hazards. The pressure for infrastructure development to meet the need of rapid urbanisation and global competition has led to expansion of construction activities even in hilly terrains and has catapulted frequency of landslides to dramatic proportions in recent decades.

For the state of Karnataka, landslide susceptibility mapping was proposed for 34,156sq.km area lying mainly in Western Ghat. The investigations cum mapping of these areas were started from FS: 2015-16. Out of the total area, an area of 26,909 sq. km was covered by the end of FS 2018-19. An area of 7247 sq.km was proposed for the field season: 2019-20 as shown in **PLATE-1.** The prime objectives of the macro-scale landslide susceptibility mapping were: (i) Preparation of landslide inventory database using high resolution remote sensing data, archival information and field inputs; (ii) Preparation of spatial database for geo-factors of landslides on 1: 50,000 scale and (iii) Categorization of hill slope in terms of landslide susceptibility using multi-class index overlay method in GIS platform.

Landslide susceptibility mapping on scale 1:50,000 covering 1456Sq. Km. area in parts of Udupi and Shimoga Districts, Karnataka was carried out under the Annual Programme of Geological Survey of India, Southern Region, vide FSP Code No: M4LSSM/NC/SR/SU-KG/2018/25178for field season 2019-20.

1.2 Study area:

The study area lies in SOI Toposheets No's. 48K/13, 48N/03 and 48N/04, Udupi and Shimoga Districts, Karnataka. Geographically, the area is bounded between latitudes13°45'00" N and 14°00'00" N& longitudes 74°45'00" E and 75°00'00" E in T.S No. 48K/13 and 14°00'00" N and 14°16'34" N & 75°00'00" E and 75°15'00" E in parts of T.S No.48N/3 and 48N/4 **(PLATE-2)**.The area falls on the central and western part of Shimoga district and northern part of Udupi district of Karnataka. The study area of 1165 sq.km (80%) is falling under Shimoga district, while 291 sq.km (20%) area is lying under Udupi district of Karnataka. Majority of the study area (80%) lies under Shimoga district.

The major localities of the area are Sagar, Anandapuram, Gowthampura, Tagarti, Avinhalli, Kollur etc. The areas are fairly well connected with road network which includes National Highway (NH 206), State Highways (SH – 62, SH – 77, SH – 27 and SH – 1) and other all-weather metal roads. Birur-Talguppa section of south western railway lines passes through the area. Due to the Linganamakki reservoir, quite a sizeable area is submerged

under water and thus few villages have been isolated. Ferry service is the only means available for transport to these isolated villages.

The area overall represents tropical to sub-tropical climate. The monsoon season extends from the mid-June to middle of October where the Western Ghat ranges receive heavy rainfall. The average normal rainfall in Shimoga district aggregates up to 2237 mm., while in Udupi district it is 4571 mm (as per rainfall data of KSNDMC).

1.3 Present work:

The present work includes preparation of various thematic layers on 1:50,000 scale using Arc-GIS software and Google Earth imageries. Open Series Maps of the study area were also taken into account while preparing Land use/Land cover, Road and Location maps. Landslide inventory prepared at headquarters was validated and updated in field. The pre field maps were validated in field and were updated in Arc-GIS software at headquarters. The final landslide susceptibility map of the study area was prepared using Knowledge driven indirect method (Analytical Hierarchy Process) and then classified into low, moderate and high susceptibility zones. The nature and target of work envisaged for FS: 2018-19 and the achievements are given in **Table 1**.

Table 1:Nature, quantum of work and achievements

Nature of Work	Target F.S 2019-20 (Sq. Km.)	Achievements (Sq. Km.)
1. Pre field map preparation		
a) Slope forming material map	1456	1456
b)Geomorphology and lineament map	1456	1456
c)Slope morphometry (slope, aspect & curvature) map	1456	1456
d)Land use/Land cover map	1456	1456
e) Drainage map	1456	1456
f)Regolith depth map	1456	1456
ii)Preparation of landslide inventory map	1456	1456
2. Field based studies		
i)Field checking of all thematic maps. Field validation of landslide inventory and collection of recent and historic landslides	1456	1456
ii) collection of landslide inventory and damage data as per 42 point geo – parametric sheet	1456	1456
3. Post Field studies		
i)Updation of thematic and inventory maps in GIS	1456	1456 (Inventory of 117 Landslides prepared)

ii)Preparation of Landslide susceptibility map in GIS	1456	1456
4. Collection of rainfall data	1456 (Data from Udupi &Shimoga dist. have been collected for the last ten years)	

1.4 Physiography and Drainage:

Physiographically, the area has a mixed topography represented by rugged hilly terrain and slightly undulating terrain with rolling topography. The South and South Western part of the study area are mostly rugged that forms part of Malnad region of Western Ghats represented by lowly to moderately dissect hilly slopes. The terrain in this part is very rugged with steeply sloping conical hills and deep valleys. These hills have a general trend of NW- SE. The north and north eastern part of the area is the eastern foot hill areas of the Western Ghats and shows slightly undulating / rolling topography. The highest peak in the area is Kodachadri Δ 1343m and is also the 13th highest peak of Karnataka. The Shola Forests and thick forest cover Kodachadri and the nearby hills.

River Sharavathi is draining the area and Linganamakki Reservoir is constructed across this river in the Northeastern part and Southwestern part of toposheet no. 48K/13 & 48N/4 respectively. The area shows the dendritic and trellis type of drainage pattern. The area is drained by Nagodi Hole, Birer hole, Hurli Hole, Yenne Hole, Sowpranika hole and Belakallu-Tirtha Hole. Nagodi Hole, Birer hole, Hurli Hole and Yenne Hole follow northerly to north-easterly course and joins Linganamakki reservoir. Kollur River is flowing south-westerly on the SW quadrant of toposheet no. 48K/13. Chakra nadi originated from Chakra reservoir (SE quadrant of toposheet no. 48K/13) flowing south-westerly. Another reservoir in SE quadrant of toposheet no. 48K/13 is Savehaklu reservoir. In the north-east quadrant of toposheet no. 48N/4, Ambaligolla reservoir is present.

1.5 General Geology:

The area exposes the rocks of Peninsular gneiss, Bababudan Group of Archaean age, acid and basic intrusive of Paleo-proterozoic age and laterite capping of Cenozoic age.

In the study area, Peninsular Gneiss – I is represented bybiotitic gneiss and granite gneiss is seen exposed in the Northeastern and Southwestern part of thetoposheet no. 48K/13 and in the Southwestern and Southern part of toposheet no. 48N/4.

Bababudan Group is represented by Lower Kudremukh Formation and Upper Kodachadri Formation. The topmost formation of Chitradurga Group is Ranibennur Formation, which comprises greywacke-argillite suite of rocks and overlies BIF.

Greywacke-argillite is the dominant rock type in the north-western part of Toposheets no.48N/4. The various litho-types are meta-greywacke-argillite, quartzite, and banded hematite quartzite/chert, meta-acidvolcanics of Dharwar Supergroup and granite gneisses of Peninsular Gneissic Complex. These rocks are cut across by younger dolerite dykes and quartz veins. The meta-greywacke-argillite group consists of quartz-mica-chlorite schist and calc-chlorite schists often intercalated with ortho-quartzites. These rocks have well defined schistosity and vary from green to pink. They are essentially made up of quartz, chlorite and mica.

The Lower Kudremukh Formation consists of metabasalt, metagabbro, actinolite-chlorite schist, quartz porphyry, quartz-sericite schist, greywacke, quartzite and banded iron formation are exposed in the northern, northwestern and southeastern part of the toposheet no. 48K/13. Metabasalt and meta-gabbro are exposed as narrow bands and lenses. Metabasalt is exposed in and around Hadihaklu, Salageri, Kollur and Halliberu. Metabasalt occur both in massive and schistose form. Actinolite-chlorite schist, quartz-sericite schist and sericite schists are exposed as narrow bands and lenses in the western and southern partof the toposheet no. 48K/13. Quartz-sericite schist and sericite schist occurs as narrow, linear bands along with quartz-chlorite schist and actinolite-chlorite schist.

Kodachadri Formation consists of quartz-chlorite schist and banded iron formation are exposed in the northern and central partof the toposheet no. 48K/13. Quartz-chlorite schist is widely exposed in and around Mattimane, Kargode, along road section from Nittur to Nagodi and nalas near Changavalli and Talgod. The rock is fine grained, greenish grey colour, schistose consists of quartz, chlorite and feldspars. Narrow linear bands of BIF of Kodachadri Formation are exposed within quartz-chlorite schist at around Kodachadri hills.

Granitic gneiss generally occupies the low grounds and undulating plains. Laterite occurs as irregular patches in the study area It is buff to reddish brown and dark brown, hard, compact (in some places, concretionary or cavernous) and occurs as capping ranging in thickness from 3 m to 12 m.

Foliations found in meta-sedimentary, gneiss and meta-volcanic are trending in NW-SE direction with NE dips varying from 25°-40°. The schistose formations have been isoclinals folded; the trend of the fold axes is NW-SE. In gneiss trend of foliation is NW-SE which is in structure conformity with that of schistose formations. Joints are very well developed in granite and gneiss. They are trending in N-S, E-W, and NW-SE to NE-SW

with steep dips to vertical in meta-volcanic. Joints are trending in NW-SE to NE-SW with 60°-65°dips.

Laterite is extensively quarried for building stone. Granitic gneisses are also locally used for construction and as road metal.

Table 2: Stratigraphy of the study area in parts of T.S No. 48N/03, N/04 and 48K/13.

Age	Supergroup	Group	Formation	Lithology
Cenozoic				Aluminous laterite
				Ferruginous laterite
				Laterite
Palaeoproterozoic		Younger Intrusive	Acid Intrusive	Quartz vein
			Basic Intrusive	Dolerite
Archean	Dharwar	Chitradurga (Shimoga)	Ranibennur	Argilite
			Medur	Rhyolite
			Joldal	Banded Iron formation
				Maganiferous Phylite
			Jhandimatti	Quartz- chlorite schist
		Bababudan (Western Ghat)	Kodachadri	Banded Magnetite quartzite
				Quartz- chlorite schist
			Kudremukh	Banded Magnetite quartzite
				Acid volcanic
				Graywacke
				Quartzite
				Quartz- chlorite schist
				Sericite schist
				Quartz-sericite schist
				Hornblend-actinolite-chlorite schist
				Actinolite-chlorite schist
				Mata gabbro
				Meta Basalt
	Peninsular Gneissic complex	Peninsula Gneiss-I	Granitoids	Granitoid(Karwar)
				Granite(Kanara)
			Gneisses	Granite gneiss
				Biotite gneiss

Source: *GSI Geological Maps of T.S No. 48N/03, N/04 and 48K/13(compiled).*

1.6 Methodology:

The methodology to be followed is primarily landslide dependent following a raster-based GIS modelling approach for integration of all selected and weighted thematic maps to prepare 1:50,000 scale landslide susceptibility map. For areas where a-prior knowledge of landslide is missing or scarce and/or insufficient, any one of the following approaches may

be adopted as per priority or terrain conditions and/or after due discussion with the local experts/workers**(Fig.1)**

a) Individual ratings for geo-factor classes and weights of geo-factors will first be determined based on a pilot study in the adjacent smaller area/ road corridor (preferably within the study area) where well-distributed landslide data are available by using various spatial association techniques. Later such ratings and weights will be used for the entire study area for model integration using the same multiclass index overlay method. In case of availability of similar or research work in adjacent and similar terrain nearby, the ratings and weights developed are used in such work and may also be used after due discussion with the local experts.

b) Individual ratings for geo-factor classes and weights of geo-factors will be determined using Analytical Hierarchy Process (AHP) after preparing the pair wise qualitative comparison matrix of all factors (Saaty, 1977) after due discussion with local experts and workers.

Methodology adopted can be broadly classified as follows: -

1.6.a. Pre-Field Studies:

Total nine pre-field thematic maps were generated by using differentdata capturing sources. The slope morphometry maps viz. slope aspect, slopecurvature, slope angle and drainage map were prepared as raster outputs from30m CARTODEM (Digital Elevation Model). Geomorphology and LandUse-Land Cover (LULC) mapswere prepared as vector products with the help of Google imageries (Multitemporal images have been used for digitization of Geomorphology layer andimage generated in the period between November 2011 to March 2012 was usedfor digitization of LULC layer) in Arc GIS software. The Slope Forming Material(SFM) map and regolith thickness (R.T) map was generated from LULC and Geomorphology proxies in Arc-GISsoftware, whereas landslide inventory map was generated by collecting the data from old GSI landslide reports and field observations.

1.6. b. Field Based Studies:

As given in the Table 1.1, there were three objectives of the field studies:

- Validation of pre-field maps i.e. Geomorphology, LULC, Slope Forming Material (SFM), regolith thickness (R.T) map and Landslide Inventory map were validated in field.
- Augmentation of existing landslide database by identifying new slope failure incidences and recording field observation in 42 geo-parametric sheets at each of the identified sites. The field data recorded at field check spots (attributes of geo-factors and 42 geo-

parametric points of landslides incidences) were recorded in tough pad/field device to direct upload the collected field data on OCBIS.

1.6.c. Post-Field Studies:

The post-field studies were aimed at:

A. Updation of Pre-Field Maps: During field validation, the modifications in thepre-field maps were done wherever required. Corrections were incorporated in Arc-GIS Platform by using cut polygon method and by changing the name of the polygon of a particular class in accordance with the observations in the field. Ultimately, polygons/classes of all thematic layers viz. Geomorphology, LULC, Slope Forming Material and Regolith thickness map were finalized.

B. Landslide Susceptibility Modeling: In Karnataka & Goa, owing to the lesser number of landslides, Analytical Hierarchy Process (AHP) was used for landslide analysis and preparation of Landslide Susceptibility Map, instead of landslide dependent method involving Statistical Analysis of landslide incidences. The AHP is multi criteria decision making process of measurement through pair-wise comparison and it relies on the judgment of the experts to drive priority scale (Saaty 2008). The entire process of landslide susceptibility modeling is given below:

B1. Criteria for assigning ranks to Geo-factor Classes and Maps: Ranking of each geo-factor class was done on the basis of expert opinion, knowledge, field experience and observations by different knowledge-experts working in landslide domain in different parts of southern and western India. Similarly, average rank was assigned to every geo-factor map based on its importance in inducing a slope failure. This consensus of rankings was developed with a view to bring out the uniformity of approach in identifying landslide susceptibility zones in Southern India in general and Karnataka in particular. The nine point ranking scale, ranging from 0 (lowest ranking) to9 (highest ranking) was finalized and each class/ geo-factor was ranked accordingly. Classes/ Maps that have higher control on inducing failures were assigned relatively higher rankings and vice-versa.

B2. AHP Modeling: For AHP modeling, pair-wise comparison matrix of geo-factor classes was executed following calculation of eigen values, fraction rate values and Landslide Occurrence Favorability Score ratings (LOFS).After determination of LOFS ratings for each geo-factor class of a particular geo-factor map, integer weights of individual geo-factor maps were calculated. Thereafter, the integer weights were normalized by minimum weight.

A raw susceptibility score map was generated using integer weights and LOFS values. The raw susceptibility score map was, finally reclassified based on the logic of providing mutual comparison expert-driven ranking of High, Moderate and Low categories/ classes. A cut off margin of 50% and30% were used for high-moderate and moderate – low classes respectively.

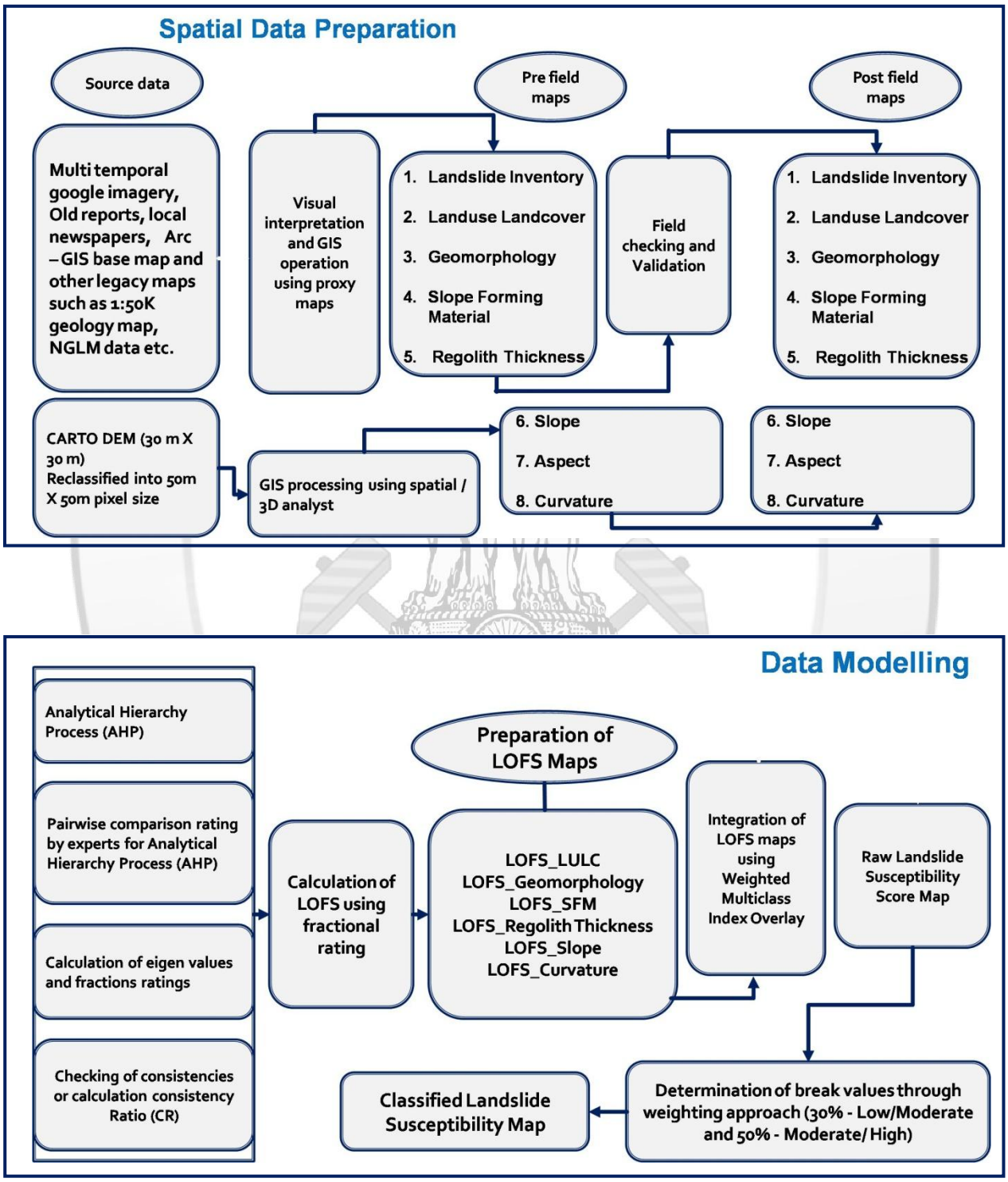


Figure 1:Flow diagram showing process of Landslide Susceptibility Mapping

1.7 Acknowledgements:

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2. PREVIOUS WORK ON LANDSLIDE STUDIES

Landslides and slope instabilities are major hazards to humans often causing economic losses, property damages and high maintenance costs, as well as injuries or fatalities. They can occur in natural slopes or man-modified slopes, and are triggered by various agents like rainfall, earthquakes, stream/gully erosion. Under natural slope conditions, the occurrence of landslides is mainly due to the favourable geo-environmental factors aided by rainfall or earthquakes. On the other hand, in man-made slopes, due to construction for major transportation systems and excavations which are triggered by rainfall, earthquake etc. Thus, it becomes more challenging to deal with man modified slopes for landslide susceptibility mapping.

In Karnataka, the landslide studies are mainly focused in the hilly regions of Western Ghats. The Western Ghats extend from Coorg (now Kodagu) District in the South to Uttar Kannada district in the north in Karnataka state. The landslide prone areas in Western Ghat covering an area of about 34,156Sq. Km. Out of this total area, an area of 26,909 sq. km was covered by the end of FS 2018-19. An area of 7247 sq.km was proposed for the field season: 2019-20. Several Macro scale landslide susceptibility studies and preparation of landslide inventories have been carried out along NH and SH road corridors in Karnataka and Goa states in the past decade. In Karnataka, landslides are mainly cut slope failures primarily consisting of debris and sometimes rock and are mostly located along National Highways (NH-13, 17, 48 and 206) and State Highways (SH-1, 27, 48, 50, 64, 66, 69, 88, 89, 90, 93 and 95). In Goa region, landslides are mainly cut slope failures consisting of rock as well as earth/ debris, and are mostly located along National Highways (NH-4A and 17A), State Highways (SH-1, 3 and 4) and Konkan Railroad.

Landslide studies in the area have been carried out only along transportation corridors (NH & SH) in the Western Ghats. Landslides in the study area generally occur on untreated cut slopes. These are usually small in size but pose considerable risk to life and property. Several landslides are reported along roads (Highways) every year during the monsoons indicating that the triggering factor for these slides may be rainfall besides anthropogenic activities.

There was no previous work done in the study area pertains to landslide studies. Though, almost all the landslides in an area appear to have been caused due to the human inference in modifying the existing natural slopes. The steep zones along the Ghat roads in the Kodachadri reserve forest are the most vulnerable zones as far as the landslide activity is concerned. Moreover, the landslides were commonly noticed in the area where toe

support was removed by natural agencies or cultural activities. Road construction/road widening and encroachment of valley for increasing agriculture area together with the diversion of streams are the main causes for mass failure, triggered mostly by rainfall.

Landslide susceptibility mapping of the road corridors have been carried out in GIS, according to the methodology prescribed by Bureau of India Standards IS 14496 (Part2): 1998, modified by Geological Survey of India. The recommendations suggested include geometrical modification of the slope by grading / benching, bio-technical measures of slope protection and proper drainage.As per the landslideinventory along National Highway & State Highway of Ghat Roads in Coorg, Dakshin Kannada, Udupi, Shimoga and Chikkamagalur Districts, Karnataka" by K. V. Maruthi and K. V. Chandran., 2013, majority of the slides seem to have occurred due to anthropogenic causes and triggered by heavy rainfall. The recommendations include proper drainage as the drainage is seen blocked or absent in around 60% of the affected areas. The water from uphill slope needs to be diverted in order to minimize sliding by providing contour drainage at the crown part & insertion of horizontal perforated pipes into the slopes which will act as weep-holes in the vertical slopes, thereby reducing the pore water pressure by draining out the excess water. This has to be given at appropriate intervals and lined drainage at the toe part is suggested. Support structures like retaining wall, stone pitching etc. are recommended as per the site condition.Bio geotechnical measures of slope protection like plantation of Vetiver grass along the slope will reinforce most of the slides.

3. LANDSLIDE INVENTORY

Landslide inventories form an essential basis for landslide susceptibility, hazard and risk analysis. Landslide inventories that span a substantial period of time are one of the key requirements for landslide studies (Van Westen et al. 2008). The generation of a landslide inventory is a tedious work as landslides occur individually and have to be identified, mapped and inventoried. Each data source used to construct the new landslide inventory has its own uncertainties and limitations and therefore the details captured for each landslide entry vary in completeness and scientific content. In this study, satellite images and historical records are used as the main source for obtaining a multi-temporal landslide data.

3.1 Data Source:

Landslides leave discernible signs on slopes, most of which can be recognized, classified and mapped in the field or from photo-interpretation (Varnes, 1978). These signatures are mostly visible as morphological changes such as changes in slope type, break in slopes, hummocky surfaces, etc. These morphological signs are interpreted here to determine important landslide information such as type of failure, the surface area, cause and the run-out distance. Detailed and systematic field work was carried out to generate the 42-point attribute data for landslides.

Preparation of the landslide inventory commenced with the search of archival data sources, particularly published and unpublished reports of GSI. The SPOT images available as a base map in ESRI Arc-GIS (up to the resolution of 30m) and high resolution Google Earth data of different time periods (from 2002 to 2015) were used as the main data product for generating the multi-temporal landslide inventory for this area.

3.2 Inventory Mapping:

The following steps were used for digitizing a landslide polygon in Arc-GIS and building its inventory attribute.

1. In Google Earth, every segment of the study area was viewed for all available time frames. Once the landslide is identified the same is marked as a polygon. The source or the zone of depletion and the run out is marked separately.

2. The mapped polygon is then saved as kml file and later imported to Arc-GIS using "conversion" function. In Arc-GIS the kml to layer conversion is first done and then the layer data is exported as a polygon shape file or directly to the geo-database. In this study the WGS- 84 datum and UTM projection (43N) is taken for analysis.

3. The landslide polygon is then corrected with the help of the ESRI base map. Any shift in the spatial location of the polygon, due to shift in the multi-temporal images of Google Earth data, is adjusted manually. Few landslides were also mapped directly from satellite imagery data and toposheet in Arc-GIS.

4. For each landslide polygon, the attributes such as name, state, district, taluk, toposheet number, initiation and reactivation year based on dates of Google Earth images, slide type, slide material, length, width, surface area, cause, land use and element at risk is attached. Archival data were used for naming and defining the cause of the landslides.

5. A systematic and detailed field check was then carried out to validate the pre-field map at all the accessible locations. The morphological signatures left by landslides on slopes were used to identify the shape of landslides.

6.The morphological parameters of the slide (landslide scar length, width and depth) are noted carefully after measuring them in the field using a meter tape. Additional data such as landslide type, run-out distance, present land use/land cover class, regolith thickness, and structure, probable cause, and damage details were also added to the inventory. Any new landslides identified were plotted in the topographic maps and were digitized as polygons or points depending upon the dimension of slide and entered in a geo-database of Arc-GIS.

During the field survey a total of 117 landslides were noted and data collected for different attributes documented in 42-point Geo-parametric sheet for landslide inventory**(PLATE:11).** A total of 83debris slides, 29earth slides,03 debris flows, 01 earth flow and 1 subsidence are recorded. Most of the slides are recorded on the road cut and along stream bank. This is attributed to extensive slope cut and toe removal due to erosion respectively. Of all, the majority of landslides can be categorized as shallow translational with depth of slip plane being < 5 m.

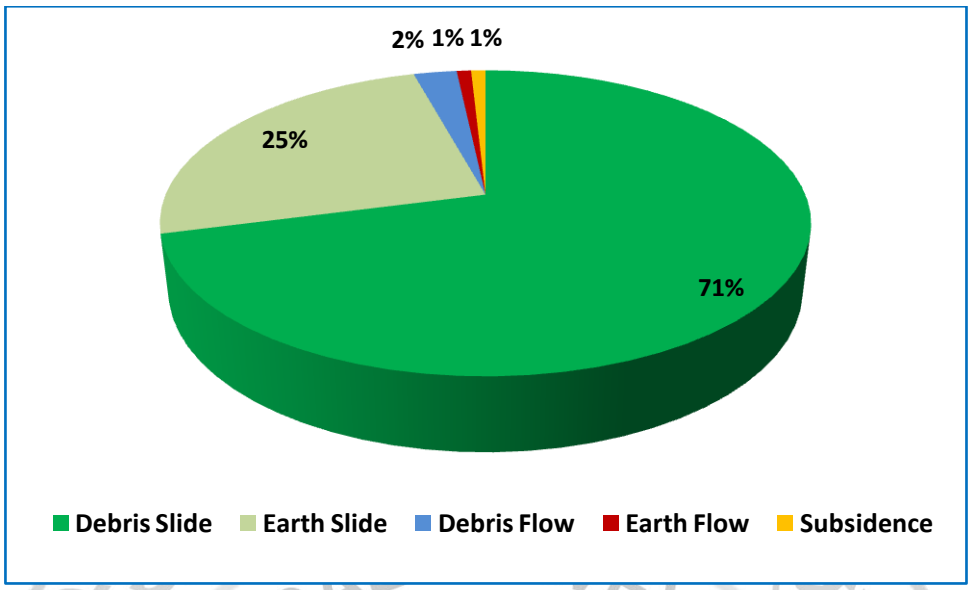


Figure 2: Spatial distribution of Landslides

The spatial distribution of mapped landslides is shown in**Annexure-II**, which gives detail inventory of 117 landslides for which 42-point inventory data were prepared.

Maximum Number of landslides (39 no's) observed in Kollur-Nagodi road section. Steep slopes at Kollur-Nagodi road section is highly weathered, jointed /fractured at places and saturated with numerous first order stream leading to make slope vulnerable to mass failure. Majority of the cut slopes and embankment failure consequently, making the road unstable. These slides are mainly aggravated by human activities such as road cutting/ widening or by removing of soil for construction purpose. The chance of re-activation in monsoon seasons & post-monsoon season cannot be ruled out as heavy rain in the season making the steep slope more saturated and vulnerable.

Few of the slides have been recorded along the rim of Linganamakki reservoir. These slides of different dimensions are attributed to the periodic fluctuation of the reservoir level during and after the rainy season. Slides observed in Kirkodi, Hebbige, Kesaremane and Bailgi are occurred due to filling of reservoir. The first three locations are suffered from massive debris/earth flows in August, 2019 during high and incessant rain event.

Encroachment of flow path of stream (valley part) for increasing agriculture/plantation area and simultaneously diversion of streams towards hill side are making the slope unstable**(Photot:13,14).**Numerous streams of different orders are feeding the reservoir. Consequently, during high and sustained rainfall in August 2019, ground-water levels rose as a result of filling reservoirs that subsequently raises the stream level. The increase in water level ultimately aggravated the toe erosion by stream causing steepening of slope due to undercutting making the slope exposed to fail. The slides

observed due to such anthropogenic activities are observed in Ambiladi, Vatgod, Belur, Madvi, Holegaru, Deviyaramane, Sunkadavaramane, Sidlukuni, Hebbige,Kesaremane,Kirgodi,Habbigai,Alur and Changvalli. Massive slide occurred in Sunkadavaramane, Kesaremane and Hebbige, where streams are blocked due to huge debris flow. Plantation at downslope also suffered with loss of forest land at upslope. Few of the slides, below the road bench are retrograding and leading to road failure in the future**(Photo:15,16).**

Unscientific way of cutting slope for making settlement by removing toe support is another cause in the area that increases slope instability**(Photot:3,4,5).** Extensively slope cutting without giving any lateral support was observed in Nittur, Muduru, Baregundi,Sampekatte and Mani areas. A large debris slide occurred at the back side of Govt. High School, Sampekatte due to cutting of the slope and authorities have constructed school building without any mitigation measure.

Removal of toe support after road cutting contributed to around 70% of landslides in the study area. It is noticed that due to toe erosion by stream below the road bench, some roads are in grave danger. Road leading to Kollur, near village Holegaru;Kumbli-Sampekatte road, 0.5 km N of Vill. Ambiladi; Road leading to Nittur,near village Sidalguni and Road leading to Sampekatte near Vill. Deviyaramane need immediate attention to safeguard the roads.

Of total landslides observed 49% are active, 16% reactivated and 35% are old slides. This can be inferred that around 65% of the landslides observed that were triggered in the year 2019; mostly in the month of August, 2019. A comprehensive and comparative study of rainfall data (last 10years) of Shimoga & Udupi district reveals that the highest rainfall occurred during the month of August 2019 and is coinciding with most of landslidesin our study area.

The presence and abundance of discontinuities in the rock mass including bedding planes, foliation, faults, joints & other openings are controlling the stability of the slope in study areas. The locations of the recorded landslides superimposed on geology map show that many of the slides are occurring along the contact or in close vicinity of this. The failure has been accelerated after the road construction through these contacts which later added by rainfall. The contact between Hb-actinolite-chlorite schist with Metabasalt and Qtz-chlorite schist with BMQ is well evident in Kollur-Nittur Ghat road**(Photo: 12)** and near Sampekatte respectively. Around 26 landslides are occurring at the contact of different lithology. These discontinuities are acting as a plane of weakness and provide storage space and pathway for

groundwater migration. Groundwater saturation may increase pore pressures within these weakened planes resulting in a reduction of strength. Increased moisture can easily percolate and reduce friction along zones of weakness causing material above that particular plane to slide along the lubricated surface. Hence, failures are common during rains when the exposed overburden mass resting on the cut slopes experience hydrostatic pressure.

Lithology is also one of the important factors controlling the stability of hill slopes in the area, where the rocks are mostly weathered, low strength and low internal friction**(PLATE:12).** Though, it is not a geo-factor theme in preparing the landslide susceptibility analysis map. The resistance to processes of weathering and erosion differs for different rock types. The erodibility or the response to rocks to the process of weathering and erosion are the cause for formation of regolith. An attempt has been made to build a relation between different lithology present in the area with associated landslide incidences.

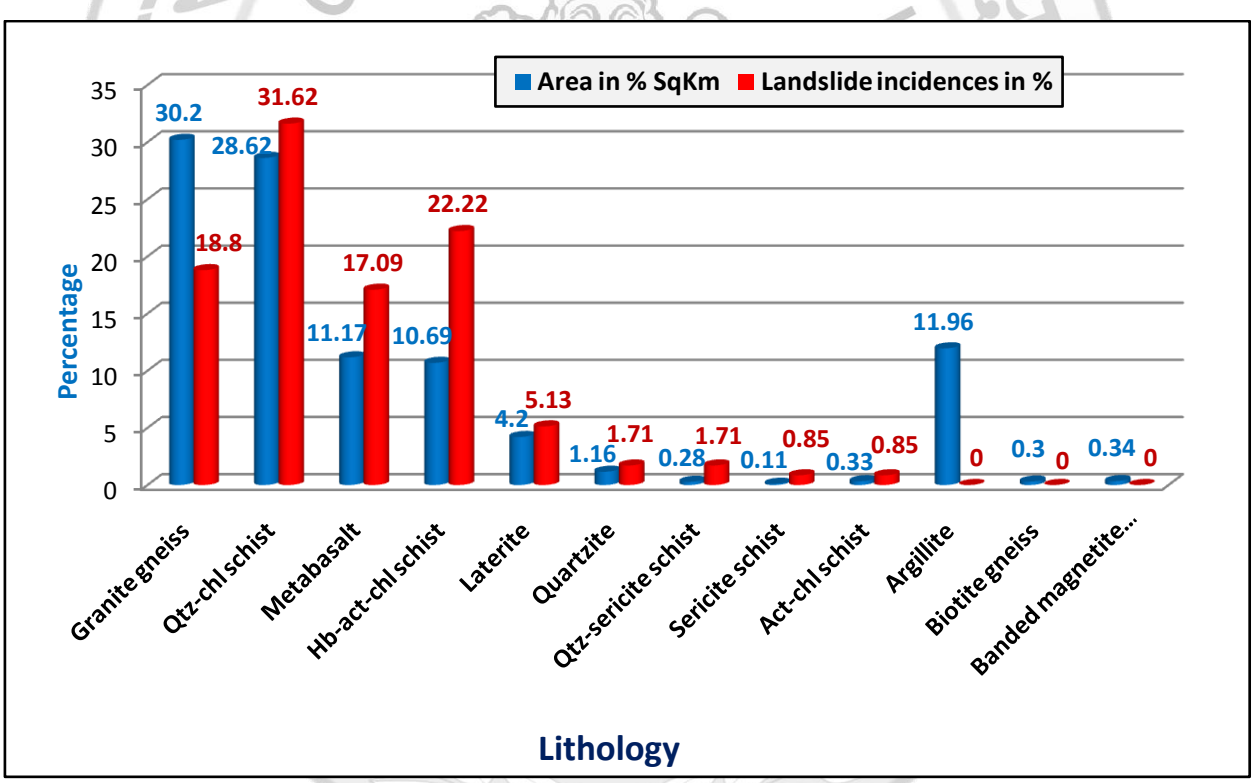


Figure 3: Spatial distribution of Landslides with respect to Lithology & associated areas

After completion of field work, a note on temporary mitigation measure has been submitted to DC, Shimoga, highlighting the areas which requires urgent/immediate attention pertains to landslide hazard/subsidence of ground.

4. LANDSLIDE SUSCEPTIBILTY ANALYSIS

This chapter comprises of the materials and methods used in landslide susceptibility analysis using Analytical Hierarchy Process (AHP) for areas deficient in landslides.

4.1 Background Information:

Landslide susceptibility deals with the likelihood of landslide occurrence in an area on the basis of interplay of various geo-factor themes. Landslide susceptibility is the relative probability for the occurrence of landslide in an area. This does not necessarily mean that slides will essentially occur in high susceptible zones and that the low susceptible zones will not have any slides. It is only a qualitative and quantitative estimation that how a particular mapping unit, under the effect of several factors may behave in the landslide perspective. Since the study area lacks natural and sufficient number of landslides AHP method of analysis is used.

The analytical hierarchy process (AHP) is a semi-quantitative method in which decisions are taken using weights through pair wise relative comparisons without inconsistencies in the decision process (Saaty, 1980). The AHP consists of the following five steps:

(i) Breakdown a decision problem into component factors
(ii) Arrangement of these factors in a hierarchic order
(iii) Assignment of numerical values (Saaty, 1977) to determine the relative importance of each factor according to their subjective relevance
(iv) Setup of a comparison matrix and
(v) Computation of the normalized principal Eigen vector, which gives the weight of each factor (Saaty andVargas, 2001).

The advantages of using AHP as an expert based method in landslide susceptibility analysis (Long and DeSmedt, 2012) are : (i) all types of information related to landslides can be included in the discussion process; (ii) judgment is structured so that all information is taken into account; (iii) discussion rules are based on expert's knowledge and experience; (iv) when a consensus is reached, weights for each relevant factor are obtained automatically by eigenvector calculation of the comparison matrix; and (v) inconsistencies in the decision process were verified using consistency index values.

4.2 Selection of Preparatory Factors:

For susceptibility mapping, the selection of preparatory factors for landslides depends on the scale of analysis, the characteristics of the study area, the landslide type, the failure mechanisms and the prior knowledge of the main causes of landslides (Guzzetti et al., 1999). A systematic overview of the important preparatory factors required for susceptibility mapping in different scales is given by Van Westen et al. (2008). A priori knowledge of the main causes of landslides in the area of interest is essential in selecting the most relevant factors out of the many known preparatory factors that can "theoretically" cause landslides (Ghosh and Carranza, 2010).

For susceptibility analysis six factor maps were prepared that are considered to be the main spatial causal factors for landslides in the area, out of the six maps, two are related to terrain morphometry derived from DEM and four are field based maps prepared from remote sensing data. A brief description of the significance and mapping techniques for each factor is given below.

4.3 Geo-factor Themes:

In general, the factors which influence where a landslide will occur, typically include slope angle, climate, weathering, water content, vegetation, overburden, geology, and slope stability. How these factors interrelate is important in understanding what causes landslides along with an understanding of the impact humans have on these factors by altering natural processes. Mentioned below are the factors that have been taken into account for estimating landslide susceptibility in an area using GIS. As far as data model is concerned, some of the geo-factor themes are categorical (e.g., geomorphology, aspect etc.) and others represent continuous data (e.g., slope, elevation etc.). These spatial factor maps are prepared using various source data and employing different mapping techniques which are detailed below.

4.3.1 Slope Morphometry:

Slope angle is one of the factors for the cause of landslides. Slope angle is formed between any part of the surface of the earth and the horizontal datum. It is a mean by which gravity induces stress in the slope rocks, flux of the water or other material: therefore, it is of great significance in hydrology and geomorphology. As the slope angle increases, then the shear stress in the soil or other consolidated material generally increases. Gentle slopes are expected to have a low frequency of landslides because of low shear stresses and associated low gradients. Slope failures tend to increase with slope angle but when the slope becomes

near vertical, land sliding is scarce or absent altogether as there is lack of soil development and debris accumulation in such topographic conditions (Selby, 1993; Derruau, 1983).

Slope morphometry is defined by slope gradient, aspect and curvature **(PLATE 3, 4, 5).** The data for these factors was derived from CARTO DEM, downloaded from BHUVAN portal, of having 30m resolution. Slope gradient and slope curvature for the study area was generated in Arc-GIS software using spatial analyst tool.

Slope gradient map as a derivative of DEM derived from CARTO DEM (Resolution:30m), the area was classified in to five classes ranging from <15° up to >45°**(PLATE: 5)**. A large part of thearea (about 83%) falls in low slope range i.e.,<15° class. 15°-25° slope gradient class occupies about 12.87% of the study area. About 3.10% of the area is occupied by 25° to 35° class, which is having maximum weightage according to the ratings given in AHP.Around 36% of the recorded slides correspond to slope gradient class of 25°-35°, 32% slides are lies in between 15°- 25° gradient, 15% in 35°- 45° gradient followed by 11% in less than 15°& only 6% in greater than 45° gradients. The area coverage in sq.km. with LOFS and rank is given in **Table – 3.**

Table 3: Rank, LOFS and area coverage for Slope gradient of T.S Nos. 48K/13, 48N/3 and 48N/4

CLASS	Rank	LOFS	Area coverage (sq.km.)	Area covered (%)
<15	2	0.1631	1209.72	83.08
15-25	4	0.4597	187.40	12.87
25-35	8	1.0000	45.20	3.10
35-45	6	0.2817	10.86	0.75
>45	2	0.1631	2.83	0.19

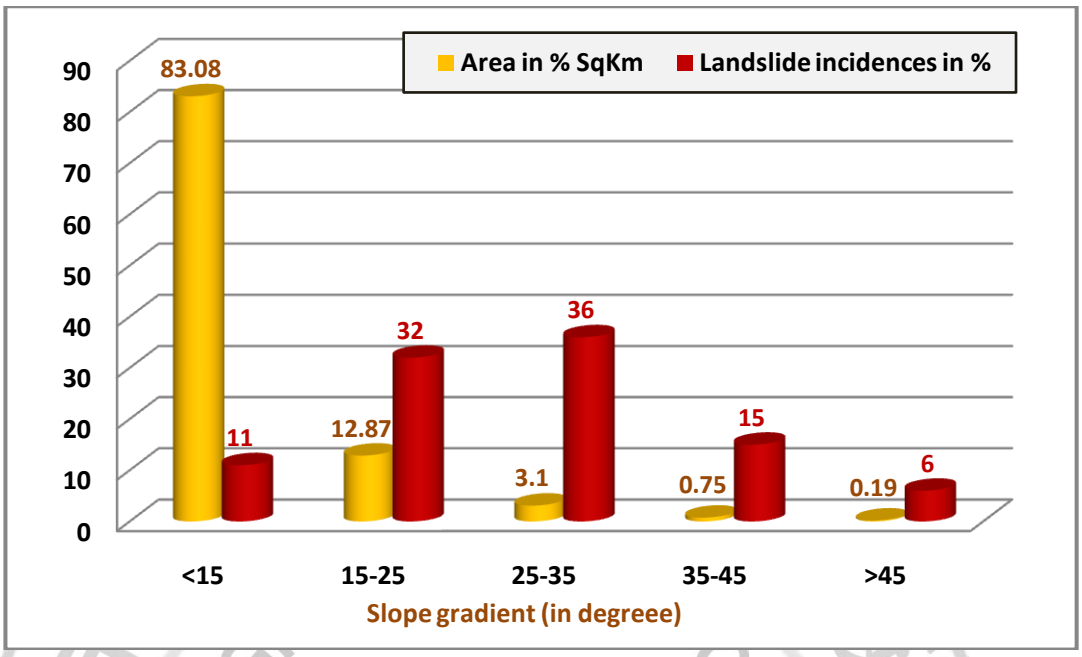


Figure 4: Spatial distribution of Landslides with respect to slope gradient& associated areas

Slope curvature is another important geo-factor in landslide susceptibility analysis**(PLATE: 4)**. Apositive curvature represents upwardly convex surface, while a negative curvature indicates that the surface is upwardly concave at a given pixel. Curvature map is classified into three classes' i.e. convex, flat and concave slopes. About 13% of thearea falls in flat slope. The Convex slope (>0.1) class which is given the maximum weightage in the area covers about 42% of the study area while 45% of the area falls under Concave slope (<0.1). The concave hill slopes are areas having high soil moisture content and receive more surface run-off. Failures can be expected to occur more frequently in those areas than the slopes that are convex along the contour. Around 51% of the slides are occurring in convex slope and 45% in concave followed by 4% in flat terrain. It is inferred that both convex and concave slope are fragile for mass failure and almost equally contributing to landslide initiation. More weightage and ranking is given to convex slope class (>0.1) and slope gradient (25°-35°).

Table 4: Rank, LOFS map and area coverage for slope curvature map of T.S Nos. 48K/13, 48N/3 and 48N/4

CLASS	Rank	LOFS	Area coverage (sq.km.)	Area covered (%)
Concave	**4**	**0.4113**	**661.85**	**45.46**
Flat	**2**	**0.1676**	**186.99**	**12.84**
Convex	**6**	**1.0000**	**607.16**	**41.70**

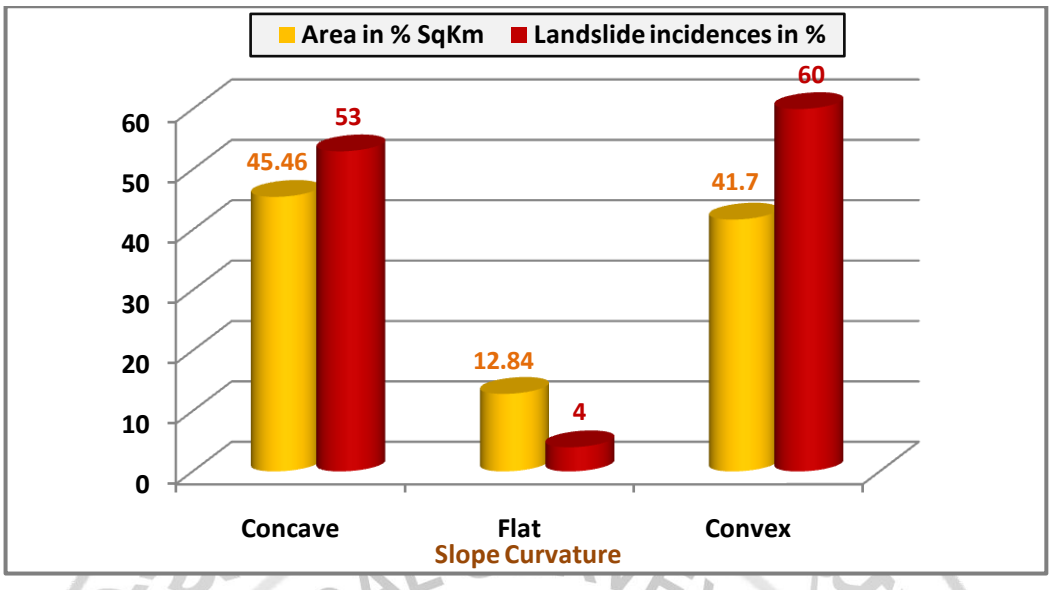


Figure 5: Spatial distribution of Landslides with respect to curvature& associated areas

Slope aspect explicates the direction that a natural slope faces**(PLATE: 3)**. The aspect of the slope plays a role in controlling some microclimatic factors such as exposure to sunlight, windward (wet) or leeward (dry) conditions, rainfall intensity, soil moisture and weathering, all of which control the material properties of the slope deposits (Dai et al. 2001; Cevik and Topal, 2003). The slope aspect map was derived from the 30m CARTO DEM using Arc GIS and the values were grouped into 08 directional classes with interval separation of 45°.

During the preparation of landslide susceptible map, slope aspect map has not taken into consideration.

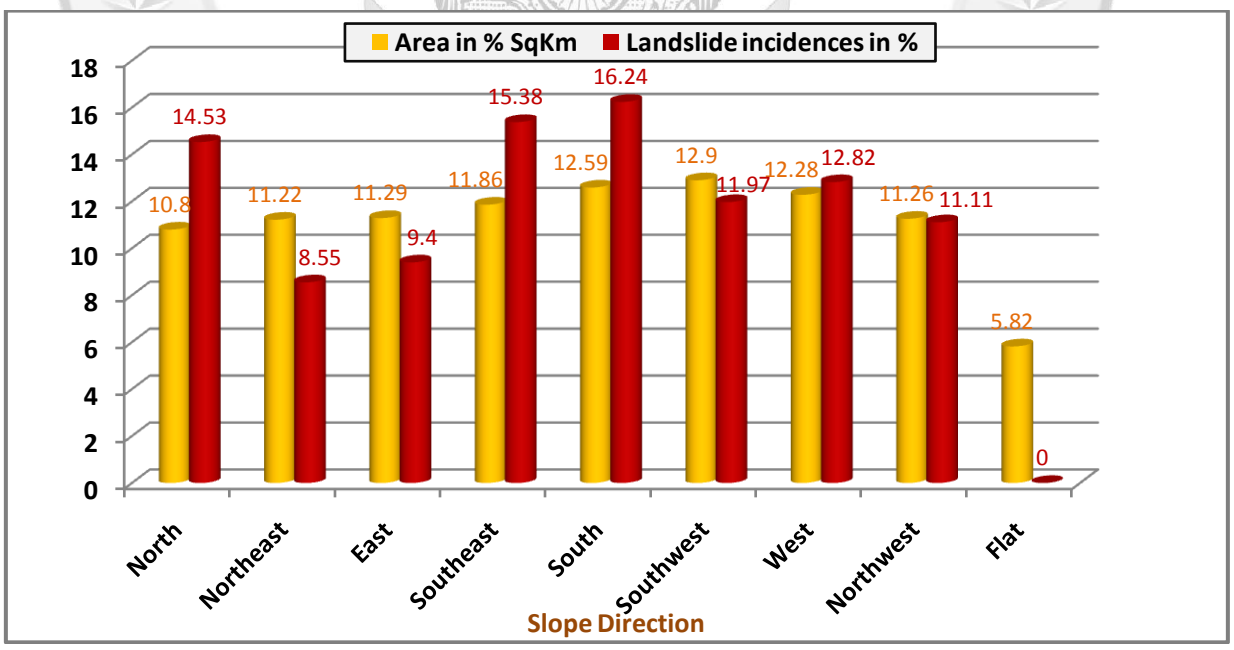


Figure 6:Spatial distribution of Landslides with respect to slope direction& associated areas

4.3.2Geomorphology:

Geomorphology, along with information on soil, water and vegetation has become one of the essential inputs in planning for various developmental activities. The scope of geomorphology has further expanded with the landform maps widely used in various fields of resource surveys, environmental analysis, hydrological studies, engineering applications and geo-technical studies.

Geomorphology map **(PLATE-7)**of the study area was prepared in Arc-GIS software through visual interpretation of multi-temporal Google Imageries of the area. The obtained pre field map was checked and validated in field. In terms of geomorphology the area was grouped into the following classes namely highly dissected slopes, moderately dissected slopes, lowly dissected slopes, escarpment, valley fill, pediment-pediplain complex, rolling plains, plateau top and ridge trop. The dissected slopes (high, moderate or low) were mapped based on visual interpretation by taking topographic ruggedness and presence of drainage as criteria. An area of about 27.57% falls under pediment-pediplain complex followed by19.13%, lowly dissected slopes and with 17.65%, highly dissected slopes. An area of 9.4% lies under moderately dissected slopes, while 17.69% area is contributed by rolling plains and valley fills. Only 2.5% area corresponds to escarpment or near vertical slope exposing rock. Highly dissected slope is given maximum weightage (rating 8) using AHP method followed by moderately dissected slopes (rating 6).Most of the slides have been observed to occur in highly dissected slopes where large scale slope modification was observed. These slides are mainly retrogressive and widening in nature.

The area coverage for each class in sq.km. LOFS and rank is given in **Table – 4**. It is observed in the study area that the anthropogenic activities like toe cutting for construction /widening of road and settlement are predominantly causative factors apart from natural causes.

The details of geomorphic features are given as follows:

Dissected Structural Hills: Hills, which are originated due to tectonic process and are highly dissected by the drainage lines. This can be further classified as highly, moderately and low dissection depending on the density of joints and drainage. Mostly this will be interpreted from a planimetric satellite data and the classification is highly subjective. (NGLM Manual, 2010)

Escarpment: The long continuous steep face of a ridge or plateau formed by erosion; usually scarp or scarp face, such as one resulting from faulting.

Pediment: A broad, flat or gently sloping, rock floored erosion surface or plain of low relief, typically developed by sub aerial agents (including running water) in an arid or semiarid region at the base of an abrupt and receding mountain front or plateau escarpment, and underlain by bedrock (occasionally by older alluvial deposits) that may be bare but more often partly mantled with a discontinuous veneer of alluvium derived from the upland masses and in transit across the surface. (NGLM Manual, 2010)

Pediplain: Pediplain is a broad, relatively flat rock surface formed by the joining of several pediments. Pediplain is usually formed in arid or semi-arid climates and may have a thin veneer of sediments. (NGLM Manual, 2010)

Pediment – Pediplain complex:A complex landform where both pediplain and pediments occur and it is difficult to separate them.

Valley fill: The unconsolidated sediment deposited by any agent so as to fill or partly fill a valley(NGLM Manual, 2010).

Rolling plain: An undulating plain with rugged topography. (NGLM Manual, 2010)

Table 5: LOFS, rank and area coverage for Geomorphology of TS nos. 48K/13, 48N/3 and 48N/4

Class	Rank	LOFS	Area coverage (sq.km)	Area covered (%)
Lowly Dissected Slope	4	0.1947	278.48	19.13
Moderately Dissected Slope	6	0.4020	136.94	9.4
Highly Dissected Slope	8	0.7279	256.96	17.65
Escarpment	2	0.0819	36.15	2.48
Pediment Pediplain Complex	0	0	401.48	27.57
Rolling Plain	0	0	144.35	9.91
Valley Fill	0	0	113.34	7.78
Ridge top	0	0	0.55	0.04
Plateau top	0	0	0.54	0.04
River	0	0	2.45	0.17
Water body	0	0	84.84	5.83

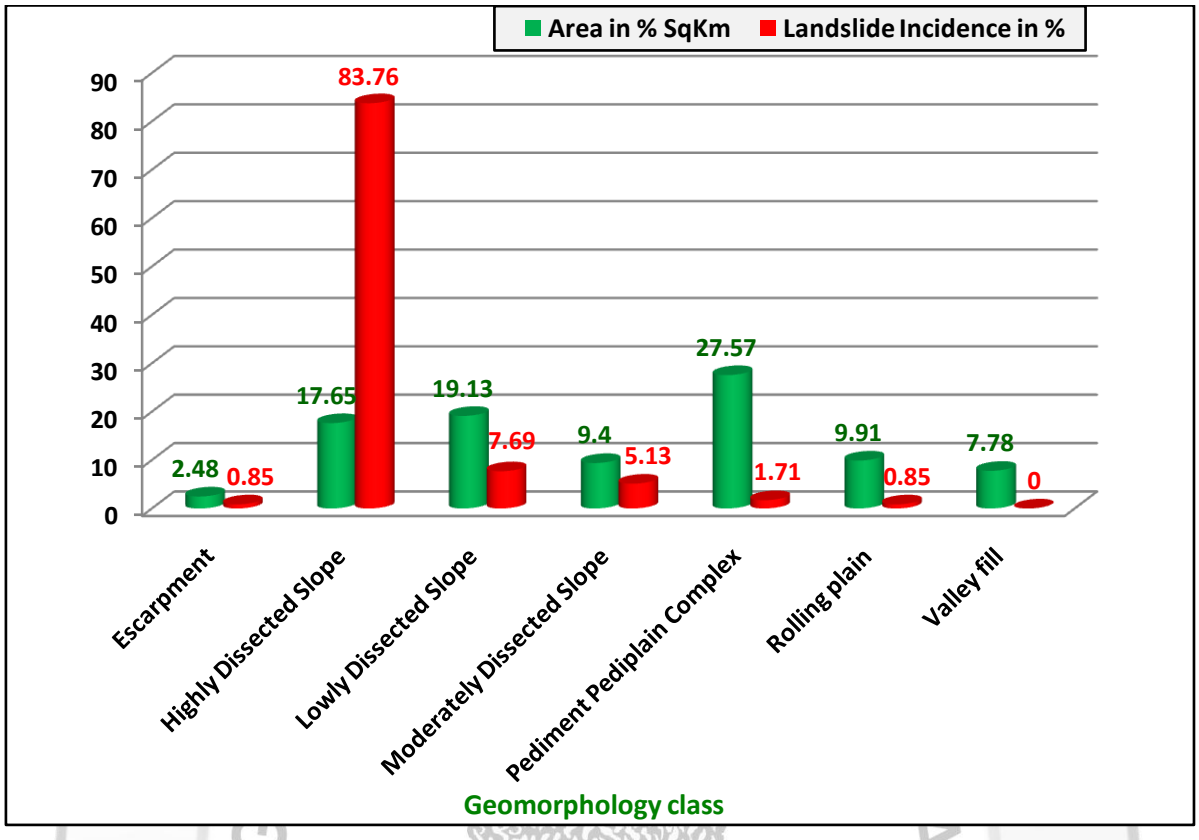


Figure 7: Spatial distribution of landslides with respect to Geomorphology & associated areas

4.3.3 Land Use and Land Cover:

Land use & land cover of an area refers to how the land is being used and the density of vegetation in that area. The vegetation cover influences directly the susceptibility to landslides through various factors including (i) protection of the surface, (ii) consolidation of the soil and (iii) agriculture resulting in bare soil for long periods (Atkinson et al, 1998).The mechanical properties of slope materials can be altered through agricultural activities involving ploughing or other modifications of the existing cover, as well as through conversion, i.e. changes of the cover from one type class to another. As the requirements of the society are dynamic, the land use- land cover too changes over a period of time. Given the dynamic character of this class and appreciable influence that the density of vegetation and different land use practices have over the stability of hill slopes, it is necessary to specifically mention the time frame of the data source used for making LULC map of the area under study.

The study area consists of lush green forests, followed by cultivation. The commercial plantations form a small part of land use in this area. Settlements are observed in almost all parts of the study area. This often results in slope cut failures, mostly along road. This is augmented by heavy rainfall during monsoon. Encroachment in valley part for

increasing agriculture/plantation area often observed. Simultaneously, diversion of stream from its natural path towards hill side for irrigation is also observed. This practice of disturbing the slope and natural course of stream rendering the slope vulnerable to fail during high discharge/rainfall. The major part of the area is occupied by thick vegetation, followed by cultivation and plantation; mainly Arecanut, Nilgiri, Acacia, Coconut and other high height trees.In many areas natural soil of the forest is disturbed by growing Acacia & Arca nut trees that change the soil chemistry of the area. Presence of Linganamakki reservoir in the study area drastically changes the ground water level. In response to this, anthropogenic activities like road creation, human habitation and other development had to be pushed higher up the valleys into the terrain of higher elevation. Road cut slopes from Nagodi to Kollur are highly vulnerable and has exceptional importance due to tourism and pilgrimage activities. The stability of road cut slopes in the region degraded notably due to inadequate excavations during road construction and widening projects.

Construction of roads, railways and reservoirs has opened channels for exploitation and caused rapid changes in LULC of the area. The land use and land cover (LULC) map**(PLATE-6)** was prepared from the Google Earth data of the year 2012-time frame. Following the normal mapping procedure in Google Earth, first the polylines of different land use/cover classes were drawn and the same were imported in Arc GIS through kml to feature conversion. In Arc GIS the features were converted into polygons and then again exported to Google Earth through layer to kml conversion. Each polygon was named as per its LULC class and reconverted into a shape file through kml to layer conversion. The obtained pre-field land use/land cover map was checked in the field at all accessible locations. The area in terms of land use/land cover can be classified in to the following classes: Barren land, cultivation land, settlement, settlement on modified slope, sparse vegetated areas, moderate vegetated areas, thick vegetated areas, low height plantation, high height plantation, extensive cut slope, quarry fallow land, river and water body. The area along river banks is covered with transported material and low lying valleys are covered with overburden material and are being used for cultivation. In many areas stream course is converted into cultivation land, while natural course of stream is diverted towards the slope-cut section for increasing the cultivation area. This stream forced to cut the toe of slope to accommodate large volume of water during rainfall and resulted in landslide. Major part of the area (48%) is covered with thick forest in all of the study area. The next class of highest percent is occupied by cultivation that constitutes about 20.84% of the area. High height plantation is covering almost 11% area, while moderate vegetation covers 7.27% of the study area followed by 2.52% of sparse vegetation. Settlements and settlement on modified

slopes occupy about 2.78% of the area. Extensive slope cut is observed to be most vulnerable sites for slope failures and occupies only0.01% of the study area.The maximum weightage is given to extensive slope cut (Photo-1, 2, 6, 9) followed by sparse vegetation and settlement on modified slopes which occupy about 2.52% and 0.06 % of the area respectively. The area coverage of each factor class in pixels, LOFS and rank is given in **Table – 5**.

Thick vegetation: Thick vegetation (forest cover) covers most parts of 48K/13, northern parts of48N/4 and southern part of 48N/3 toposheets. The area is densely forested and presents picturesque scenic spots, especially to the south of Nagodi.The thick forest cover in the northern and eastern part of the toposheet no. 48K/13 is deciduous. The Western and Southern part of the toposheet no. 48N/4, has been fragmented at many places by human activities. At places forest cover has been modified into Acacia and Nilgiri plantation, thus reducing the natural strength of soil.

Plantations: The whole area is rich in forest wealth with bamboos, teak-wood, rose-wood and other valuable timber.These include commercial plantations like coconut, cashew, areca nut, teak, silver oak etc. Arecanut forms the most flourishing and revenue yielding crop of the area. The other crops cultivated in the area are paddy and sugar cane. They mostly cover the low lying region of the area.

Settlements: Due to high degree of commercialization and improvement in communication routes more and more area of the Western Ghats is being encroached upon by human settlements. Laborers from other states,who are brought in to work in plantations and other commercial activities also live here.

Settlements on Modified slope: Linganamakki reservoir present in the study area has submerged much of the land area, thereby increasing water table of the area. In response to this, anthropogenic activities, including creation of road and houses had to be pushed higher up the valleys into the terrain of higher elevations. Thus increasing the landslide susceptibility index of the area.

Extensive slope cut: Roads and railways are required for improving connectivity and communication in an area. The study area also has good road connectivity though at the cost of extensive damage to slopes **(Photo: 1,2,6)**. Slopes need to be cut in order to construct roads in the hilly terrains of the Western Ghats. This weakens the slopes a great deal. This class has been given high rating for the same. Nagodi to Kollur road stretch crossing steep terrain and has numerous slope-cuts formed during road construction.

Table 6: LOFS, rank and area coverage for Land-use/Land-cover of TS nos. 48K/13, 48N/3 and 48N/4

Class	Rank	LOFS	Area coverage (Sq.km)	Area covered (%)
Barren	1	0.0626	25.45	1.75
Cultivation	2	0.0937	303.43	20.84
Extensive Slope Cut	9	1	0.09	0.01
Fallow Land	1	0.0626	3.52	0.24
Moderate Vegetation	5	0.2912	105.88	7.27
Plantation (HHP)	4	0.1988	152.62	10.48
Plantation (LHP)	3	0.1366	0.09	0.01
Quarry	5	0.2912	1.49	0.1
Settlement	1	0.0683	39.39	2.71
Settlement on modified slope	7	0.5631	0.9	0.06
Thick Vegetation	4	0.1988	699.07	48.01
Sparse Vegetation	7	0.5631	36.72	2.52
River	0	0	2.45	0.17
Water body	0	0	84.84	5.83

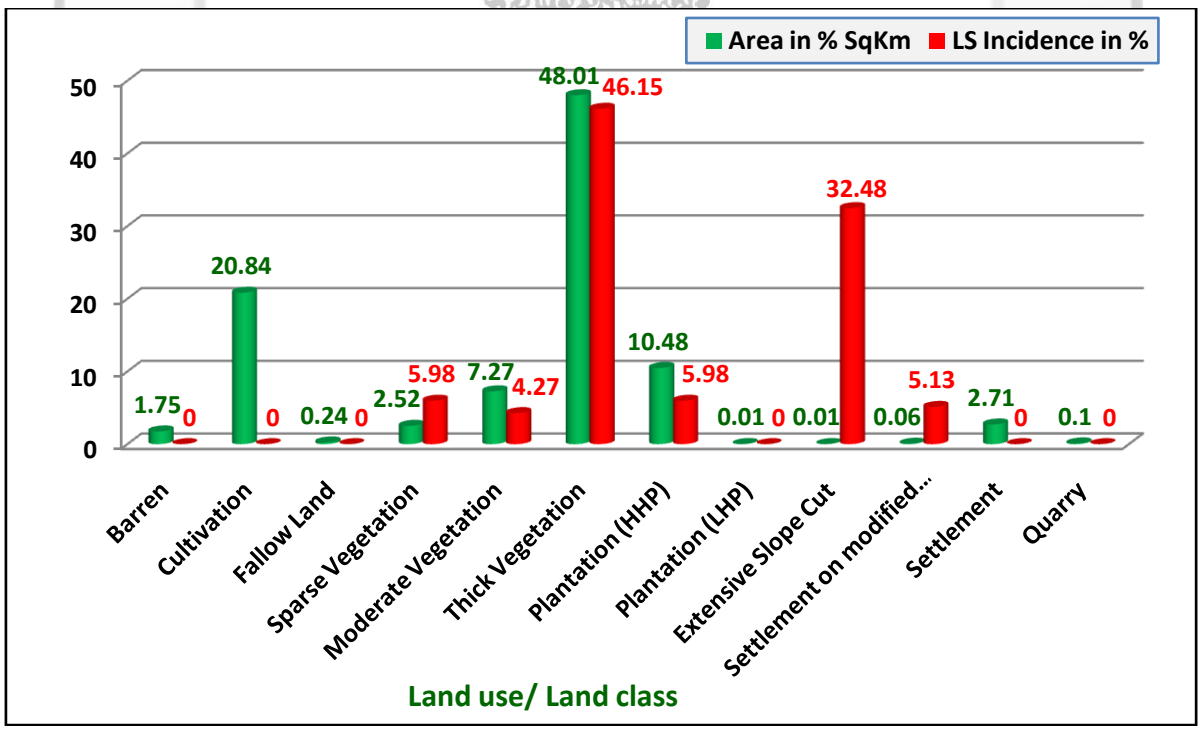


Figure 8: Spatial distribution of landslides with respect to LULC& associated areas

4.3.4 Slope Forming Material (SFM):

The slope forming material has a great deal of bearing on the slope stability as their physio-mechanical properties depend on the climatic setup, slope gradient, aspect of the slope and slope curvature. Thus this theme is as important as other geo-factors in

considering the landslide susceptibility analysis. Thus careful study of slope forming material is a must for any area. Slope Forming Material (SFM)(**PLATE-9**) map was prepared in Arc-GIS through visual interpretation of multi-temporal Google Imageries of the area and collection of data for material present on slopes. The study area in terms of Slope Forming Material (SFM) is classified in to the following classes: In-situ soil, rock, weathered rock, transported soil and loose soil debris.

Due to the humid climate of the region substantial intense in-situ weathering has taken place, leading to extensive creation of laterite (in-situ soil). Slope Forming Material with a thickness of approx. 5 m is generally observed in the area. In-situ soil with weathered rock together forms the slope forming material in the western Ghat hill slopes. The eastern and western parts of the study area is partly cover with transported soil, while western hills slope and northern part of the study area is mostly covered with the in-situ soil. The central part of the toposheet no.48K/13, is partly covered with weathered rock. At places, barren patches of rocks are observed where the slope angle is exceeding 40° and is covering top of the hill. Escarpments at Steep slope in Kollur- Nagodi road section are devoid of any slope material.

A large part of the study area (around62%) is covered by in-situ, lateritic soil (**Photo-1, 8)**and transported soil (20.81%). Weathered rock constituting 5% of the area and rocks are exposing in 3% of the total area (**Photo10, 11**).A small proportion of loose slide debris (0.002%) is vulnerable to slide and contributing almost 8.5% of the slide studied during the field. The factor class rock includes overburden material of≤ 0.5m thickness. For this class different rock names are taken from the geological map of the study area by GSI. The class loose slide debris is assigned maximum weightage of 8; while weathered rock has been assigned a value of 6. The loose in-situ soil has poor shear strength due to water saturation in Western Ghats climatic conditions. The area covered in Sq.km, LOFS and rank is given in**Table – 6**.

Table7: LOFS, rank and area coverage for Slope forming material of48K/13, 48N/3 and 48N/4

CLASS	Rank	LOFS	Area Coverage (Sq.km)	Area Coverage (in %)
In-situ soil	**4**	**0.2409**	**901.46**	**61.91**
Banded magnetite quartzite	**1**	**0.0682**	**4.77**	**0.33**
Granite	**1**	**0.0682**	**0.23**	**0.02**
Granite gneiss	**1**	**0.0682**	**5.59**	**0.38**
Quartzite	**1**	**0.0682**	**0.43**	**0.03**
Banded iron formation	**1**	**0.0682**	**0.71**	**0.05**
Dolerite	**1**	**0.0682**	**1.85**	**0.13**
Metabasalt	**1**	**0.0682**	**29.07**	**2.00**

Biotite gneiss	**2**	**0.2409**	**0.96**	**0.07**
Transported Soil	**3**	**0.1506**	**303.13**	**20.82**
Ferruginous laterite	**4**	**0.2409**	**0.26**	**0.02**
Laterite	**4**	**0.2409**	**3.89**	**0.27**
Argillite	**4**	**0.2409**	**2.52**	**0.17**
Quartz-chlorite schist	**4**	**0.2409**	**14.75**	**1.01**
Quartz-sericite schist	**4**	**0.2409**	**1.30**	**0.09**
Actinolite-chlorite schist	**4**	**0.2409**	**0.85**	**0.06**
Hornblende-actinolite-chlorite schist	**4**	**0.2409**	**22.47**	**1.54**
Sericite schist	**4**	**0.2409**	**22.47**	**0.02**
Weathered Rock	**6**	**0.5437**	**74.17**	**5.09**
Loose slide Debris	**8**	**1.0000**	**0.03**	**0.002**
River	**0**	**0.0000**	**2.45**	**0.17**
Water body	**0**	**0.0000**	**84.84**	**5.83**

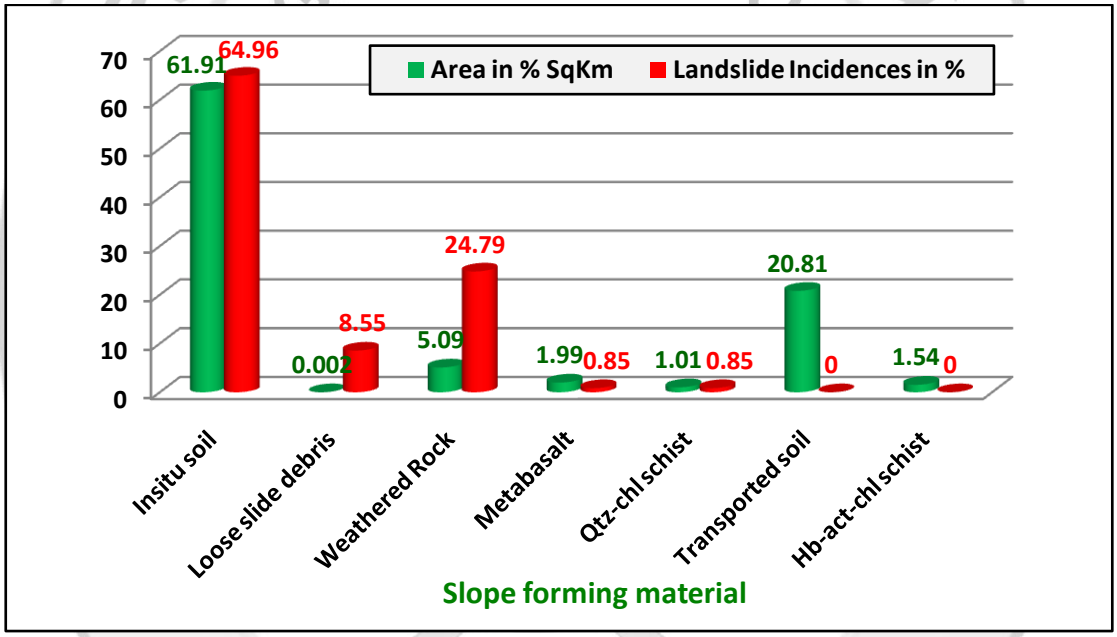


Figure 9: Spatial distribution of landslides with respect to SFM & associated areas

4.3.5 Regolith Thickness:

One of the most sensitive parameters is soil thickness (Van Westen et.al, 2008 and Page et al., 1994) to correlate sediment thickness with landslide events. Landslide is triggered due to the decrease in shear strength of the soil as a result of increase in pore water pressure on the failure surface. An increase in pore water pressure can be caused directly by percolating rainfall or indirectly by an accumulation of water at a certain depth due to changes in permeability within the soil cover (perched water tables) or by an accumulation of water at the soil – bedrock contact (Terlien, 1998).

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 bed 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 modeling, large number of observations (such as drill holes, data, 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. During field work, regolith/overburden thickness is estimated by observing road cuts, forest trenches and nala sections wherever available. An attempt is made to get the approximate overburden depth and it is observed that in low dissected hill slope having low slope gradient, the overburden depth is relatively more (approx. 2-5 m or >5m) where as in low dissected slopes having steeper slope gradient, the overburden depth varies from 1-2m to occasionally up to 5m. In the study area, it can be classified in to four classes less than 0.5 m, 0.5m to 5 m, 5m to 10mand greater than 10m (**PLATE8**). Along the moderate and steep slopes depth of overburden, in general, is less while along major weathered profiles, regolith thickness is more, and these areas are more prone to landslides. Overburden thickness of <0.5m is observed on rocky, steep slopes and is included into rock class. The map is grouped into four classes. About 6.34% of the area falls under rock cover with very thin slope wash at moderate to steep slope thus< 0.5m regolith class will be consider for the same. Another60.30 % of the area comes under 0.5-5 m overburden thickness. The 5-10m overburden thickness comprises nearly 18.8% of the study area and is present mainly in the north-eastern, south-eastern and central part of the study area, while >10m overburden thickness covers a small area of 8.57% and is sporadically observed in toposheet no.48N/04. The area covered by each factor class in terms of pixels, LOFS and rank is given in **Table – 7**

Table 8: LOFS, rank and area coverage in pixels for Regolith Thickness of T.S No. 48K/13, 48N/3 and 48N/4

CLASS	Rank	LOFS	Area coverage (Sq.km)	Area covered (%)
< 0.5 m	**0**	**0**	**92.29**	**6.34**
0.5 - 5 m	**7**	**1**	**877.97**	**60.30**
5 - 10 m	**4**	**0.32296**	**273.76**	**18.80**
>10m	**2**	**0.13627**	**124.76**	**8.57**

River	**0**	**0.0000**	**2.45**	**0.17**
Water body	**0**	**0**	**84.84**	**5.83**

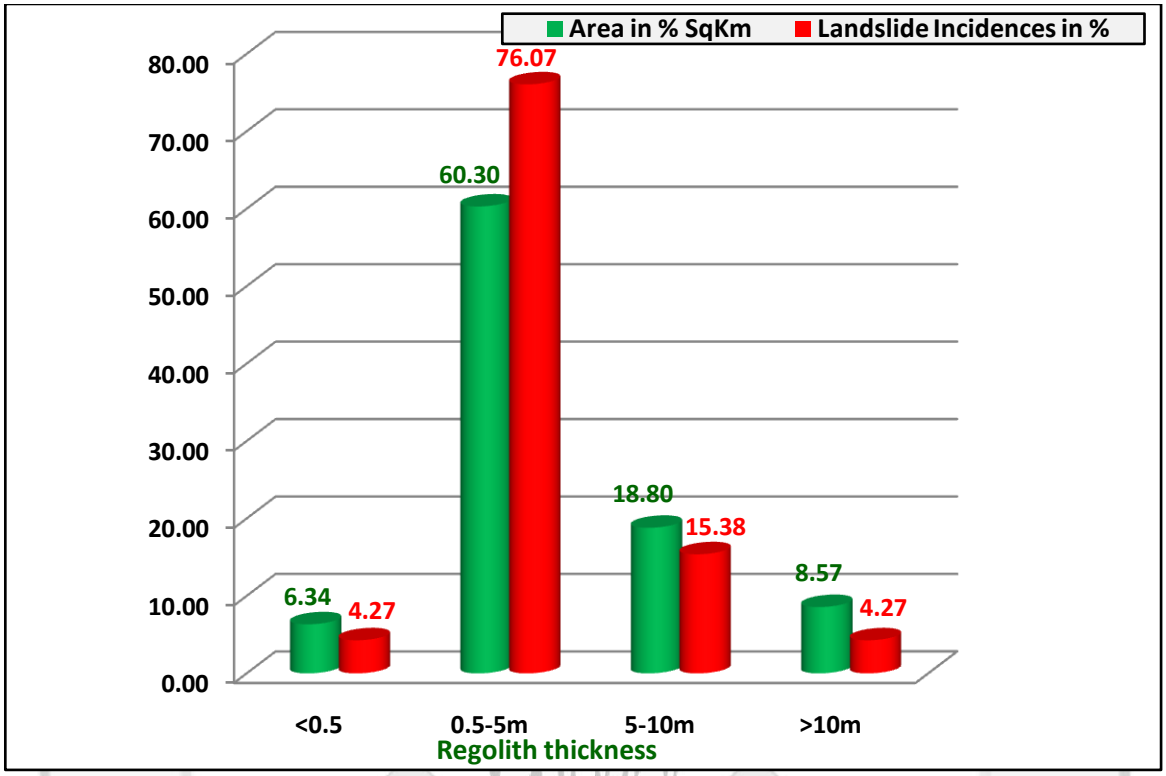


Figure 10: Spatial distribution of landslides with respect to regolith thickness & associated areas

4.4Analytical Hierarchy Process (AHP):

Landslide Susceptibility Mapping is a qualitative study of slope failures in an area with focus on identifying zones susceptible to landslides as low, moderate and high. The presence of climatic change necessitates greater focus on slope failures, identification of hillsides prone to slope failures, study of causative and triggering factors, depiction of vulnerable areas on GIS based and locality specific maps and on evolving innovative technologies for future management.

Since very few, almost negligible amount of slide is observed elsewhere in the area, the normal method of modeling cannot be used herein this situation, ratings and inter-predictor weights can only be determined using expert or knowledge driven techniques by implementing one of the following alternatives or by combining knowledge derived from attempting all the alternatives.

Alternative 1: Finalization of ratings and weights in a smaller neighboring area-If landslide inventory data is available in a smaller catchment or road-corridor within or

adjacent to the proposed study area (or Toposheet), attempts should be made to determine terrain-specific ratings and weights of geo-factors through a pilot study in that particular pilot study area. This can be executed by employing different spatial association analysis such as determination of Yule's Co-efficient, Distance Distribution Analysis etc. The ratings and weights determined so far through that pilot study can then be utilized for the entire study area where landslide data is not available. Since NLSM aims to develop and utilize terrain-specific ratings and weights, this seems to be the best approximation of terrain-specific importance of geo-factors.

Alternative 2: Finalization of ratings and weights using expert opinion and Analytical Hierarchy Process (AHP)-

In a situation of complete non-availability of landslide inventory data, there is absolutely no remedy other than utilizing complete expert or knowledge driven ratings and weights into susceptibility modeling despite its subjectivity. However, this knowledge-driven ratings/ weights in quantitative matrices can easily be determined mathematically using AHP (Saaty, 1977; Ghosh et al., 2010), after preparing/ deciding on the qualitative pair wise importance matrix for different geo-factor classes and amongst different geo-factors for inter-predictor weights, obtained so far through discussion and comments received from local experts and landslide scientists engaged in landslide investigation of the area. The procedures of application of AHP through some examples are illustrated below.

In line of the above proposition, for determining the terrain-specific knowledge-driven ratings and weights through application of AHP, a mandate form/ questionnaire is prepared, where all the concerned landslide scientists, other geologists working in similar terrain and all experts of the concerned Region may submit their mandate/ answer in a semi-quantitative term by rating each geo-factor theme separately. While giving the semi-quantitative rating in a scale of 1-9 for each geo-factor theme, the mutual relative importance for influencing/ causing a single proposition that is land sliding in this case should be taken into account. A particular geo-factor class having higher rating would be considered as more instrumental in influencing land sliding. For example, if we classify our slopes into 5 classes say 0-15, 15-25, 25-35, 35-45 and >45 and give semi-quantitative rating as 2, 4, 8, 6, 1 then it will be presumed that for land sliding, slope class 25-35 is the most important among all other classes.

4.4.1 Methodology:

The Analytic Hierarchy Process (AHP), developed by Saaty (1980) is a method of structuring decision problems. The AHP consists of three levels of hierarchy. The first hierarchy level is the goal of the decision making, the second level involves how each of the existing criteria contributes to achievement of goal, and the third level is to find out how each of the alternatives contributes to each of the criteria.

The AHP method is appropriate and to be used where decisions are to be assessed quantitatively. It is assumed that human beings' natural reaction when facing a complex decision making process, is by grouping the decision elements according to common characteristics. This involves ranking the decision elements, and then comparing between each pair in each group in a form of matrix. Then inconsistency ratio and weight for each element can be measured. This provides ease in testing the data consistency. The higher consistency ratio, the assessment result becomes more inconsistent. The acceptable consistency ratio is less than or equal to 10%.

According to Taylor, Consistency Index (CI) can be calculated by using the following formula:

CI= maks eigen value-n/n-1 …… **Eq-1**

$maks.\ eigenvalue = \sum_{\iota} wi.ci$ …… **Eq-2**

The consistency ratio is then calculated as,

CR= CI/ RI …… Eq-3

Where, n is the amount of items compared, w*i* is the weight, ci is the sum of column, CR is theConsistency Ratio, CI is the Consistency Index and RI is the Random Consistency Index.

If CR ≥ 10%, the data acquired is inconsistent and If CR < 10%, the data acquired is consistent. The ratio-scale form is used as an input. The values in the ratio are organized in a matrix, which is called the pair-wise comparison matrix. In the AHP method, the scale range 1–9 is assumed. It is limited to a ratio-scale 1–9 because according to the research conducted by Miller, human beings cannot simultaneously compare more than seven objects. The Standard Preference Scale used is given in table:

Table 9: Class value and their ratings

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

Using the above Standard Preference Scale, a group of geoscientists from GSI engaged in landslide studies in India and in Western Ghats, in particular, were asked to rank the factor classes and the factor maps. The obtained score for individual factor class was used for determining the ratings for each factor class. The average score for the factor maps were ranked between 0 and 9. Matrix of pair-wise ratings; estimated eigenvectors of pair-wise rating matrix; and estimation of consistency vector (CV), consistency index (CI) and consistency ratio (CR) for judgment of consistency of pair-wise ratings of factors, respectively for all maps was calculated. Example of LULC for calculation of LOFS is given in **Table 9-12.**

Table 10: Generic Table showing mutual comparison rank of LULC factor classes

CLASS	Rank	LOFS
Barren	1	0.0626
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
River	0	0.0000

Table 11: Table showing matrix of mutual comparison ranks of LULC classes given rank >0

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
Sum Clm	49.00	38.50	3.00	49.00	15.18	21.58	29.50	15.48	49.00	6.96	21.58	6.96

Table 12: Table Showing Fraction rate and LOFS values

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV	Sum rows	Frac rate	LOFS
B	0.02041	0.01299	0.03702	0.02041	0.01551	0.01158	0.01113	0.01292	0.02041	0.02052	0.01158	0.02052	0.21283	0.01774	0.0626
CL	0.04082	0.02597	0.04165	0.04082	0.01647	0.01544	0.01695	0.01615	0.04082	0.02394	0.01544	0.02394	0.3184	0.02653	0.0937
ESC	0.18367	0.20779	0.3332	0.18367	0.32931	0.27799	0.23729	0.32293	0.18367	0.43092	0.27799	0.43092	3.39936	0.28328	1.0000
FL	0.02041	0.01299	0.03702	0.02041	0.01551	0.01158	0.01113	0.01292	0.02041	0.02052	0.01158	0.02052	0.21283	0.01774	0.0626
MV	0.10204	0.10139	0.06664	0.10204	0.06586	0.09266	0.10169	0.06459	0.10204	0.04788	0.09266	0.04788	0.98989	0.08249	0.2912
HHP	0.08163	0.07792	0.05553	0.08163	0.03293	0.04633	0.06078	0.03229	0.08163	0.03591	0.04633	0.03591	0.67586	0.05632	0.1988
LHP	0.06122	0.05195	0.0476	0.06122	0.02195	0.02317	0.03039	0.02153	0.06122	0.02873	0.02317	0.02873	0.46439	0.0387	0.1366
QR	0.10204	0.10139	0.06664	0.10204	0.06586	0.09266	0.10169	0.06459	0.10204	0.04788	0.09266	0.04788	0.98989	0.08249	0.2912
S	0.02041	0.01299	0.03702	0.02041	0.01551	0.01158	0.01113	0.03229	0.02041	0.02052	0.01158	0.02052	0.2322	0.01935	0.0683
SM	0.14286	0.15584	0.11107	0.14286	0.19759	0.18533	0.16949	0.19376	0.14286	0.14364	0.18533	0.14364	1.91425	0.15952	0.5631
TV	0.08163	0.07792	0.05553	0.08163	0.03293	0.04633	0.06078	0.03229	0.08163	0.03591	0.04633	0.03591	0.67586	0.05632	0.1988
SV	0.14286	0.15584	0.11107	0.14286	0.19759	0.18533	0.16949	0.19376	0.14286	0.14364	0.18533	0.14364	1.91425	0.15952	0.5631

Table 13: Table showing estimation of consistency vector (CV)

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV	Sum rows	CV
B	0.01774	0.01327	0.03148	0.01774	0.0165	0.01408	0.0129	0.0165	0.01935	0.02279	0.01408	0.02279	0.2192	12.3591
CL	0.03547	0.02653	0.03541	0.03547	0.02062	0.01877	0.01935	0.02062	0.0387	0.02659	0.01877	0.02659	0.3229	12.1696
ESC	0.15962	0.21227	0.28328	0.15962	0.41245	0.33793	0.27089	0.41245	0.17415	0.47856	0.33793	0.47856	3.71773	13.1239
FL	0.01774	0.01327	0.03148	0.01774	0.0165	0.01408	0.0129	0.0165	0.01935	0.02279	0.01408	0.02279	0.2192	12.3591
MV	0.088	0.106	0.056	0.088	0.082	0.112	0.116	0.082	0.096	0.053	0.112	0.053	1.049	12.72

	68	13	66	68	49	64	1	49	75	17	64	17	61	4
HHP	0.07094	0.0796	0.04721	0.07094	0.04125	0.05632	0.0774	0.04125	0.0774	0.03988	0.05632	0.03988	0.69839	12.4001
LHP	0.05321	0.05307	0.04047	0.05321	0.0275	0.02816	0.0387	0.0275	0.05805	0.0319	0.02816	0.0319	0.47182	12.1921
QR	0.08868	0.10613	0.05666	0.08868	0.08249	0.11264	0.1161	0.08249	0.09675	0.05317	0.11264	0.05317	1.04961	12.724
S	0.01774	0.01327	0.03148	0.01774	0.0165	0.01408	0.0129	0.04125	0.01935	0.02279	0.01408	0.02279	0.24395	12.6068
SM	0.12415	0.1592	0.09443	0.12415	0.24747	0.22529	0.1935	0.24747	0.13545	0.15952	0.22529	0.15952	2.09543	13.1358
TV	0.07094	0.0796	0.04721	0.07094	0.04125	0.05632	0.0774	0.04125	0.0774	0.03988	0.05632	0.03988	0.69839	12.4001
SV	0.12415	0.1592	0.09443	0.12415	0.24747	0.22529	0.1935	0.24747	0.13545	0.15952	0.22529	0.15952	2.09543	13.1358
													Sum CV	151.33

In the same manner LOFS and consistency ratio (CR) were calculated for all the six factor maps. All the tables of the six factor maps for LOFS and consistency ratio calculations have been attached in **Annexure – I.**

Table 14: Table showing calculation of consistency index (CI) and consistency ratio (CR).

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Mean CV		**12.6109**	
Consistency Index (CI) =			**(Mean CV-number of themes)/(No of themes -1)**
CI	**0.05553**		
Consistency Ratio (CR) =			**CI/RI**
CR	0.00463		
CR should never be more than 0.1			

Table 15: Table showing mutual comparison of individual factor maps and weights.

Factor Classes	
Factor	**Rank**
Slope	9
Curvature	2
SFM	6
LULC	8
Geomorphology	6
Regolith Thickness	4

Factor	Slope	Curvat	SFM	LUL	Geom	RT
Slope	1.00	8.00	4.00	2.00	4.00	6.00
Curvature	0.13	1.00	0.20	0.14	0.20	0.33
SFM	0.25	5.00	1.00	0.33	1.00	3.00
LULC	0.50	7.00	3.00	1.00	3.00	5.00
Geom	0.25	5.00	1.00	0.33	1.00	3.00
RT	0.17	3.00	0.33	0.20	0.33	1.00
Sum Clmn	2.29	29.00	9.53	4.01	9.53	18.33

Factor	Slope	Curvature	SFM	LULC	Geom	RT	Sum rows	Frac rate	Weight	Weight W N
Slope	**0.43636**	**0.27586**	**0.41958**	**0.49881**	**0.41958**	**0.32727**	**2.37747**	**0.39625**	**12.8653**	**13**
Curvature	**0.05455**	**0.03448**	**0.02098**	**0.03563**	**0.02098**	**0.01818**	**0.18480**	**0.0308**	**1**	**1**
SFM	**0.10909**	**0.17241**	**0.10490**	**0.08314**	**0.10490**	**0.16364**	**0.73807**	**0.12301**	**3.99392**	**4**
LULC	**0.21818**	**0.24138**	**0.31469**	**0.24941**	**0.31469**	**0.27273**	**1.61107**	**0.26851**	**8.718**	**9**
Geom	**0.10909**	**0.17241**	**0.10490**	**0.08314**	**0.10490**	**0.16364**	**0.73807**	**0.12301**	**3.99392**	**4**
RT	**0.07273**	**0.10345**	**0.03497**	**0.04988**	**0.03497**	**0.05455**	**0.35053**	**0.05842**	**1.89685**	**2**

Once the LOFS values for geofactor sub classes are determined, all the LOFS values against the sub classes are compiled in an excel sheet. Then the LOFS attributes are joined in the raster map attribute table using "join and relates" option. Finally, LOFS map of the geofactor is prepared with the help of "Lookup" command in Arc GIS, using raster map of the geofactor as "input raster" and "geofactor_LOFS$LOFS" as lookup field.

For determination of Predictor Weight for the geo-factor, one comparison matrix is calculated in Microsoft excel software for the pair wise qualitative comparison of all the geo-factors. In the comparison matrix, fraction weight is calculated for all the geo-factors**(Table 14).** Once all the fraction weights are determined, minimum value within the fraction ratings is identified using the "MIN" command in excel software. Then all the fraction weight values are divided with the minimum fraction weight value to determine the Predictor Weight or weight of geo-factors. In this way, as the fraction weights are divided with the minimum fraction weight value, the Predictor Weight or weight values will be one

or more than one. For each geo-factor, consider the nearest whole number as its Predictor Weight or weight.

For generation of **"Raw Landslide Susceptibility Score Map"** in Arc – GIS, "raster calculation" command under map algebra is used. For "Raw Landslide Susceptibility Score Map" the following formula is used.

Susc Score *= (LOFS_Factor1*weight of Factor1 + LOFS_Factor2*weight of Factor2 + LOFS_Factor3*weight of Factor3 + ……. + LOFS_Factor$_n$*weight of Factor$_n$) / Sum of inter – predictor weight*

In this type of knowledge-driven models, classification break values can be determined on the basis of the logic applied while giving mutual comparison expert driven ranking. It is always thought by any expert that rank value for any factor class is ≥ 5, and it is considered that the particular factor class has higher likelihood in influencing the landslides. This rank value of "5" in a scale of "0" to "9" comes after 50% of the absolute difference values (9-0 = 9; 50% of 9 is 4.5). That is why this 50% cut-off margin or weightage can be used to determine the break raster value between "*Moderate*" and "*High*" susceptibility classes (*BrMH*). Similarly, when rank value for any factor class is ≤ 3 (lower than 30% of the absolute difference value of 9), and it is considered that the particular geo-factor class has lesser likelihood in influencing any landslides. Accordingly, 30% cut-off margin or weightage can be used to determine the break values between **"***Low***"** and **"***Moderate***"** susceptibility classes (*BrLM*).

Using the above logic, the required break values can be doneusing the above logic the required break values can be determined by solving the following formula:

BrMH = [(Abs Diff LOFS Factor1*50)*weight of Fcator1 + (Abs Diff LOFS Factor2*50)*weight of Fcator2 + (Abs Diff LOFS Factor3*50)*weight of Fcator3 + …… + (Abs Diff LOFS FactorN*50)*weight of FacatorN] / Sum of inter – predictor weight

BrLM = [(Abs Diff LOFS Factor1*30)*weight of Fcator1 + (Abs Diff LOFS Factor2*30)*weight of Fcator2 + (Abs Diff LOFS Factor3*30)*weight of Fcator3 + …… + (Abs Diff LOFS FactorN*30)*weight of FcatorN] / Sum of inter – predictor weight

Once break values (BrMH and BrLM) are calculated, **Classified Landslide Susceptibility Map** is prepared by reclassifying the Raw Landslide Susceptibility Score Map using reclassify command in Arc – GIS. In reclassification window, three classes are chosen and in break values, 2nd topmost value given as the first value (Class 1), 1st topmost value is given as the second value (Class 2) and third value (Class 3) is given as one. Now the Raw Landslide Susceptibility Score Map is classified into the following categories: Class 1 stands for "Low Susceptibility", Class 2 stands for "Moderate Susceptibility" and Class 3 stands for "High Susceptibility".

5. LANDSLIDE SUSCEPTIBILITY MAP

Landslide susceptibility maps are key tools for land use planning, management and risk mitigation measures. Landslide susceptibility mapping aims to differentiate a land surface into homogeneous areas according to their probability of failure caused by mass-movement at specific locations (Varnes, 1978). It relies on understanding complex mass movement processes and their controlling factors. An accurate and reliable landslide susceptibility map requires high quality data to arrive at meaningful decisions, and an appropriate methodology for analysis and modelling.

According to the final susceptibility map obtained after AHP modelling, a total of 1.79 % area falls under the high susceptibility zones, while 21.89% and 76.32% area is categorized under moderate and low susceptibility zones respectively**(PLATE:13)**. Majority of the high susceptibility zones are geographically distributed in the western, central and south-eastern part of the study area, in toposheet 48K/13. Here the high susceptibility zones run almost parallel to the moderately to steep slopes (SW to NW facing) of the Western Ghat. Around 64% of the landslide investigated in Malnad region of heavy rainfall belt is responsible for erratic distribution of high susceptible zone. A road stretch of approx. 10 km along Kollur-Nagodi Ghat road cut section lying in toposheet 48K/13 passes through the high susceptibility zone. Moreover, 39 out of 117 landslides are reported along this Ghat road only. The road stretch connects the Kudarur reserve forest, Kodachadri reserve forest and Chakra reserve forest passes through the moderate susceptibility zone. This area forms a part of thickly forested Western Ghat abounded with wild life and is mostly inaccessible.

The hill slopes of Kudarur reserve forest and surroundings of Linganamakki reservoir showing sporadic distribution of high susceptibility zone. Similarly, the hill slopes of Kilandur reserve forest and Mattikai reserve forest rimming the Chakra reservoir showing erratic distribution of high susceptibility zone.

Moderate susceptible zones are mostly dispersed in toposheet 48K/13 and erratically distributed in 48N/04. The moderate susceptible zones in the study area are generally encircling high susceptibility zone. In general, moderate susceptibility zones are located over moderate to steep slopes of the study area. Some of the localities lying within this zone and are in the vicinity of high susceptibility zones cannot be ignored as the slope failure in the up slopes will definitely affect these settlements. The locations that should be kept vigilant particularly during heavy rain are Ambiladi, Vatgod, Belur, Madvi, Holegaru,

Bailgi, Deviyaramane, Sunkadavaramane, Sidlukuni, Hebbige, Kesaremane, Kirgodi, Habbigai, Alur and Changvalli lying in toposheet 48K/13.

The low susceptible zone covers the maximum area (76.32%), it is well scattered in toposheets 47N/03, 48N/04 and foothills of Western Ghat in toposheet no.48K/13. Most of this zone falls under the gentle to flat slopes with low lying hills. This part is mainly used for habitation, cultivation and plantations. The important localities of the study area viz. Sagar, Tagarti, Anandapuram, Avinhalli, Adagodi, Handravati, Mattimane, Herbettu, Babbige, Yellurmane, Areshirur and Idur are coming under Low Susceptibility Zone. However, some of the low susceptible locations are surrounded by moderate susceptible zones viz. Sulvalli, Halliberu, Kollur,Salakodu, Basribailu, Valur, Manjagalale, Sulgod and Samgad.

Most of the high susceptibility zones correspond to thick forest with slope gradient class between 25° - 35°. It has been observed that most of the slides (36%)are also occurring in the same slope gradient. In terms of land use/land cover the road constructed on steep slopes and having extensive cut slopes are coming under higher susceptibility. In terms of geomorphology, the highly dissected slopes of Western Ghats covering almost 18% of the study area are showing moderately to high susceptibility mainly due to high anthropogenic disturbance of slope.

Much of the area in toposheet no. 48K/13 falls under moderate to high susceptibility zones, which can be attributed to two facts (i) most parts in this area/ toposheet have steep slope gradients as compared to other part of the area, and (ii) natural slopes have been excavated and modified for construction of highways, settlements rendering the slopes unstable and prone to failures. There have been many small occurrences of slope failures and road subsidence observed along the roads.

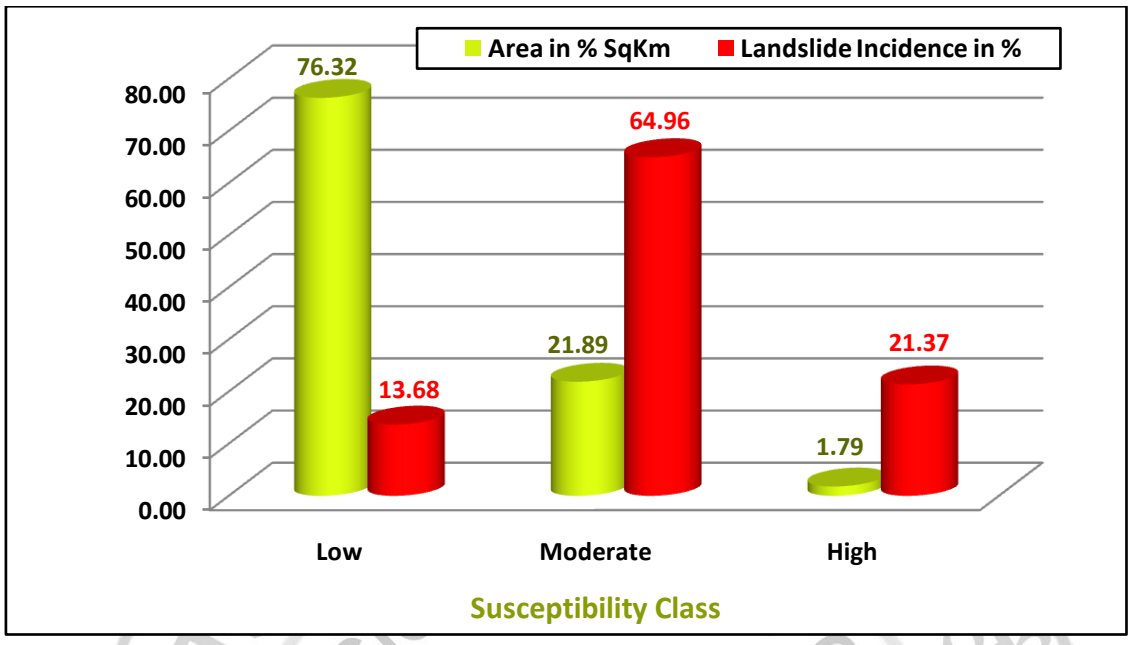


Figure 11: Spatial distribution of landslides with respect to susceptibility class & associated areas

6. Rainfall Analysis

The study area is covering part of Shimoga and Udupi district. After field observations, total 117 landslides investigated. Around 36% landslides (42no's) in Udupi district and rest 64% (75 no's) are studied in Shimoga district. The study area comprises Malnad region that comes under heavy rainfall belt. The area receives rainfall mainly from southwest monsoon from June to Sept. Maximum number of slides accounting to 64% are examine in Shimoga district, while 36% of slides in Udupi district. In Udupi district, the slides are confining mainly on Nagodi-Kollur Ghat road. In view of this more concern is given to Shimoga rainfall pattern. Around 65% of the active slides occurred during July-August, 2019, esp. many incidences occurred between 08th to 10th August 2019.The cumulative daily mean and normal rainfall of Shimoga district and Udupi district for the year 2019 in comparison to the previous year (2018) with respect to normal rainfall is given below:

Source: *Karnataka State Natural Disaster Monitoring Centre*

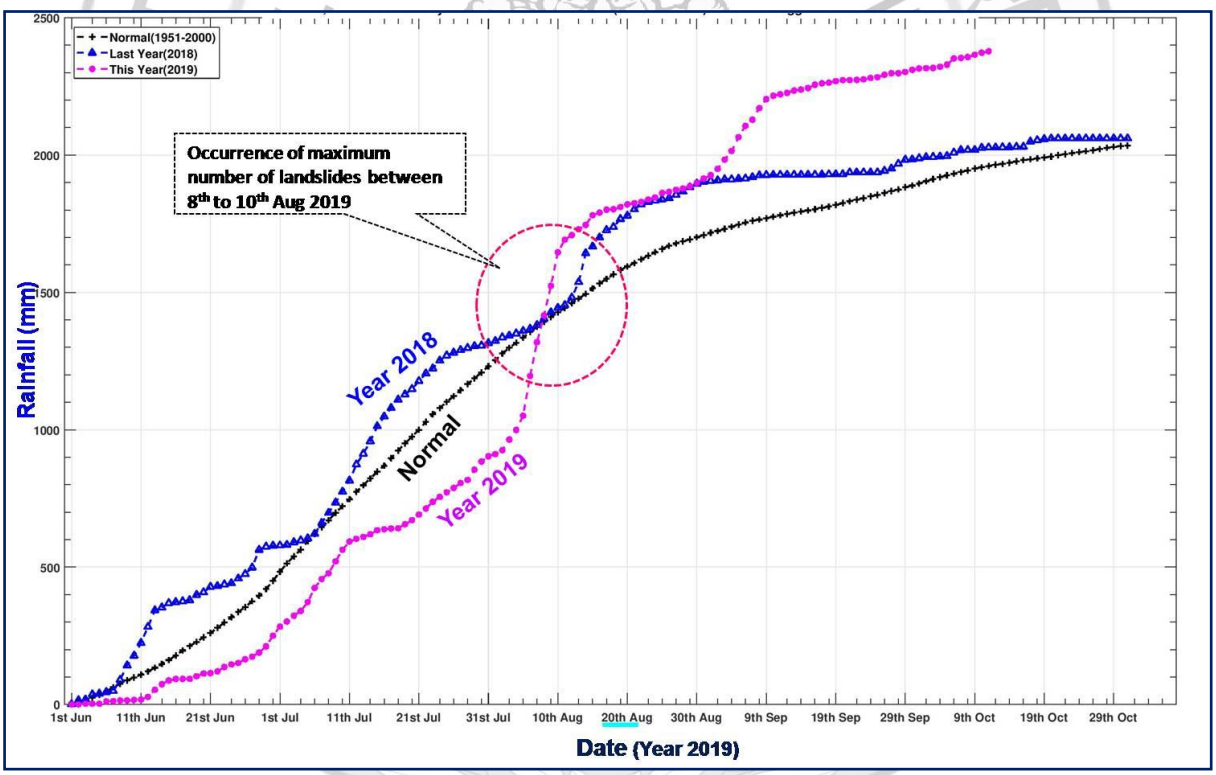


Figure 12: Cumulative Daily mean and Normal Rainfall (August-2019) of Shimoga district, Karnataka.

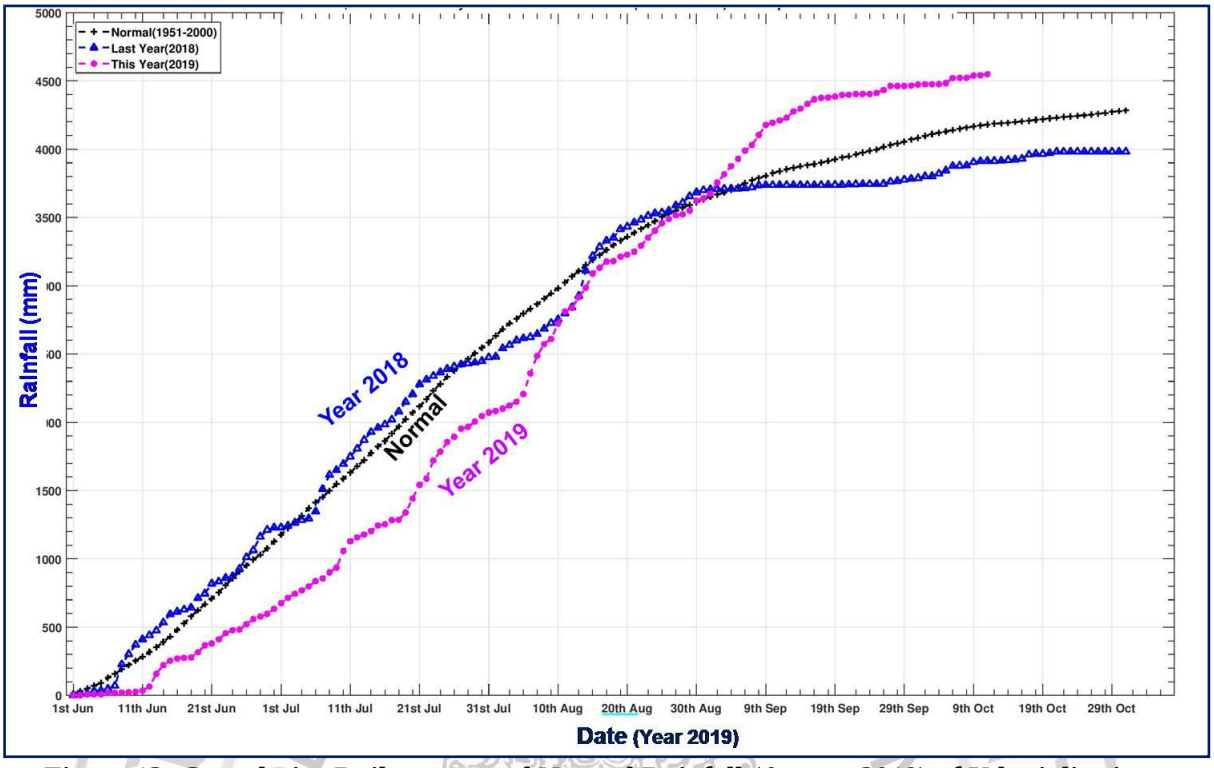


Figure 13: Cumulative Daily mean and Normal Rainfall (August-2019) of Udupi district, Karnataka.

During 2019, the annual rainfall was excess in Shimoga district with 21% departure, while Udupi with 13%departure has normal rainfall. The rainfall distribution in and around the study area for the last ten years taken from rain gauge stations is graphically represented.

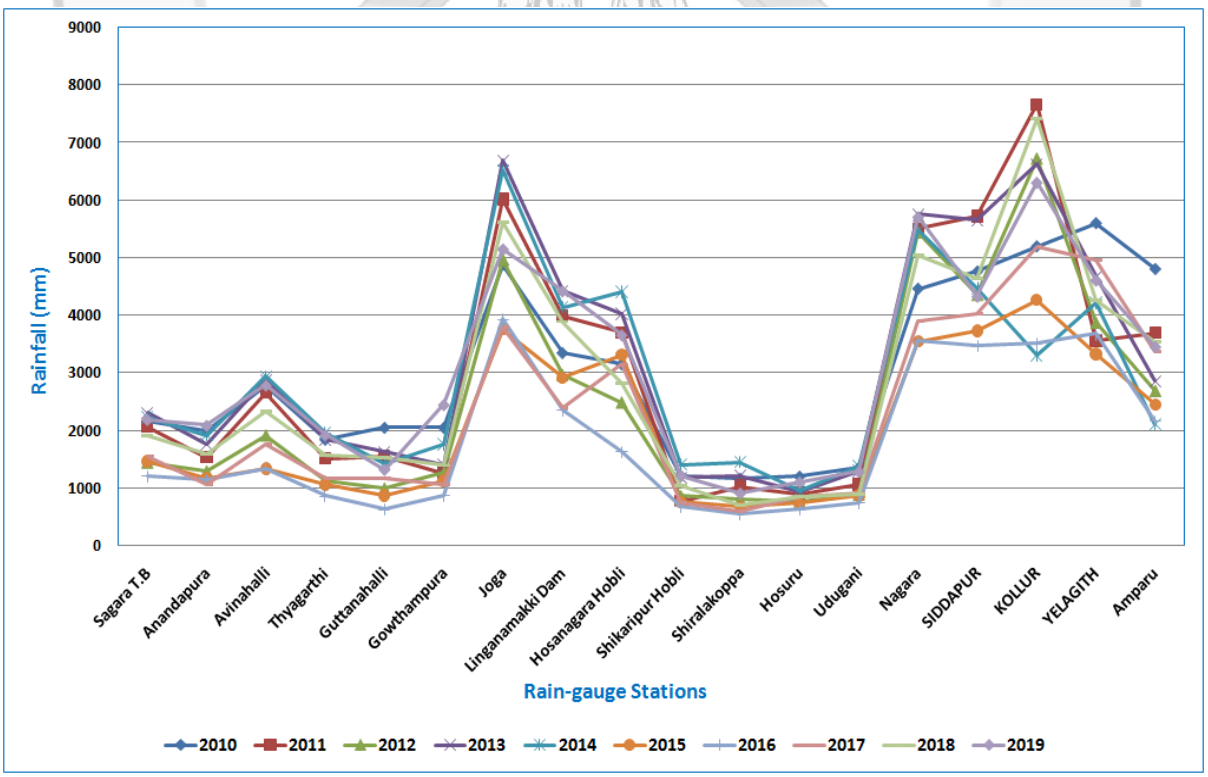


Figure 14: Average Annual rainfall pattern of last ten years at different Rain gauge stations

The annual normal rainfall in the study area is 2237 mm but some station locations even experience an annual rainfall between 4500 to 7420 mm. Southwest monsoon starts normally from the second week of June and peaks during July and August. Landslides occurred when a high intensity rain follow a prolonged steady rainy season. This normally occurs during the middle phase of southwest monsoon or if the pre-monsoon is high in the initial phase in the month of August or September.

It is noticed that Kollur generally receiving high rainfall during all years followed by Joga and Linganamakki. While preparing rainfall distribution maps of last ten years, the general trend of increased rainfall is found in and around Malnad region. The areas which receives moderate to high annual rains are Nittur, Nagodi, Sampekatte, Kollur, Kodachadri, Sullali and Kammarpal etc. During 2019, around 65% of the slides are observed to be active and occurred due to rain events. The annual average rainfall distribution map of year 2019, when overlain by landslide incidences **(Plate:17)**, reveals that 72% of the slides are occurring at rainfall interval of 5124-6289mm, 25% of slides between 4319-5124mm and only 3% are occurring at rainfall interval of 1672-3006mm.

Accordingly, the type of vegetation changes from evergreen, semi evergreen to deciduous type. In the east, where rainfall is comparatively less, soil is poor and underlying rock being granite and the disintegrated soil is rather sandy. It is evident that evergreen /semi evergreen forests are found in the areas, receiving rainfall more than 2000 mm and moist deciduous type of forests are in areas receiving rainfall between 1400-2200 mm. Further dry deciduous forests are found in areas receiving rainfall less than 1400 mm.

Due to increase of human activities like industrialization, urbanization, increase in road and rail traffic, destruction of trees and deforestation, etc., have an effect on climate resulting in growing atmospheric and water pollution and an increase in temperature.

The particulars of distribution of rainfall on year basis received from 2010 to 2019 are shown in **Annexure- III.**

The average annual rainfall distribution maps of study area from year-2010 to 2019 are given in **Plate no. 14, 15& 16.**

7. CONCLUSION AND RECOMMENDATIONS

The susceptibility map produced on 1:50,000 scales gives the qualitative estimation on how the mapping unit will be affected by a future landslide source, but the "future" here does not refer to any specific time frame or frequency of occurrence. It only indicates the stability status of a slope irrespective of a time of an event to occur.

Present item, carried out in Survey of India Toposheet Nos. 48K/13, 48N/3 and 48N/4, Udupi and Shimoga districts, Karnataka with total 1456 sq. km area coverage forms a part of this programme. The study area comprises Malnad region of Western Ghat that comes under heavy rainfall belt. The area receives rainfall mainly from southwest monsoon from June to September. The area exposes the rocks of Peninsular gneiss, Bababudan Group of Archaean age, acid and basic intrusive of Paleo-proterozoic age and laterite capping of Cenozoic age. Although, PGC-I (granite gneiss) is the main bed rock lithology of the area with rocks of Bababudan Group sequence (Quartz-chlorite schist, Metabasalt and Hb-actinolite-chlorite schist) as the subordinate bed rock lithology; overburden (In situ soil and weathered soil) developed over the bed rock lithology are the most abundantly seen as slope forming material.

As landslide is a function of different causative geo-factors, thematic maps corresponding to each of these geo-factors were prepared by using different data sources (topographic database as well as various Remote Sensing datasets and Google earth Imageries) in the pre-field stage. They include slope morphometry maps (slope inclination, aspect, curvature and drainage) using CARTO DEM data (30m resolution) and Geomorphology, Land use and Land cover, Slope Forming Material maps. The pre-field maps were validated in field and finalized by incorporating modifications, wherever required. In addition, Regolith thickness map was also prepared during the field studies. The Landslide Inventory map has been prepared by collecting the data from old inventory reports/notes of GSI, and data collected during the field studies.

As the number of landslide incidences are relatively few, use of Analytical Hierarchy Process (AHP) for the preparation of Landslide Susceptibility map for the area was envisaged.

In the post-field stage, the analytical hierarchy process (AHP) modeling of the study area was done by using six geo-factor parameters such as slope morphometry, land use/land cover, geomorphology, regolith/overburden thickness, drainage and slope forming material maps with region specific ranking and weight systems. The landslide susceptibility map was modeled using AHP and following multi-class index overlay method in GIS platform.

Slope stability is generally controlled by a series of interrelated environmental parameters, such as; lithology, structure, slope morphometry, hydrological conditions, geomorphology, land use and land cover practices etc.

During intense rainfall, some parameters can influence slope stability more than others and can contribute to generate landslides. For this reason, the analysis of the relationship between landslide distribution and environmental parameters not only leads to a better investigation of the landslide mechanisms, but can also offer a basic tool for predicting future landslides.

The landslide susceptibility map illustrates that,1.79% (26 Sq. Km.) of area is grouped under High susceptibility zone. Most of this area lies along road transportation corridors and around extensive cut slope areas. Besides, hills with steep slopes are also grouped under moderate to high susceptible zones. Majority of the high susceptibility zones are geographically distributed in the western, central and south-eastern part of the study area, in toposheet 48K/13. Here the high susceptibility zones run almost parallel to the moderately to steep slopes (SW to NW facing) of the Western Ghat. Moderate susceptible zones are mostly dispersed in toposheet 48K/13 and erratically distributed in 48N/04. The moderate susceptible zones in the study area are generally encircling high susceptibility zone. The low susceptible zone covers the maximum area (76.32%), and is well scattered in toposheets 47N/03, 48N/04 and foothills of Western Ghat in toposheet no.48K/13. Most of this zone falls under the gentle to flat slopes with low lying hills. This part is mainly used for habitation, cultivation and plantations.

Out of total 117 landslide incidences, 25 are falling in High Susceptibility zone, 76 are in Moderate Susceptibility zone and 16are in Low Susceptibility zone. The distribution of landslides in the three susceptibility zones signifies the reliability of Landslide Susceptibility Map to a greater extent [nearly 21.37% of incidences falling in High Susceptibility zone (HSZ)]. As, 70% of the landslide incidences (82 out of 117) are confined to the cut slopes, therefore, the attributes of these slope failures only partially provide the natural/ real scenario of factors controlling landslides. Hence, an attempt to correlate landslide incidences and individual geo-factors present only a partial and generalized picture about the validity of the Landslide Susceptibility Map prepared under this item.

As far as risk to various elements (at risk) located within high susceptibility zone (HSZ) is concerned, it is observed that steep slope in a road stretch of approximately 10 km length along Nagodi to Kollur Ghat in toposheet 48K/13 reported 39 numbers of slope failures. Road cut slopes from Nagodi to Kollur are highly vulnerable and have exceptional importance due to tourism and pilgrimage activities. The stability of road cut slopes in the

region degraded notably due to inadequate excavations during road construction and widening projects. The road essentially passes through the high and moderate susceptibility zones. Some of the places as observed during field work are in grave danger and need immediate attention. Massive debris slide occurred at Sunkadavaramane; Sampekatte, Sidalguni; Nittur and Kesaremane. In this regard, an advisory note highlighting the localities with proper recommendations has been submitted to *Deputy Commissioner, Shimoga, Karnataka.*

It was observed that mass wasting and landslides generally occur in response to modification of hill slope conditions and hydrology. Often there is a combination of causes for failures that involve increased water in the slide mass itself, which adds weight and reduces the soil strength by increased pore pressure. This in combination with the loss of support due to a road cutting at the toe of a slide resulted in mass wasting.

Encroachment of flow path of stream (valley part) for increasing agriculture area and simultaneously diversion of streams towards hill side are practising in most of the area. The diverted stream towards the modified slope eroding the toe of the slope, making the slope steeper and thus resulting in failure added by heavy saturation. Total 26 such slides are observed caused due to stream erosion. The Ist and IInd order stream inducing fluvial down cutting and toe erosion are contributing to 12-12 landslides respectively in the study area**(PLATE:10).** These streams at places are responsible for embankment failure resulting in road subsidence. Road leading to Kollur, near Holegaru ; Kumbli-Sampekatte road, 0.5 km N of Ambiladi; Road leading to Nittur, near Sidalguni and Road leading to Sampekatte near Deviyaramane need immediate attention to safeguard.

Unscientific way of cutting slope for making settlement thus removing toe support is another cause in the area that increases slope instability. Total 09 slides are initiated after extensively slope cut making for settlement without giving any lateral support. A large debris slide occurred at the back side of Govt. High School, Sampekatte due to cutting of the slope and constructed school building without any mitigation measure.

Of total landslides observed 49% are active, 16% reactivated and 35% are old slides. Around 65% of the observed landslides are triggered in the year 2019; mostly in the month of August, 2019.

Around 36% of the recorded slides correspond to slope gradient class of 25°- 35°,32 % slides are lies in between 15°- 25° gradient, 15% in 35°- 45° gradient followed by 11% in less than 15° & only 6% in greater than 45° gradients.

The locations of the recorded landslides superimposed on geology map show that many of the slides are occurring along the contact or in close vicinity of this. This in

combination with the loss of support due to a road cut resulted in adding stresses, that later accelerated by rainfall causing mass failure.

At places, roads are developed cracks and showing evidence of subsidence. It is noticed that toe erosion by stream rendering the road vulnerable to failure at different point. Road leading to Kollur, near Holegaru; Road leading to Nittur,near Sidalguni and Road leading to Sampekatte near Deviyaramane need immediate attention to safeguard.

During 2019, around 65% of the slides are observed to be active and occurred due to rain events. The annual average rainfall distribution map of year 2019, when overlain by landslide incidences, reveals that 72% of the slides are occurring at rainfall interval of 5124-6289mm, 25% of slides between 4319-5124mm and only 3% are occurring at rainfall interval of 1672-3006mm.

The higher susceptibility zone in the area as evident by landslide susceptibility map is coinciding with the high rainfall affected regions. Prediction of rainfall-triggered hill slope disasters has relied mostly on the valley slope, rainfall intensity and duration that can cause hill slope failure. Therefore, the western part of the region is looking more vulnerable towards mass failures.

Preventive measures like slope stabilisation, slope contour/ chute drainage and conservation of forests need to be taken up so that the roads and associated population is kept safe from any damage.

Limitations:

Every methodology tends to have its own limitations and constraints. Similarly, during the study, a few constraints in terms of the methodology adopted for this study were also identified which are enumerated below.

The mapping of, the nature and extent of, the slope forming material based on observations at accessible stretches may not depict the true picture on all studied hill slopes. Subsequently, the regolith thickness map is very subjective since the regolith thickness along a slope is visually estimated; few vulnerable sites may be explored or investigated through sub-surface exploration on the basis of its exposure in a section and extrapolated to adjacent areas considering the terrain morphology.

The assumption of the methodology that the relation/s between spatial factors and past/present landslides are relevant to the occurrence of future landslides may not always hold true in nature.

The causative factors (e.g., slope, aspect, curvature, geomorphology and drainage) are not expected to change significantly in a short time period, local morphological changes may occur due to land sliding, but this will not substantially affect the susceptibility model. However, some local changes in the land use pattern may take place, such as terracing of slope for cultivation or excavation for construction of new buildings. Such changes can induce instability "locally" and may increase or decrease the susceptibility of that slope.

The susceptibility map is only valid under the given set of geo-environmental conditions taken as input in the susceptibility modelling. Any changes in the spatial distribution of the geo-environmental factors may affect the susceptibility of the area.

Spatial-temporal prediction of a landslide is still difficult on macro-scale; hence questions can be raised about the predictive capability of a susceptibility map given the uncertainty in the occurrence of a landslide.

Limitations in understanding the terrain and its landslide characteristics thereby affecting the selection of preparatory factors are also probable.

Despite the above, the generated landslide susceptibility map of the area is the first level spatial database on regional scale which can form the basis of landslide hazard and risk evaluation indicating the vulnerability of the elements at risk.

Recommendations:

Based on the evaluation of the geo-factors and understanding their relative importance that are specific to the terrain, as well as considering the scale of the study and the observations made in the field, the following generic recommendations are proposed:

The susceptibility map is generally meant for regional application because the information is shown on scale 1:50,000; however, they are still of considerable significance from the point of specific land use and urban planning. Nevertheless, it is recommended that a detailed site-specific study may be duly conducted before planning and execution of the civil construction works. Areas with high susceptibility falling under high hazard should be given due attention while executing civil constructions or may be avoided.

Landslide susceptibility mapping is an useful tool in identifying potential landslide hazard zones but remedial measure to protect/treat the slide is of prime concern. In order to make these studies user friendly, the town planner/district administration should essentially consult the report and landslide protection work should be undertaken in consultation with civil engineers and Engineering geologists.

It is also recommended that the susceptibility map showing the potential landslide area should not be considered as standalone map for planning; the run out of potential debris flows be also considered for the specific planning.

In the event if a disaster strikes, the loss would be immense if buildings are not safely and properly located. Awareness among people is of utmost importance to reduce the loss of lives and property. The awareness should include information about the potential danger, its identification and its communication; the physical significance of hazard and inherent uncertainties; ways to reduce landslide risk and the available local mitigation options.

The risk enhancement factor needs to be analysed in view of the erratic rainfalls from last couple of years. The spectre of climatic change necessitates greater focus on slope failures, identification of hillsides prone to slope failures, study of causative and triggering factors, depiction of vulnerable areas on GIS based and locality specific maps and on evolving innovative technologies for future management.

Remedial measures for individual slides are given in ***Annexure-II*** *in 42 points geo-parametric data sheet.*

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Locality Index

Sl.No.	Locality Name	Latitude	Longitude
1	Alagerimandri	14.02	75.16
2	Alur	13.99	74.81
3	Ambiladi	13.89	74.91
4	Anandapura	14.08	75.21
5	Areshiruru	13.83	74.76
6	Avinhalli	14.08	75.01
7	Bailgi	13.94	74.89
8	Balegundi	14.15	75.11
9	Belanduru	14.20	75.21
10	Belur	13.91	74.93
11	Changvalli	13.93	74.88
12	Deviyaramane	13.90	74.94
13	Gautamapura	14.14	75.22
14	Genasinakuni	14.05	75.02
15	Habbigai	13.95	74.90
16	Halkal Junction	13.83	74.80
17	Hebbige	13.95	74.86
18	Holegaru	13.91	74.86
19	Iduru Kunjadi	13.76	74.78
20	Kammarpal	13.76	74.93
21	Kesaremane	13.95	74.89
22	Kirgodi	13.95	74.86
23	Kodachadri	13.86	74.87
24	Kollur	13.86	74.81
25	Madvi	13.90	74.92
26	Muduru	13.81	74.87
27	Nadakalase	14.19	75.08
28	Nagodi	13.91	74.85
29	Neralamane	14.01	75.22
30	Nittur	13.92	74.90
31	Purappemane	14.09	75.10
32	Sagara	14.17	75.03
33	Sampekatte	13.89	74.96
34	Sidlukuni	13.92	74.92
35	Sullali	13.96	74.79
36	Sunkadavaramane	13.89	74.93
37	Tyagarti	14.19	75.17
38	Valuru	13.88	74.86
39	Vatgod	13.81	74.98

SYNOPSIS OF WORK DONE

1	**Title of the report**	Macro-Scale (1:50,000) Landslide Susceptibility Mapping in Parts of Toposheets Nos48K/13, 48N/3 and 48N/4, Udupi and Shimogadistricts, Karnataka.
2	**FSP Code No**	M4LSSM/NC/SR/SU-KG/2019/25178
3	**Field Season**	2019 – 2020
4	**Date of Commencement**	11th October 2019
5	**Date of Completion**	21stFebruary2020
6	**Officers associated with the investigation and no. of days spent in the field**	Kapil Singh, Geologist (95days), Kamal Kumar, Geologist (84days)
7	**Quantum of work done**	

1. Pre-field preparation	
(i) Slope Forming Material map	1456 Sq. Km.
(ii) Geomorphology & Lineament map	1456 Sq. Km.
(iii) Slope Morphometry (slope, aspect & curvature) map	1456 Sq. Km.
(iv) Land use / Land cover map	1456 Sq. Km.
(v) Drainage map	1456 Sq. Km.
(vi) Regolith thickness map	1456 Sq. Km.
(vii) Preparation of Landslide Inventory Map	1456 Sq. Km.
2. Field-based studies	
(i) Field-checking of all thematic maps**.** Field validation of landslide inventory and collection of recent and historic landslides (using archives, old reports, road register etc.)	1456 Sq. Km.
(ii) Collection of landslide inventory and damage data as per 41 point geo parametric data sheet	1456 Sq. Km.(117 nos. of landslides)
3. Post-field studies & modelling	
(i) Updation of thematic and inventory maps in GIS	1456 Sq. Km.
(ii) Preparation of Landslide Susceptibility Map in GIS	1456 Sq. Km.
4. Collection of rainfall data from available rain stations	1456 Sq. Km. (Collected data for 10 years)

8 **Expenditure**

Wages (Rs.)	Rs. 77,526.00
OC (Rs.)	Rs. 90,792.00
Total (Rs.)	Rs. 1,68,318.00

* Outsourced vehicle used for field.

FIVE POINT PROFORMA

Title of the report: Macro-Scale (1:50,000) Landslide Susceptibility Mapping in Parts of Toposheets No's 48K/13, 48N/3 and 48N/4, Udupi and Shimogadistricts, Karnataka.	
1. Background of the investigation at whose instance or with what particular objective in view the investigation was undertaken	The item was taken up as per the annual programme of GSI vide FSP Code No: M4LSSM/NC/SR/SU-KG/2019/25178 with an objective to prepare seamless Landslide Susceptibility Map of India.
2. Whether the item of investigation was included in the approved programme for the year concerned. If so, particulars, such as item No. page reference etc. may be given.	Yes FSP Code No: M4LSSM/NC/SR/SU-KG/2019/25178
3. Date of commencement of the investigation with month and year, and exact number of days spent by the officer(s) in the field in connection with the investigation.	Date of commencement :11thOctober,2019 1. Kapil Singh, 95 days 2. Kamal Kumar, 84 days
4. Brief comments by Director / Supervisory officer on the conclusion and recommendation by the author(s) with suggestion for implementing the same.	I fully agree with the conclusions drawn and recommendations made by the authors.
5. Please state specifically how the results of the investigation were achieved compared with the objective for which it was undertaken	The objective of the investigation is fully achieved.
Date: Place: Bengaluru	Shri K.VMaruthi Director

GEOLOGICAL SURVEY OFINDIA

Certificate of Quality of the report

Project/ Division:NLSM/EG Division **FSP No.**:M4LSM/NC/SR/SUKG/2019/25178**Mission**:IV

Title of the report:Macro-Scale (1:50,000) Landslide Susceptibility Mapping in Parts of Toposheets Nos.48K/13, 48N/3 and 48N/4, Udupiand Shimogadistricts, Karnataka.

Part -A: This is to certify that the following Officer(s) have carried out the above mentioned FSP and are responsible for collection of field data, carrying out required laboratory analysis, compilation and synthesis of field data, collation of the data and writing of the report as per the approved guidelines. The duration of field stay of each Officer is as against his/ her name.

Name and designation of the Officer	Total field stay during the FSP (No. of days)	Signature with date
1.Kapil Singh, Geologist	95days	
2.Kamal Kumar, Geologist	84days	

Part-B: This is to certify that drilling has been carried out and completed as per the table given below: **Not Applicable**

Drilling Unit No	Date of commencement of drilling	Date of completion of drilling	Name and signature of the Director Drilling
1.			
2.			

Part-C: This is to certify that geophysical component of the item has been carried out as per the table given below: ----Not Applicable ------

Name(s) Designation of the geophysicist	Date of commencement of work	Date of completion of work	Signature of the Geophysicist with date
1.			
2.			
Name of the Director (Geophysics)			
Signature with date			

Part-D: This is to certify that the chemical analysis of the geological samples has been carried out as per the table given below- **Not applicable**.

Name of the Director in charge of the Laboratory	Date of receipt of samples from the Field Officer/ party	Date of providing complete analytical resultsto the Field Officer/ party	Signature with date

Part –E: This is to certify that the Supervisory Officer(s) mentioned below have supervised the above item and have provided guidance to the Field Officer(s). The number of inspection visits and total duration of field visits is as per the table below. It is also certified that the work carried out under the project is of high standards, the norms of field work, lab work etc. have been followed. It is also certified that thorough scrutiny of the report for maintaining the scientific contents and its quality has been overseen

Name(s) and designation of the Supervisory Officers	No. of inspection visits	Total No. of days spent on inspection visit	Signature with date
1. Shri.K.V Maruthi, Director	05	11	

Part-F: This is to certify that the report has been thoroughly scrutinized at the Regional Mission Head level. The scientific contents and the quality of the report are certified. The report has been peer reviewed and the needful corrections have been attended to.

Name and designation of the Regional Mission Head	Signature with date

Part-G: This is to certify that the report has been scrutinized at various levels and has also been peer reviewed. On being satisfied regarding the scientific content and quality of the report, the undersigned has accorded approval for its circulation.

Name and designation of the Regional HOD	Signature with date

PLATE 1

Map showing Western Ghat area mapped for landslide susceptibility under Karnataka and Goa state for Field Season (FS) programmes: 2015 to 2020 at 1:50,000 Scale

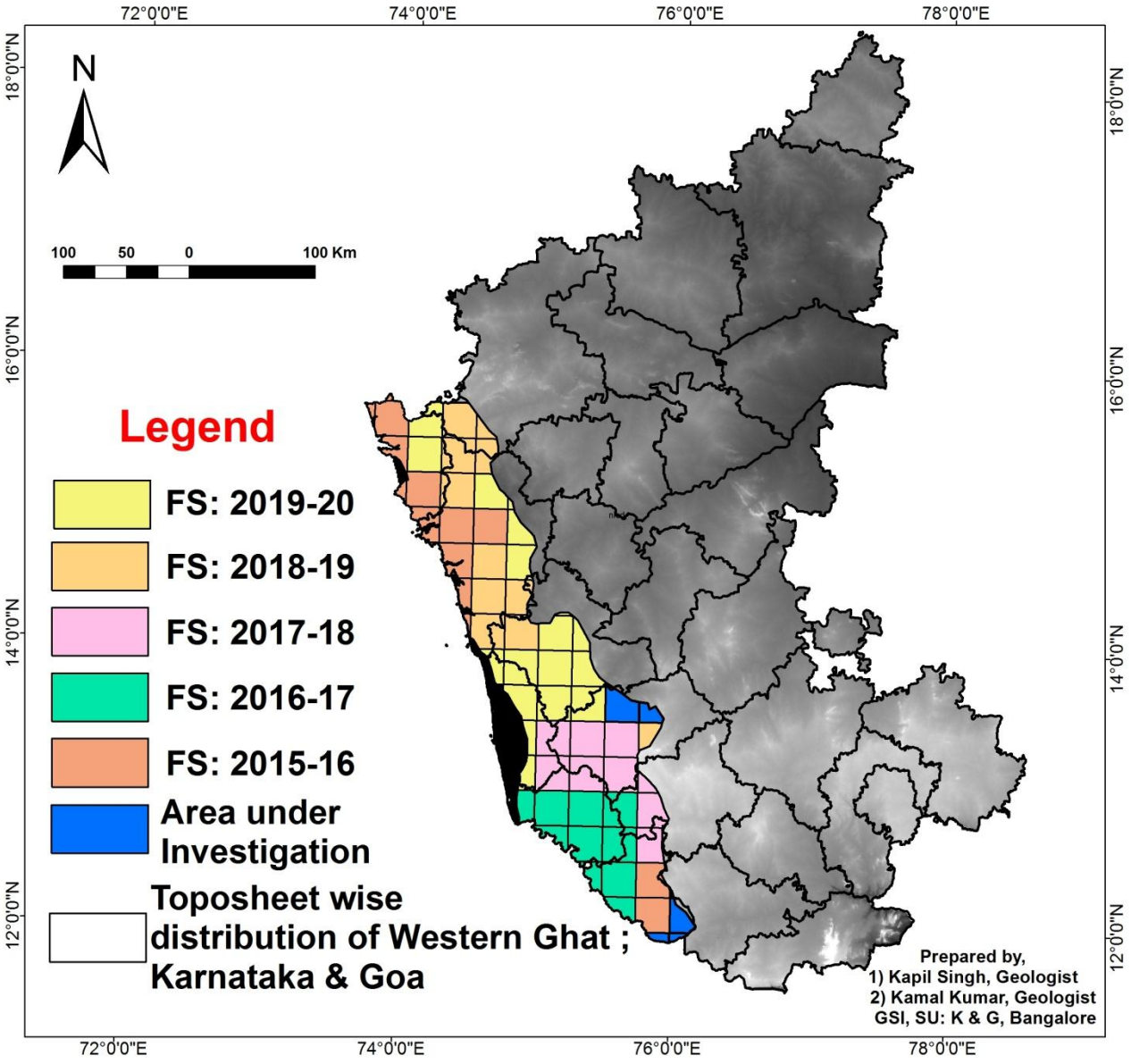


PLATE 2

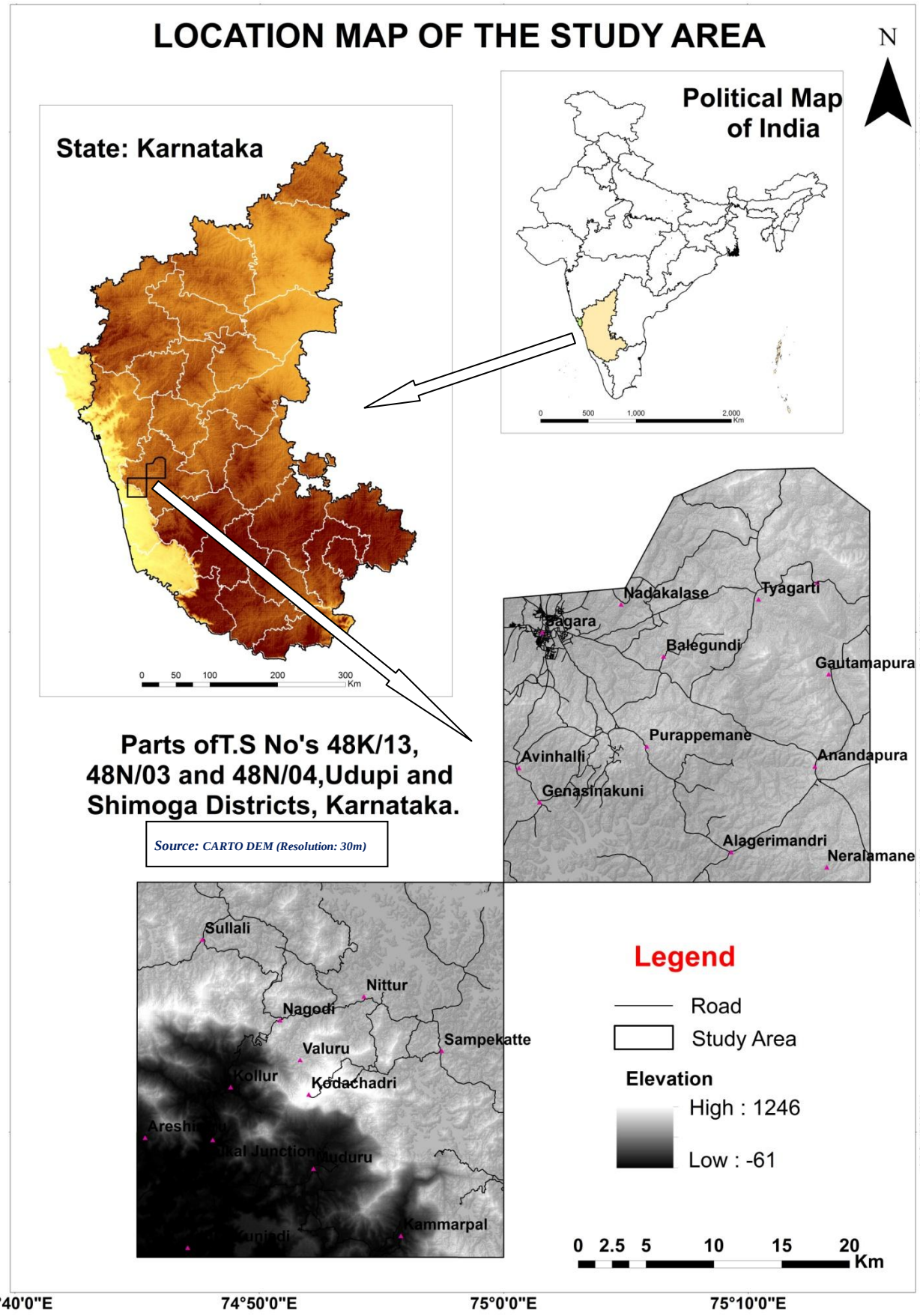
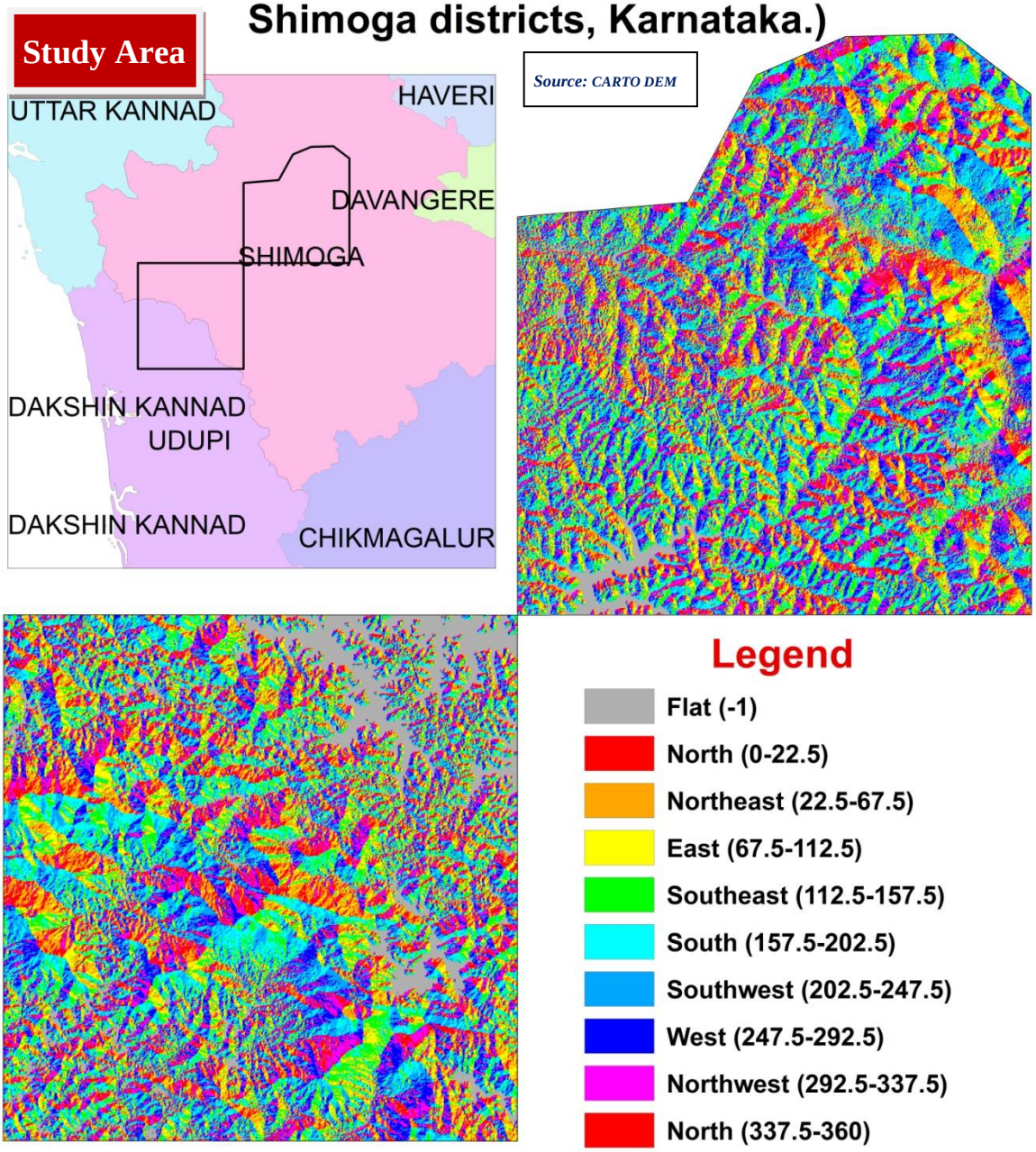

LOCATION MAP OF THE STUDY AREA
N
State: Karnataka
Political Map of India
0 50 100 200 300 Km
0 500 1,000 2,000 Km
Parts ofT.S No's 48K/13, 48N/03 and 48N/04,Udupi and Shimoga Districts, Karnataka.
Source: CARTO DEM (Resolution: 30m)
Nadakalase
Tyagarti
Sagara
Balegundi
Gautamapura
Purappemane
Avinhalli
Anandapura
Genasinakuni
Alagerimandri
Neralamane
Sullali
Nittur
Nagodi
Sampekatte
Valuru
Kollur
Kodachadri
Kammarpal
Legend
Road
Study Area
Elevation
High : 1246
Low : -61
0 2.5 5 10 15 20 Km
14°30'0"N
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
4°40'0"E
74°50'0"E
75°0'0"E
75°10'0"E

PLATE 3

Slope Aspect Map

(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)



Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore

PLATE 4

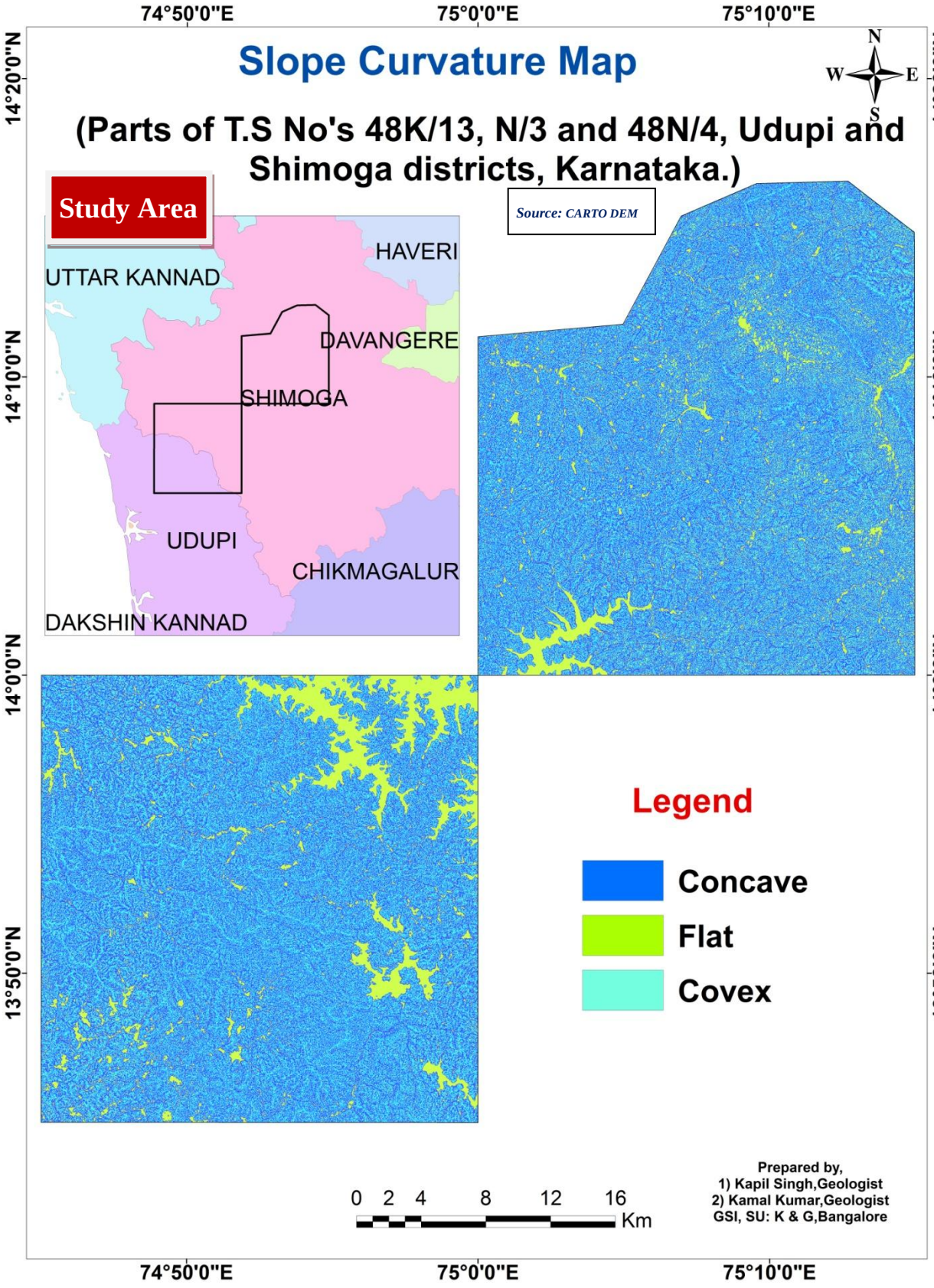

Slope Curvature Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
Source: CARTO DEM
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
Legend
Concave
Flat
Covex
N
W
E
S
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore

PLATE 5

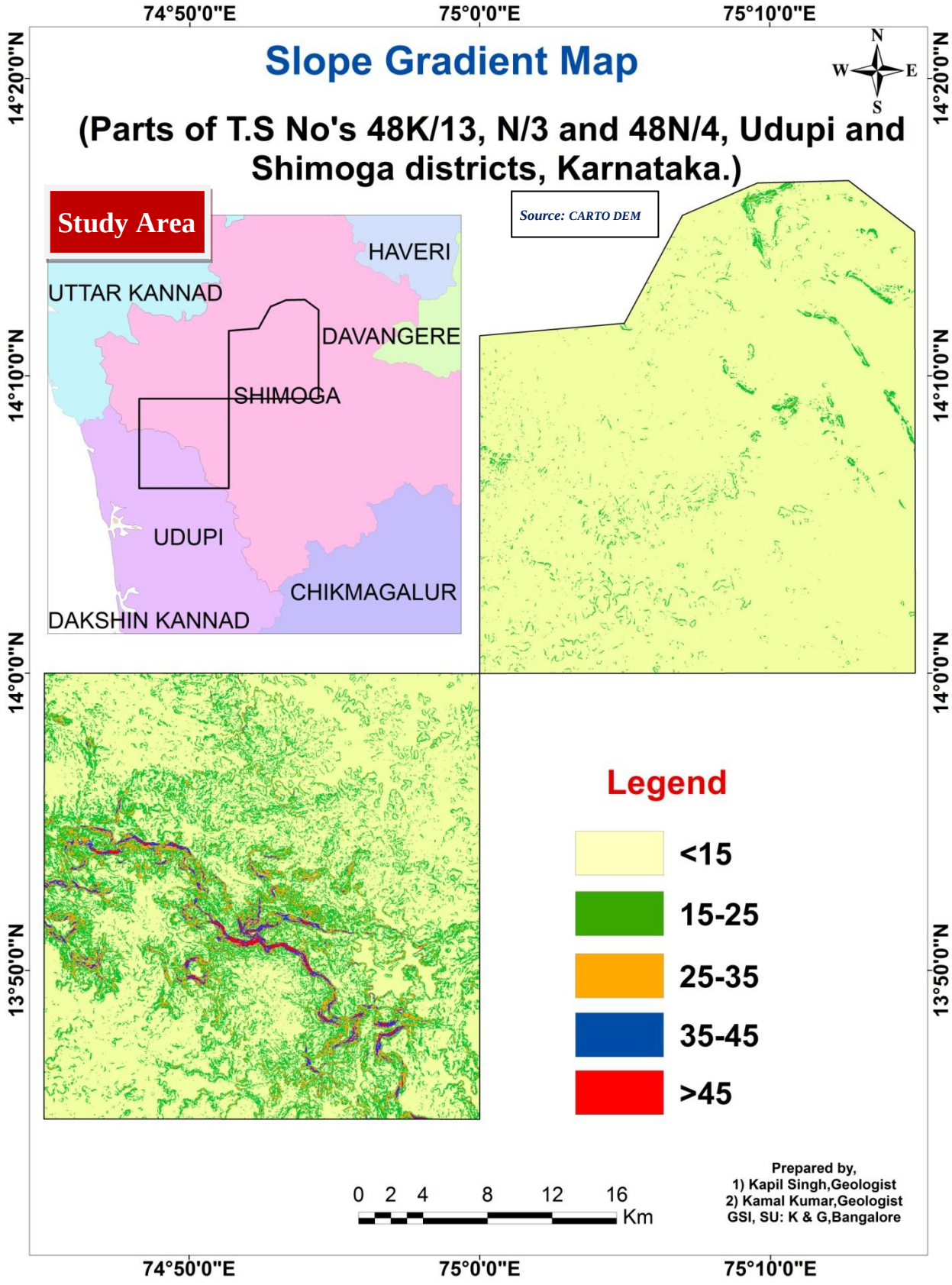

Slope Gradient Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
Source: CARTO DEM
Legend
<15
15-25
25-35
35-45
>45
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
N
S
E
W

PLATE 6

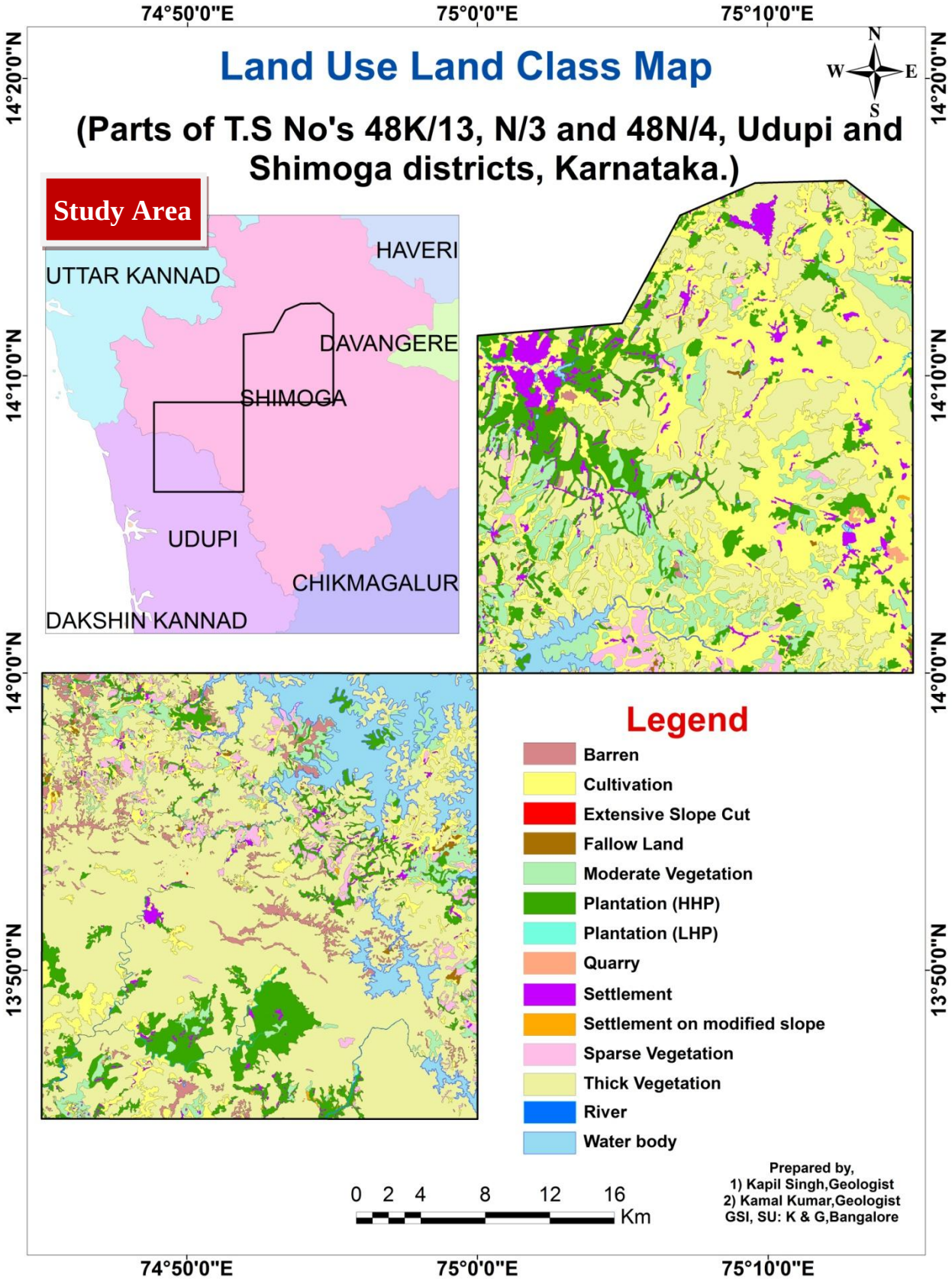

Land Use Land Class Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
N
W
E
S
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
Legend
Barren
Cultivation
Extensive Slope Cut
Fallow Land
Moderate Vegetation
Plantation (HHP)
Plantation (LHP)
Quarry
Settlement
Settlement on modified slope
Sparse Vegetation
Thick Vegetation
River
Water body
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore

PLATE 7

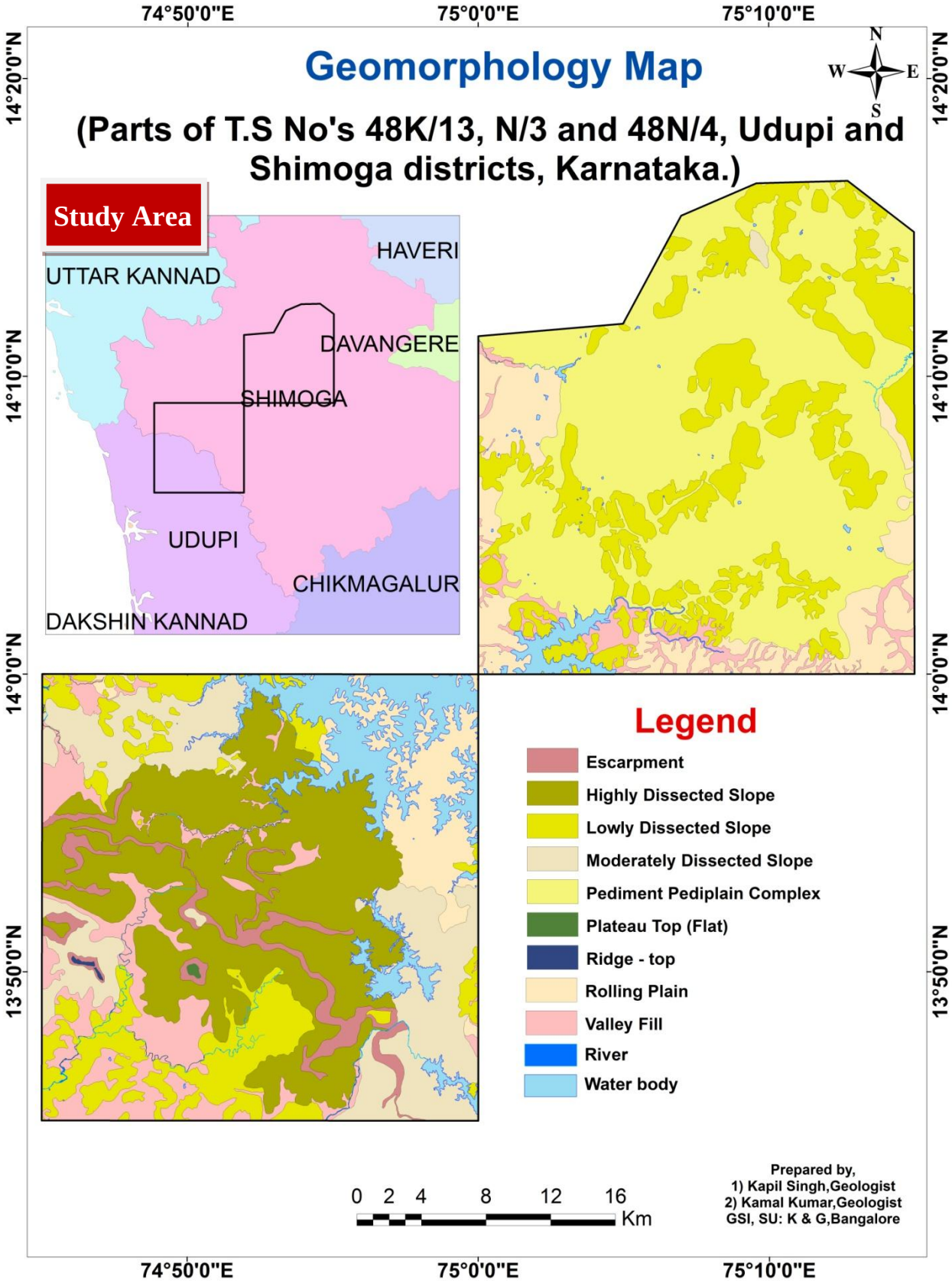

Geomorphology Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
Legend
Escarpment
Highly Dissected Slope
Lowly Dissected Slope
Moderately Dissected Slope
Pediment Pediplain Complex
Plateau Top (Flat)
Ridge - top
Rolling Plain
Valley Fill
River
Water body
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
N
S
W
E

PLATE 8

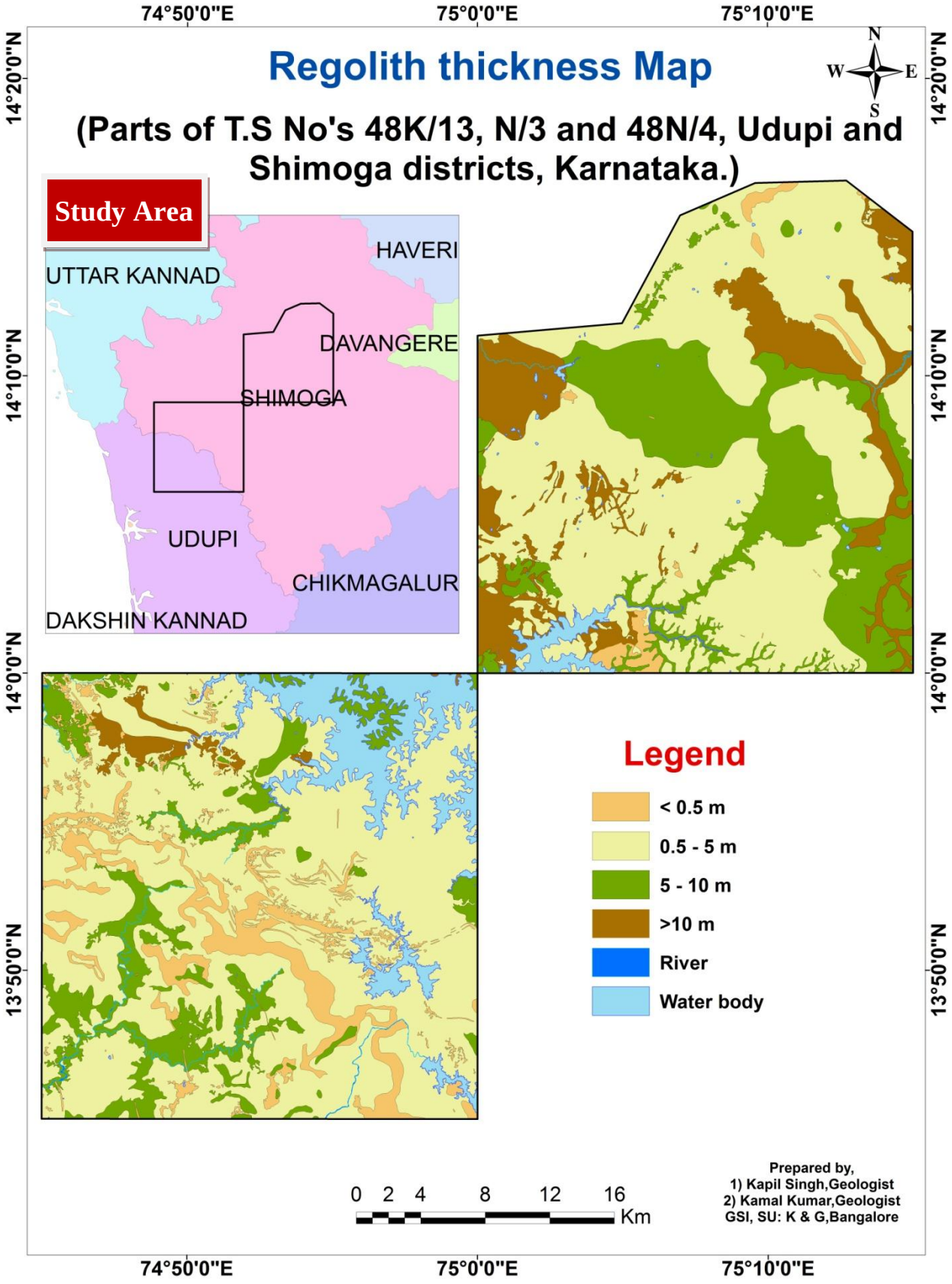

Regolith thickness Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
N
W
E
S
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
Legend
< 0.5 m
0.5 - 5 m
5 - 10 m
>10 m
River
Water body
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore

PLATE 9

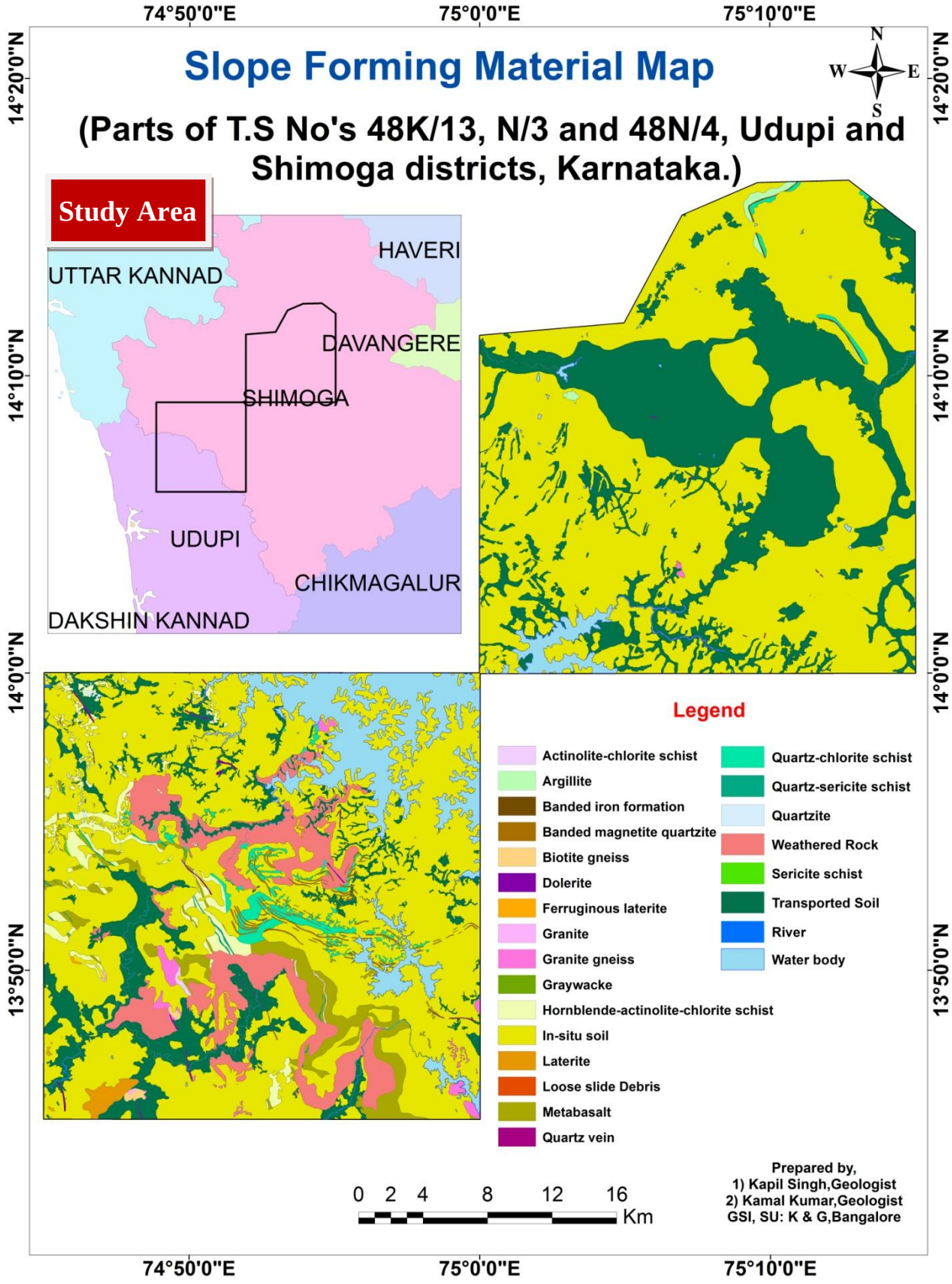

Slope Forming Material Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
N
W
E
S
Legend
Actinolite-chlorite schist
Argillite
Banded iron formation
Banded magnetite quartzite
Biotite gneiss
Dolerite
Ferruginous laterite
Granite
Granite gneiss
Graywacke
Hornblende-actinolite-chlorite schist
In-situ soil
Laterite
Loose slide Debris
Metabasalt
Quartz vein
Quartz-chlorite schist
Quartz-sericite schist
Quartzite
Weathered Rock
Sericite schist
Transported Soil
River
Water body
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore

PLATE 10

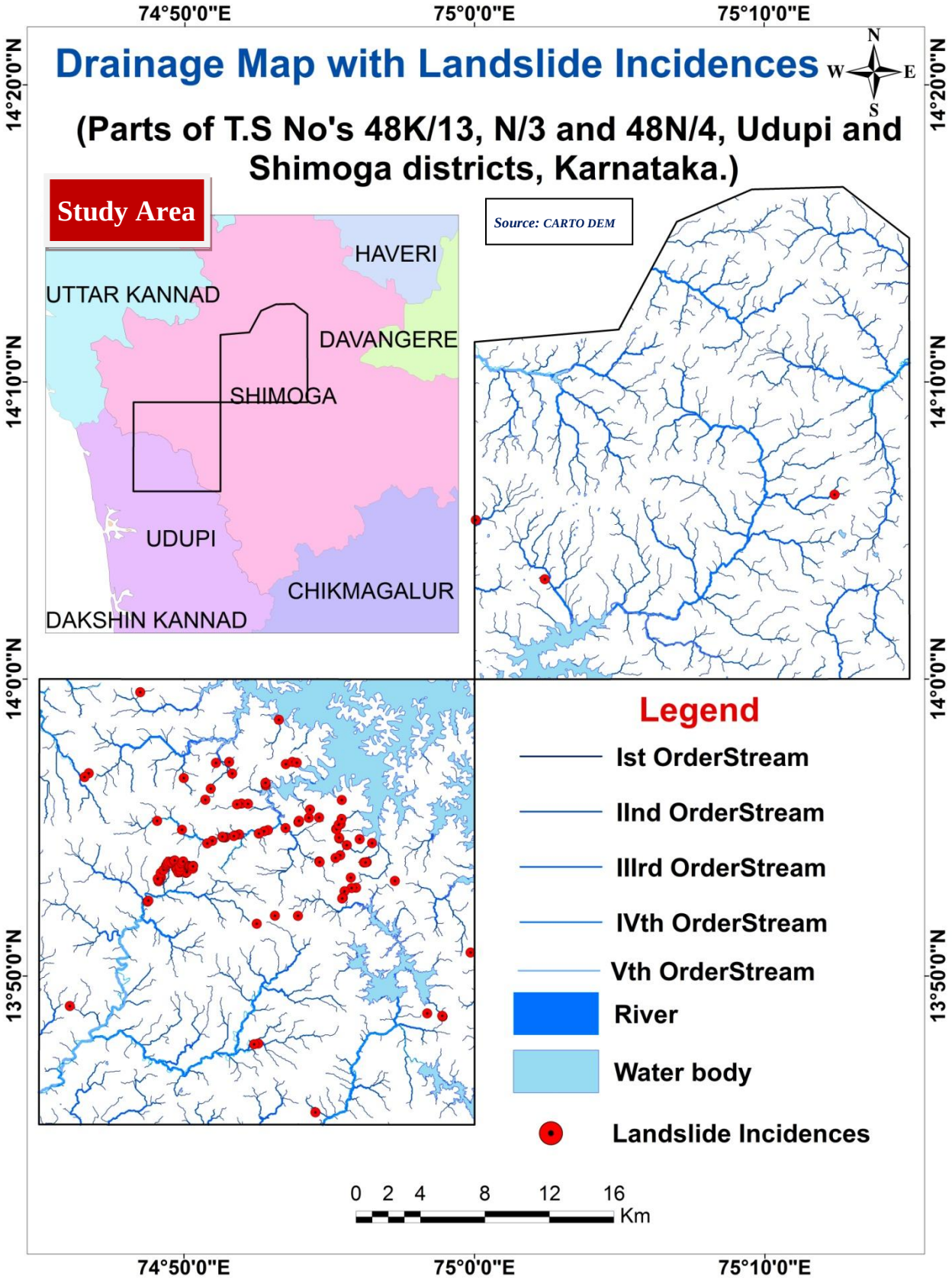

Drainage Map with Landslide Incidences
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
N
W
E
S
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
Source: CARTO DEM
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
Legend
Ist OrderStream
IInd OrderStream
IIIrd OrderStream
IVth OrderStream
Vth OrderStream
River
Water body
Landslide Incidences
0 2 4 8 12 16
Km

PLATE 11

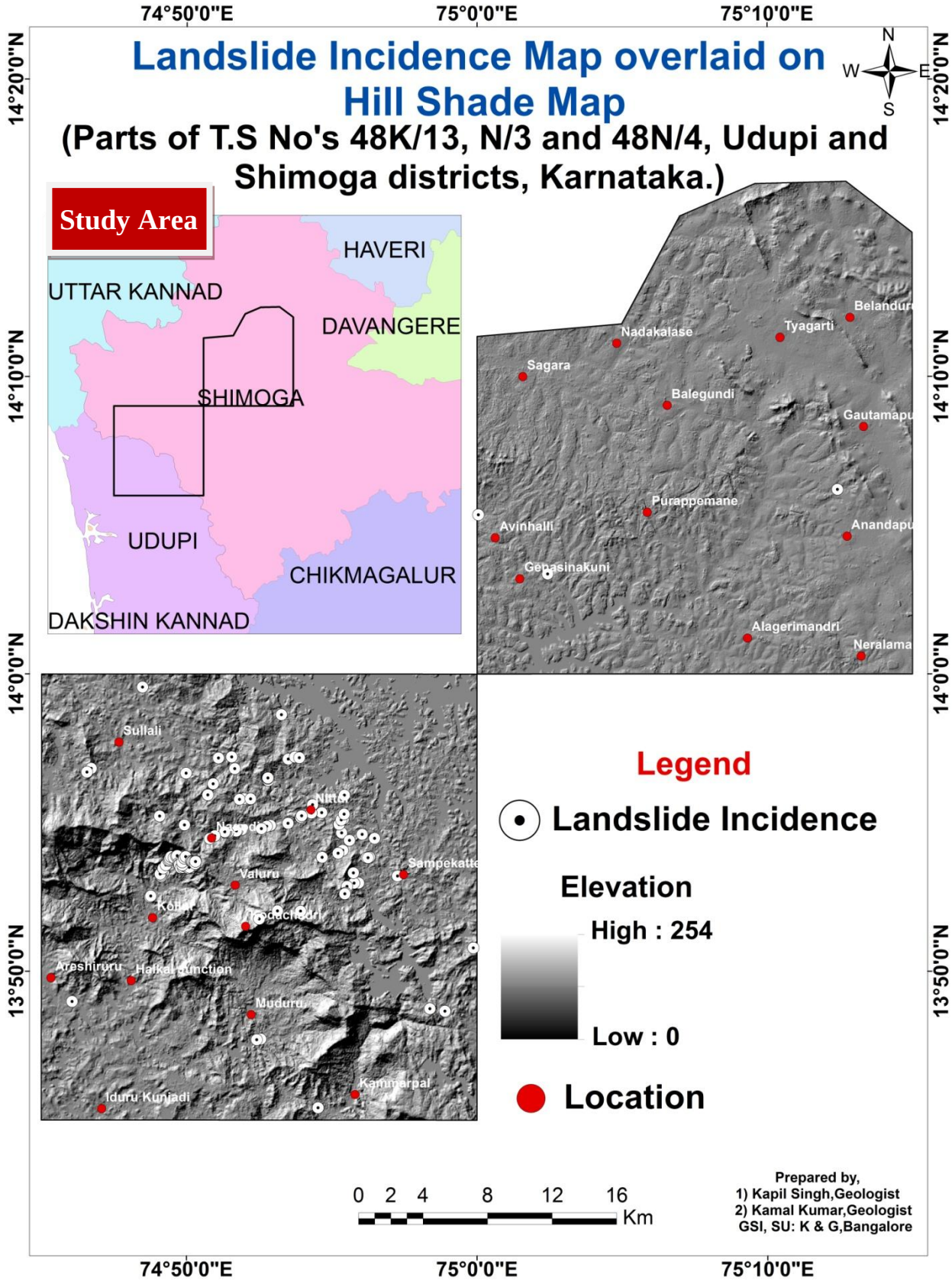

Landslide Incidence Map overlaid on Hill Shade Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
N
S
E
W
Nadakalase
Tyagarti
Sagara
Balegundi
Purappemane
Avinhalli
Alagerimandri
Sullali
Valuru
Areshiruru
Mudura
Kammarpal
Iduru Kunjadi
Legend
Landslide Incidence
Elevation
High : 254
Low : 0
Location
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore

PLATE 12

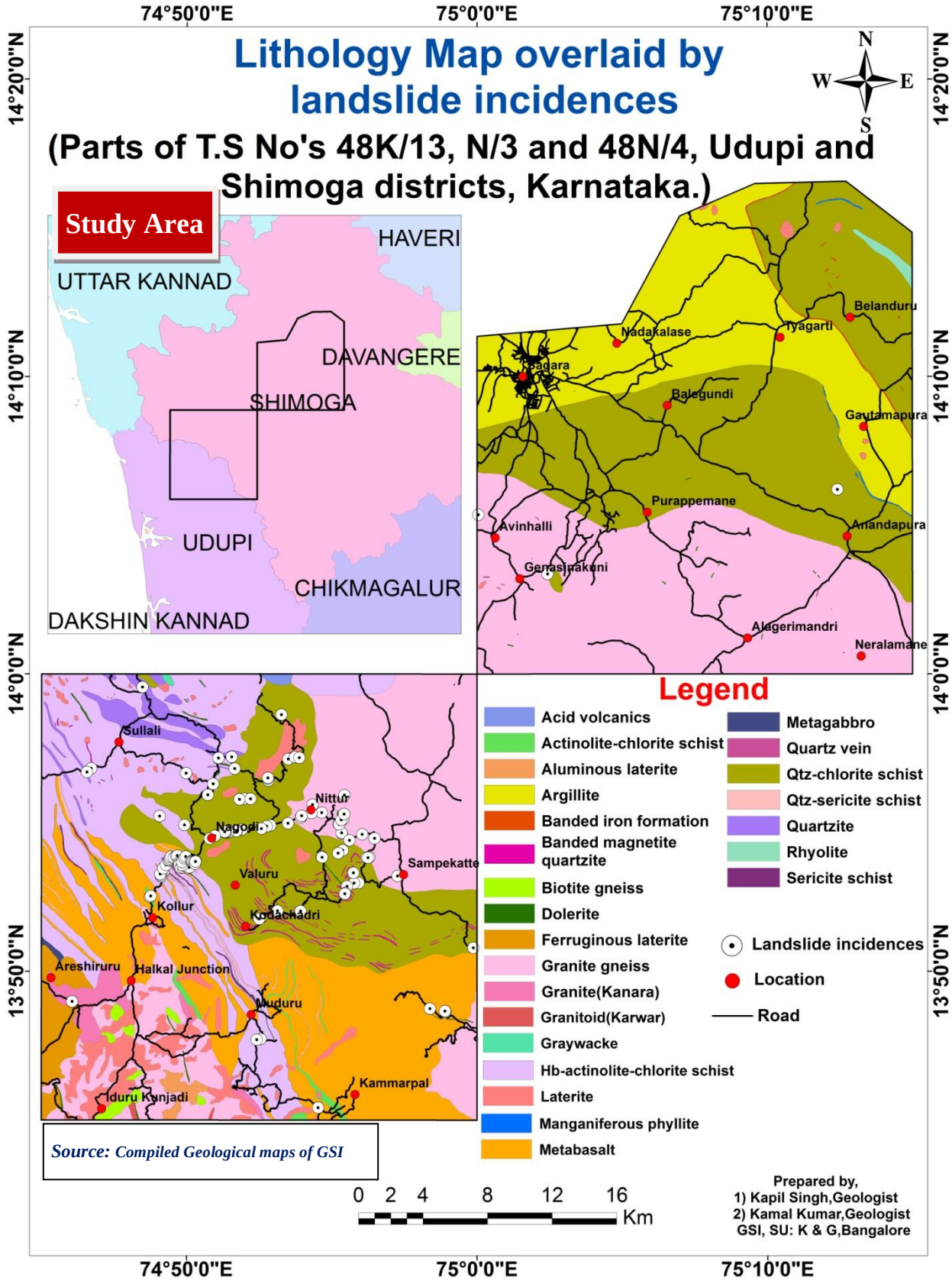

Lithology Map overlaid by landslide incidences
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
N
S
E
W
Belanduru
Nadakalase
Tyagarti
Sagara
Balegundi
Gautamapura
Purappemane
Avinhalli
Anandapura
Gerasinakuni
Alagerimandri
Neralamane
Sullali
Nittur
Nagodi
Sampekatte
Valuru
Kollur
Kudachadri
Areshiruru
Halkal Junction
Muduru
Kammarpal
Iduru Kunjadi
Legend
Acid volcanics
Actinolite-chlorite schist
Aluminous laterite
Argillite
Banded iron formation
Banded magnetite quartzite
Biotite gneiss
Dolerite
Ferruginous laterite
Granite gneiss
Granite(Kanara)
Granitoid(Karwar)
Graywacke
Hb-actinolite-chlorite schist
Laterite
Manganiferous phyllite
Metabasalt
Metagabbro
Quartz vein
Qtz-chlorite schist
Qtz-sericite schist
Quartzite
Rhyolite
Sericite schist
Landslide incidences
Location
Road
Source: Compiled Geological maps of GSI
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore

PLATE 13

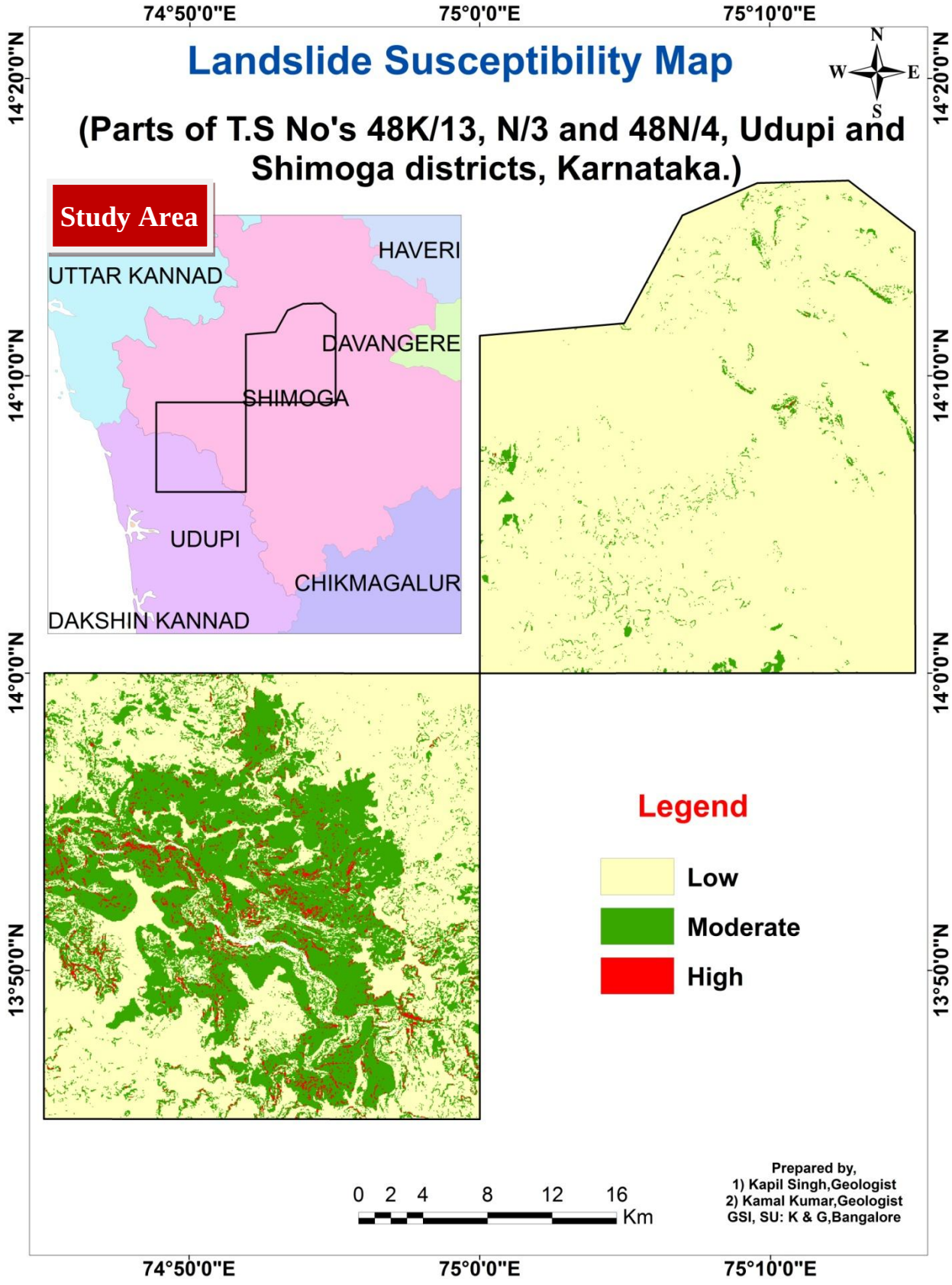
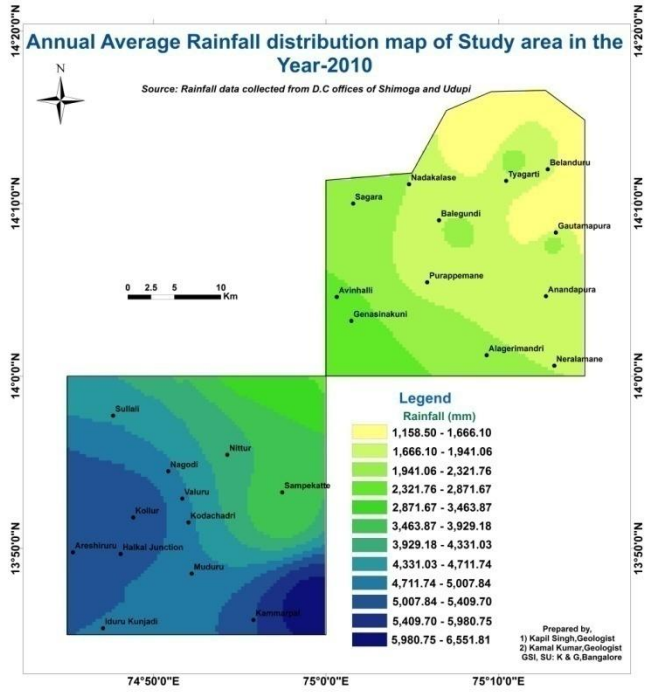
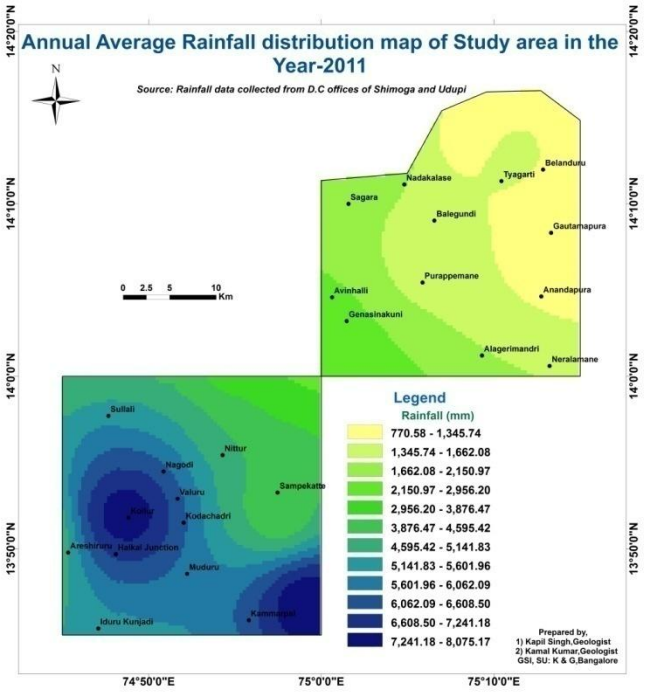
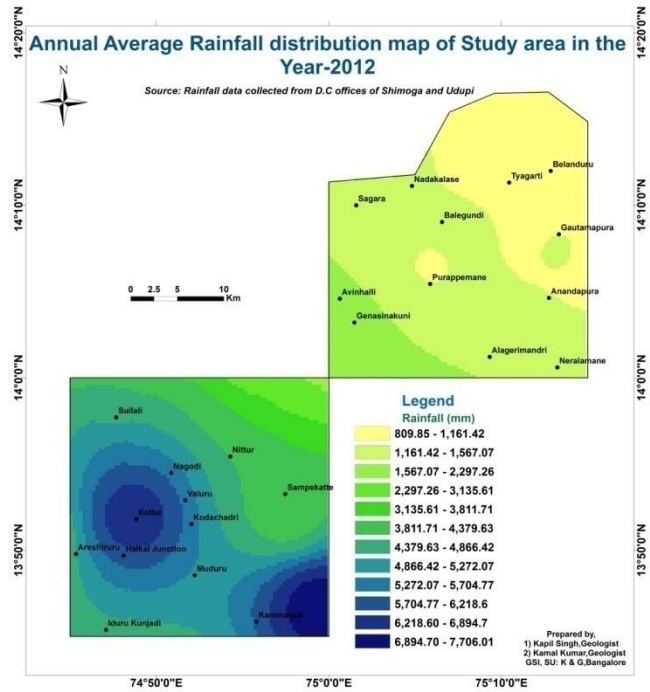

Landslide Susceptibility Map
(Parts of T.S No's 48K/13, N/3 and 48N/4, Udupi and Shimoga districts, Karnataka.)
Study Area
HAVERI
UTTAR KANNAD
DAVANGERE
SHIMOGA
UDUPI
CHIKMAGALUR
DAKSHIN KANNAD
Legend
Low
Moderate
High
0 2 4 8 12 16
Km
Prepared by,
1) Kapil Singh,Geologist
2) Kamal Kumar,Geologist
GSI, SU: K & G,Bangalore
74°50'0"E
75°0'0"E
75°10'0"E
14°20'0"N
14°10'0"N
14°0'0"N
13°50'0"N
N
W
E
S

PLATE 14

Annual Average Rainfall distribution map of Study area from Year-2010 to 2013







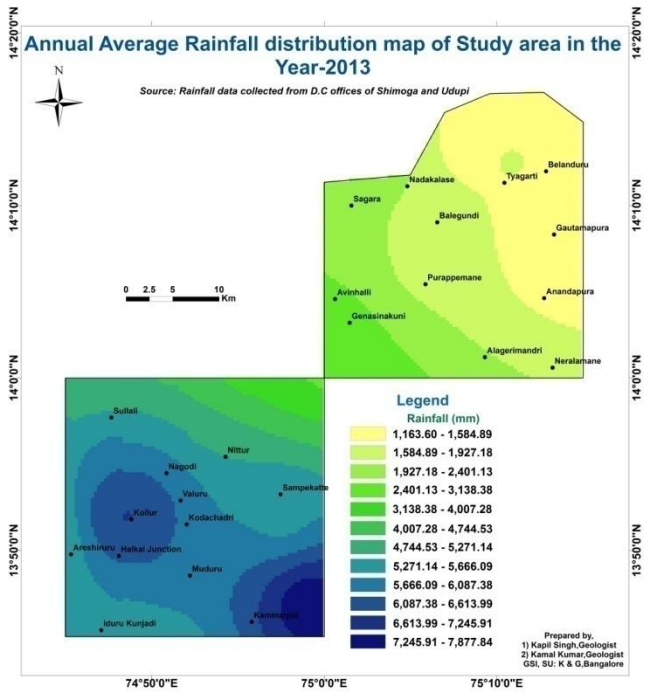
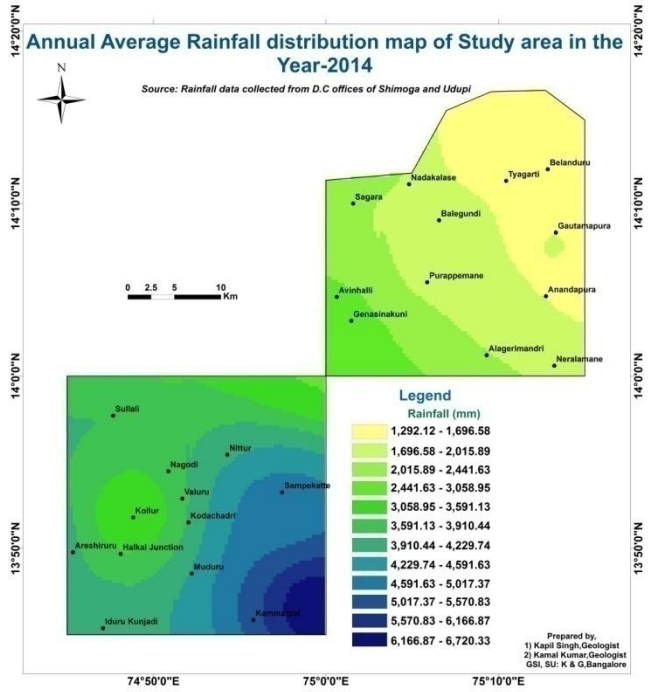
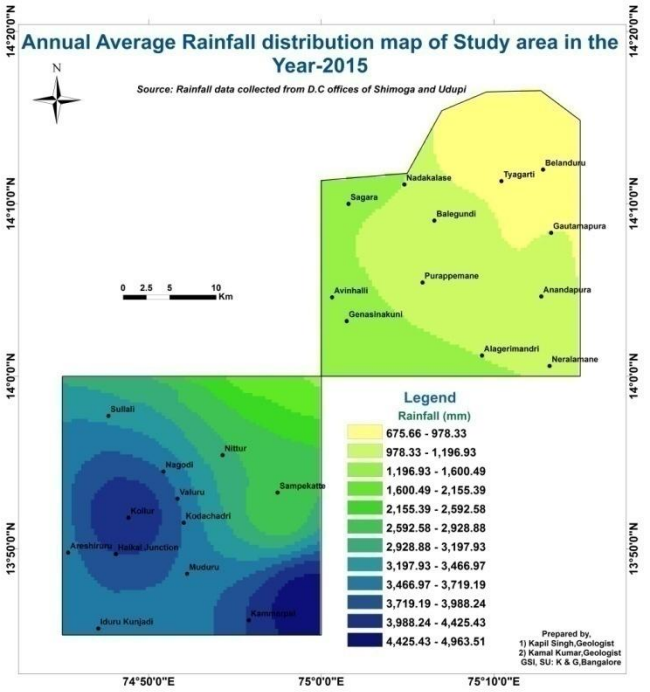
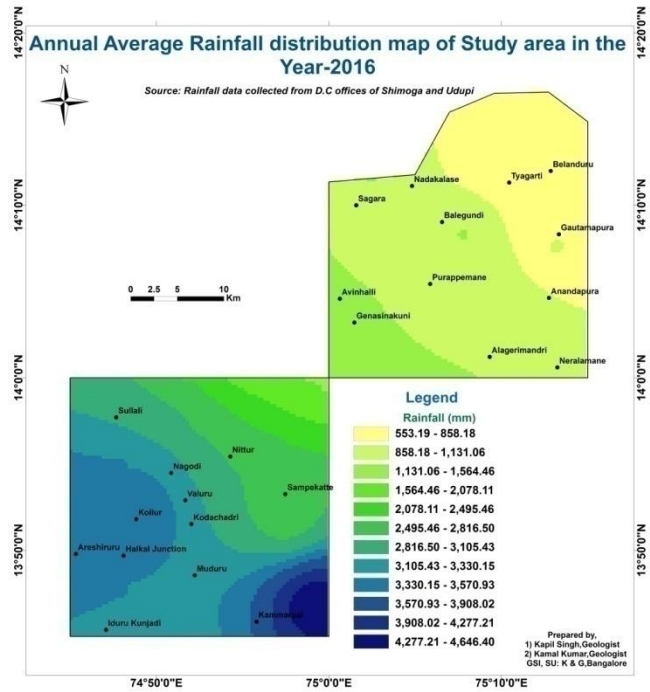


PLATE 15

Annual Average Rainfall distribution map of Study area from Year-2014 to 2017







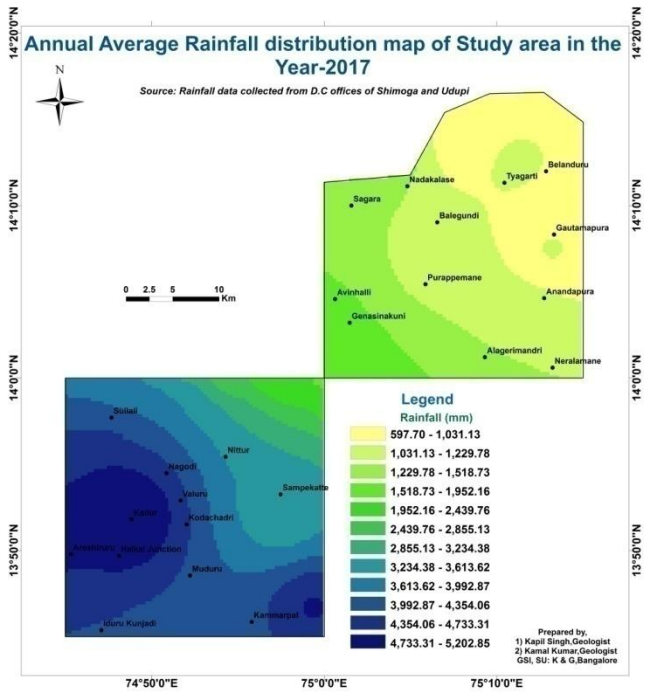


PLATE 16

Annual Average Rainfall distribution map of Study area from Year-2018 to 2019

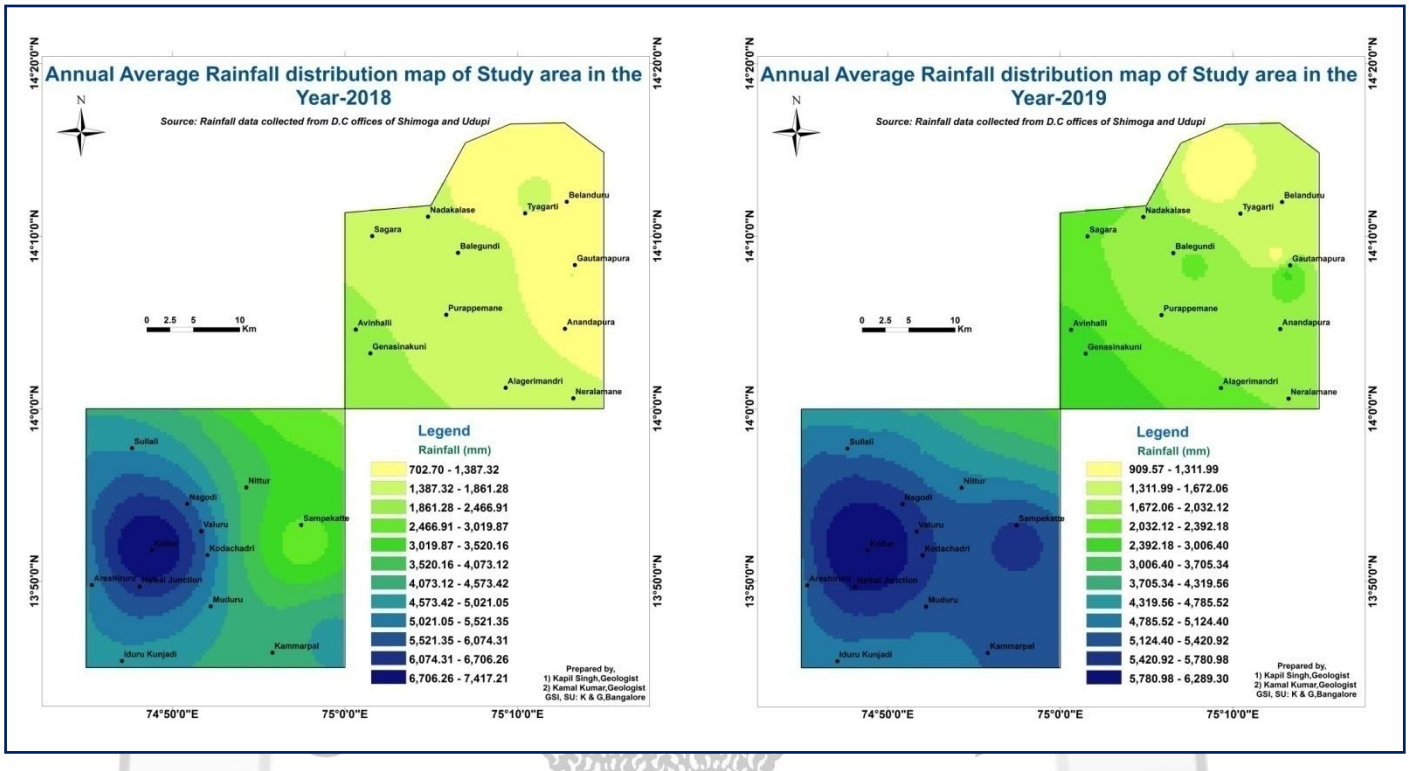
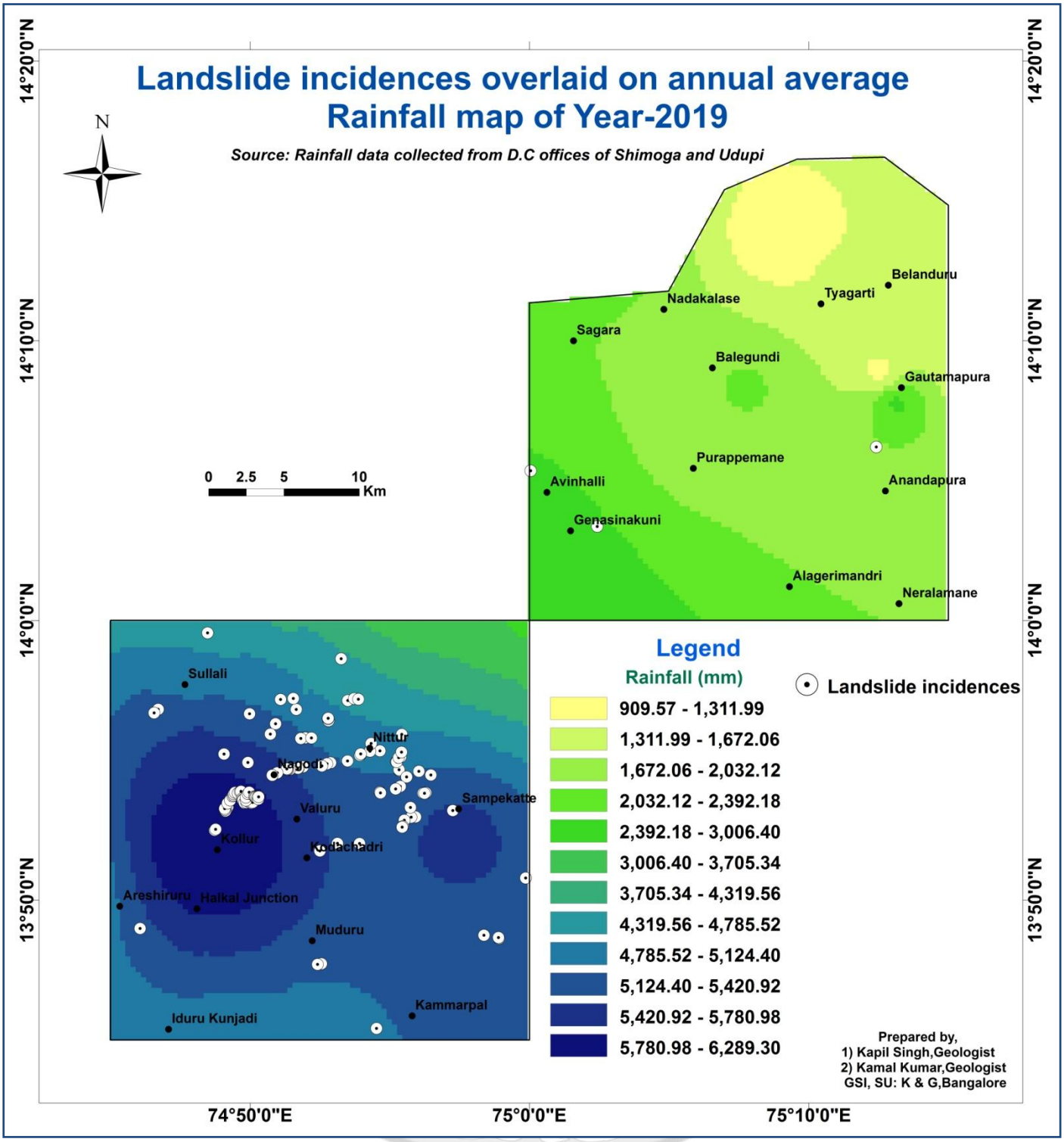


PLATE 17



Since most of the slides (around 65% of the investigated) occurred in the year 2019, therefore a relation between landslide incidences with the Rainfall, Year-2019 has been established to understand the role of rainfall (mainly in August month) in triggering those slides.

FIELD PHOTOGRAPHS



Photo 1:Extensive Cut Slope inlateritic soil; Vill. Magod , TS No. 48K/13.



Photo 2: Extensive Cut Slope in thick soil cover for constructing settlements at Nittur;TS No. 48K/13.



Photo 3: Unscientific Construction of settlementon slope increases stress; Vill. Hindgan; TS No. 48K/13.



Photo 4:Mass failure at the back of a house due to removal of toe of the slope; TS No. 48K/13.



Photo 5:Settlement at vill. Mathikai constructed on vulnerable slope need immediate attention; TS No. 48K/13.

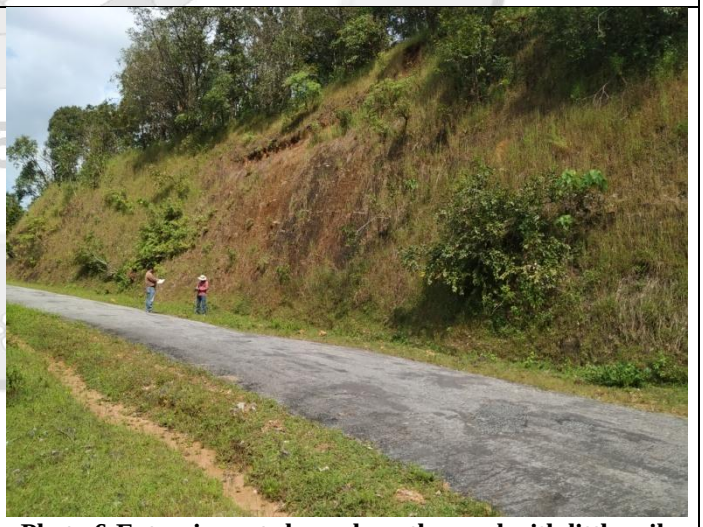


Photo 6:Extensive cut slope along the road with little soil thickness, near Chakra reservoir; TS No.48K/13



Photo 7:Loose slide debris accumulated at the slope; Vill. Sunkadavaramane;TS No. 48K/13.



Photo 8:Laterite quarry for brick making with soil thickness between 1-2m, SE of Jambani; TS No.48N/4



Photo 9:Extensive Cut Slope with soil thickness >8m; West of Changvalli; TS No. 48K/13.



Photo 10:Foliated and Jointed Rock(BMQ) dipping towards the road ; Overburden thickness <0.5m; N of Chunchnur ; TS No. 48K/13.



Photo 11:Breaking up of jointed Rock (Metabasalt)by growing roots of Trees; SW of Nagodi ; TS No. 48K/13.

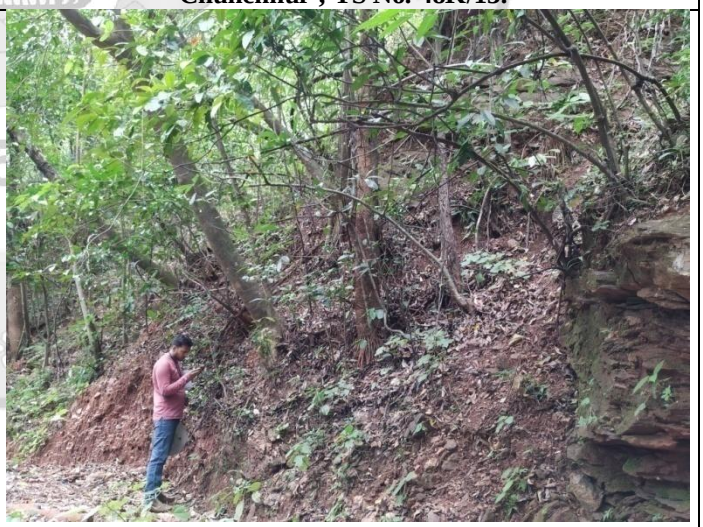


Photo 12:Mass failure at the Litho-Contact of Metabasalt and weathered schist; SW of Nagodi; TS No. 48K/13.



Photo 13:Change in Land use Pattern, Stream course has been converted into cultivation land; Vill. Vatgod; TS No. 48K/13



Photo 14:Diversion of stream towards hill side causing toe erosion and subsequent mass failure, Vill. Vatgod;TS No. 48K/13.



Photo 15:Fill and Cut-Road failure due to stream erosion; Vill. Holegaru; TS No. 48K/13.



Photo 16:Stream erosion in a steep slope can lead to road failure in future; N of Ambiladi ;TS No. 48K/13.



Photo 17:Highly dissected hill with Plantations covering the valley part; near Salakodu ; TS No. 48K/13



Photo 18:Hill covered with bushes and sparse vegetation along Kattinhole-Sampekatte road section;TS No. 48K/13.



Photo 19:Shola forest near Kodachadri;TS No. 48K/13



Photo 20:Jeepable road in steep slope of Kodachadri initiating mass failures; TS No. 48K/13



Photo 21:Folding and faulting observed in banded magnetite quartzite at Kodachadri ; TS No. 48K/13.



Photo 22:Study area largely covered by Linganamakki reservoir, changes the flow dynamics of area ; TS No. 48K/13.



Photo 23:Construction of Gabion wall practiced to prevent toe erosion by stream; Vill. Ambiladi;TS No. 48K/13



Photo 24:Concrete drainage with weep holes provided at the toe of slope; N of Vill. Ambiladi; TS No. 48K/13.

ANNEXURE-I

Calculation of LOFS and consistency ratio (CR) for all factor maps

Geofactor: Geomorphology
Rank of Geomorphology Classes

Sl No	Class Name	Code	Rank
1	Denudational Slope	DS	**9**
2	Escarpment	ESC	**2**
3	Mound	MOUND	**2**
4	Colluvial Foot Slope	CFS	**3**
5	Lowly Dissected Slope	LDS	**4**
6	Moderately Dissected Slope	MDS	**6**
7	Highly Dissected Slope	HDS	**8**
8	Piedmont Slope	PIED SLOPE	**4**
9	Ridge - top	RT	0
10	Tidal Flat	TF	0
11	Colluvial Plain	CP	0
12	Plateau Top (Flat)	PT	0
13	Rolling Plain	RP	0
14	Valley Fill	VF	0
15	Alluvial Plain	AP	0
16	Beach	BE	0
17	Pediment – Pediplain Complex	PPC	0
18	Hilltop	HT	0
19	Water body	WB	0

Geofactor: Geomorphology
Matrix of Pairwise Ratings of Geomorphology Class

GEOM	DS	ESC	MOUND	CFS	LDS	MDS	HDS	PIED SLOPE
DS	1.00	8.00	8.00	7.00	6.00	4.00	2.00	6.00
ESC	0.13	1.00	1.00	0.50	0.33	0.20	0.14	0.33
MOUND	0.13	1.00	1.00	0.50	0.33	0.20	0.14	0.33
CFS	0.14	2.00	2.00	1.00	0.50	0.25	0.17	0.50
LDS	0.17	3.00	3.00	2.00	1.00	0.33	0.20	1.00
MDS	0.25	5.00	5.00	4.00	3.00	1.00	0.33	3.00
HDS	0.50	7.00	7.00	6.00	5.00	3.00	1.00	5.00
PIED SLOPE	0.17	3.00	3.00	2.00	1.00	0.33	0.20	1.00
Sum Column	**2.48**	**30.00**	**30.00**	**23.00**	**17.17**	**9.32**	**4.19**	**17.17**

Estimated Eigen values, fraction rate and LOFS for Geomorphology classes

GEOM	DS	ESC	MOUND	CFS	LDS	MDS	HDS	PIED SLOPE	Sum Rows	Frac Weight	LOFS
DS	0.4038	0.2667	0.2667	0.3043	0.3495	0.4293	0.4778	0.3495	2.8477	0.3560	1.0000
ESC	0.0505	0.0333	0.0333	0.0217	0.0194	0.0215	0.0341	0.0194	0.2333	0.0292	0.0819
MOUND	0.0505	0.0333	0.0333	0.0217	0.0194	0.0215	0.0341	0.0194	0.2333	0.0292	0.0819
CFS	0.0577	0.0667	0.0667	0.0435	0.0291	0.0268	0.0398	0.0291	0.3594	0.0449	0.1262
LDS	0.0673	0.1000	0.1000	0.0870	0.0583	0.0358	0.0478	0.0583	0.5543	0.0693	0.1947
MDS	0.1010	0.1667	0.1667	0.1739	0.1748	0.1073	0.0796	0.1748	1.1447	0.1431	0.4020
HDS	0.2019	0.2333	0.2333	0.2609	0.2913	0.3220	0.2389	0.2913	2.0729	0.2591	0.7279
PIED SLOPE	0.0673	0.1000	0.1000	0.0870	0.0583	0.0358	0.0478	0.0583	0.5543	0.0693	0.1947

Geofactor: Geomorphology

Estimation of consistency vector (CV), consistency index (CI) and consistency ratio (CR) for Geomorphology classes

GEOM	DS	ESC	MOUND	CFS	LDS	MDS	HDS	PIED SLOPE	Sum Rows	CV
DS	0.3560	0.2333	0.2333	0.3145	0.4157	0.5723	0.5182	0.4157	3.0591	8.5940
ESC	0.0445	0.0292	0.0292	0.0225	0.0231	0.0286	0.0370	0.0231	0.2371	8.1302
MOUND	0.0445	0.0292	0.0292	0.0225	0.0231	0.0286	0.0370	0.0231	0.2371	8.1302
CFS	0.0509	0.0583	0.0583	0.0449	0.0346	0.0358	0.0432	0.0346	0.3607	8.0284
LDS	0.0593	0.0875	0.0875	0.0899	0.0693	0.0477	0.0518	0.0693	0.5623	8.1146
MDS	0.0890	0.1458	0.1458	0.1797	0.2079	0.1431	0.0864	0.2079	1.2055	8.4253
HDS	0.1780	0.2042	0.2042	0.2696	0.3465	0.4293	0.2591	0.3465	2.2371	8.6338
PIED SLOPE	0.0593	0.0875	0.0875	0.0899	0.0693	0.0477	0.0518	0.0693	0.5623	8.1146
									Sum CV	66.1711
									Mean Consistency Vector (Mean CV) = Total CV/ Nos. Of factor class (66.1711/8) =	8.2714
									Consistency Index (CI) = (Mean CV - No. Of criteria/ factor class) / (No. Of factor class - 1) =	0.0388
									Consistency Ratio (CR) = CI/ RI = 0.0388 / 1.41 =	0.0275

Geofactor: Slope Forming Material (SFM)

Rank of SFM Classes

Sl No	Class Name	Code	Rank
1	Compact Slide Debris	CSD	**3**
2	In – situ Soil	IS	**4**
3	Colluvium	CL	**5**
4	Loose Slide Debris	LSD	**8**
5	**Rock Class Type – I	R - I	**1**
6	**Rock Class Type – II	R - II	**2**
7	**Rock Class Type – III	R - III	**4**
8	Transported Soil	TS	**3**
9	Weathered Rock	WR	**6**
10	Salt	SL	0
11	Water	WT	0
12	Alluvium	AL	0
13	Barren Sand	BS	0

****Rock Classification**

R- I	R- II	R- III
Granite	Biotite gneiss	Ferruginous laterite
Granite gneiss	Graywacke	Laterite
Quartzite		Argillite
Quartz vein		Sericite schist
Dolerite		Quartz-chlorite schist
Banded iron formation		Quartz-sericite schist
Metabasalt		Actinolite-chlorite schist
Banded magnetite quartzite		Hb-actinolite-chlorite schist

Geofactor: Slope Forming Material (SFM)
Matrix of Pair wise Ratings of SFM Class

SFM	CSD	IS	CL	LSD	R – I	R – II	R – III	TS	WR
CSD	1.00	0.50	0.33	0.17	3.00	2.00	0.50	1.00	0.25
IS	2.00	1.00	0.50	0.20	4.00	3.00	1.00	2.00	0.33
CL	3.00	2.00	1.00	0.25	5.00	4.00	2.00	3.00	0.50
LSD	6.00	5.00	4.00	1.00	8.00	7.00	5.00	6.00	3.00
R - I	0.33	0.25	0.20	0.13	1.00	0.50	0.25	0.33	0.17
R - II	0.50	0.33	0.25	0.14	2.00	1.00	0.33	0.50	0.20
R - III	2.00	1.00	0.50	0.20	4.00	3.00	1.00	2.00	0.33
TS	1.00	0.50	0.33	0.17	3.00	2.00	0.50	1.00	0.25
WR	4.00	3.00	2.00	0.33	6.00	5.00	3.00	4.00	1.00
Sum Column	**19.83**	**13.58**	**9.12**	**2.58**	**36.00**	**27.50**	**13.58**	**19.83**	**6.03**

Estimated Eigen values, fraction rate and LOFS for SFM classes

SFM	CSD	IS	CL	LSD	R – I	R – II	R – III	TS	WR	Sum Rows	Frac Weight	LOFS
CSD	0.0504	0.0368	0.0366	0.0645	0.0833	0.0727	0.0368	0.0504	0.0414	0.4730	0.0526	0.1506
IS	0.1008	0.0736	0.0548	0.0774	0.1111	0.1091	0.0736	0.1008	0.0552	0.7566	0.0841	0.2409
CL	0.1513	0.1472	0.1097	0.0967	0.1389	0.1455	0.1472	0.1513	0.0829	1.1706	0.1301	0.3727
LSD	0.3025	0.3681	0.4388	0.3869	0.2222	0.2545	0.3681	0.3025	0.4972	3.1409	0.3490	1.0000
R - I	0.0168	0.0184	0.0219	0.0484	0.0278	0.0182	0.0184	0.0168	0.0276	0.2143	0.0238	0.0682
R - II	0.0252	0.0245	0.0274	0.0553	0.0556	0.0364	0.0245	0.0252	0.0331	0.3073	0.0341	0.0978
R - III	0.1008	0.0736	0.0548	0.0774	0.1111	0.1091	0.0736	0.1008	0.0552	0.7566	0.0841	0.2409
TS	0.0504	0.0368	0.0366	0.0645	0.0833	0.0727	0.0368	0.0504	0.0414	0.4730	0.0526	0.1506
WR	0.2017	0.2209	0.2194	0.1290	0.1667	0.1818	0.2209	0.2017	0.1657	1.7077	0.1897	0.5437

Geofactor: Slope Forming Material (SFM)

Estimation of consistency vector (CV), consistency index (CI) and consistency ratio (CR) for SFM classes

SFM	CSD	IS	CL	LSD	R – I	R – II	R – III	TS	WR	Sum Rows	CV
CSD	0.078834	0.06305	0.065035	0.087248	0.107155	0.102422	0.06305	0.078834	0.071153	0.716781	9.09223
IS	0.157669	0.1261	0.097553	0.104697	0.142873	0.153632	0.1261	0.157669	0.09487	1.161163	9.208286
CL	0.236503	0.2522	0.195106	0.130872	0.178592	0.204843	0.2522	0.236503	0.142305	1.829123	9.375031
LSD	0.473007	0.630499	0.780423	0.523486	0.285746	0.358475	0.630499	0.473007	0.853831	5.008973	9.568486
R - I	0.026278	0.031525	0.039021	0.065436	0.035718	0.025605	0.031525	0.026278	0.047435	0.328822	9.205977
R - II	0.039417	0.042033	0.048776	0.074784	0.071437	0.051211	0.042033	0.039417	0.056922	0.466031	9.100245
R - III	0.157669	0.1261	0.097553	0.104697	0.142873	0.153632	0.1261	0.157669	0.09487	1.161163	9.208286
TS	0.078834	0.06305	0.065035	0.087248	0.107155	0.102422	0.06305	0.078834	0.071153	0.716781	9.09223
WR	0.315338	0.378299	0.390212	0.174495	0.21431	0.256054	0.378299	0.315338	0.28461	2.706955	9.511097
										Sum CV	83.36187
										Mean Consistency Vector (Mean CV) = Total CV/ Nos. Of factor class (83.36187/9) =	9.26243
										Consistency Index (CI) = (Mean CV - No. Of criteria/ factor class) / (No. Of factor class - 1) =	0.032804
										Consistency Ratio (CR) = CI/ RI = 0.032804/ 1.45 =	0.022623

Geofactor: Regolith Thickness
Rank of Regolith Thickness Classes

Sl No	Class Name	Code	Rank
1	< 0.5 m	< 0.5 m	0
2	0.5 m – 5 m	0.5 m – 5 m	**7**
3	5 m – 10 m	5 m – 10 m	**4**
4	> 10 m	> 10 m	**2**

Matrix of Pairwise Ratings of Regolith Thickness Class

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
Sum Column	**1.42**	**5.33**	**10.00**

Geofactor: Regolith Thickness

Estimated Eigen values, fraction rate and LOFS for Regolith Thickness classes

Regolith Thickness	0.5 – 5 m	5 – 10 m	> 10 m	Sum Rows	Frac Weight	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

Estimation of consistency vector (CV), consistency index (CI) and consistency ratio (CR) for Regolith Thickness classes

Regolith Thickness	0.5 – 5 m	5 – 10 m	> 10 m	Sum Rows	CV
0.5 – 5 m	0.685294	0.885294	0.560294	2.130882	3.109442
5 – 10 m	0.171324	0.221324	0.280147	0.672794	3.039867
> 10 m	0.114216	0.073775	0.093382	0.281373	3.013123
				Sum CV	9.162433
				Mean Consistency Vector (Mean CV) = Total CV/ Nos. Of factor class (9.162433/3) =	3.054144
				Consistency Index (CI) = (Mean CV - No. Of criteria/ factor class) / (No. Of factor class - 1) =	0.027072
				Consistency Ratio (CR) = CI/ RI = 0.027072 / 0.58 =	0.0467

Geofactor: Slope Angle

Rank of Slope Angle Classes

Sl No	Class Name	Code	Rank
1	< 15°	< 15°	**4**
2	15° - 25°	15° - 25°	**6**
3	25° - 35°	25° - 35°	**8**
4	35° - 45°	35° - 45°	**5**
5	> 45°	> 45°	**4**

Matrix of Pairwise Ratings of Slope Angle Class

Slope Class	< 15°	15° - 25°	25° - 35°	35° - 45°	> 45°
< 15°	1.00	0.33	0.20	0.50	1.00
15° - 25°	3.00	1.00	0.33	2.00	3.00
25° - 35°	5.00	3.00	1.00	4.00	5.00
35° - 45°	2.00	0.50	0.25	1.00	2.00
> 45°	1.00	0.33	0.20	0.50	1.00
Sum Column	**12.00**	**5.17**	**1.98**	**8.00**	**12.00**

Geofactor: Slope Angle
Estimated Eigen values, fraction rate and LOFS for Slope Angle classes

Slope Class	< 15°	15° - 25°	25° - 35°	35° - 45°	> 45°	Sum Rows	Frac Weight	LOFS
< 15°	0.083333333	0.064516129	0.100840336	0.0625	0.083333333	0.394523132	0.078904626	0.1631
15° - 25°	0.25	0.193548387	0.168067227	0.25	0.25	1.111615614	0.222323123	0.4597
25° - 35°	0.416666667	0.580645161	0.504201681	0.5	0.416666667	2.418180175	0.483636035	1.0000
35° - 45°	0.166666667	0.096774194	0.12605042	0.125	0.166666667	0.681157947	0.136231589	0.2817
> 45°	0.083333333	0.064516129	0.100840336	0.0625	0.083333333	0.394523132	0.078904626	0.1631

Estimation of consistency vector (CV), consistency index (CI) and consistency ratio (CR) for Slope Angle classes

Slope Class	< 15°	15° - 25°	25° - 35°	35° - 45°	> 45°	Sum Rows	CV
< 15°	0.078904626	0.074107708	0.096727207	0.068115795	0.078904626	0.396759962	5.028348531
15° - 25°	0.236713879	0.222323123	0.161212012	0.272463179	0.236713879	1.129426072	5.080110684
25° - 35°	0.394523132	0.666969368	0.483636035	0.544926358	0.394523132	2.484578025	5.13728888
35° - 45°	0.157809253	0.111161561	0.120909009	0.136231589	0.157809253	0.683920665	5.02027957
> 45°	0.078904626	0.074107708	0.096727207	0.068115795	0.078904626	0.396759962	5.028348531
Sum CV							**25.29438**
Mean Consistency Vector (Mean CV) = Total CV/ Nos. Of factor class (25.68495/5) =							**5.05888**
Consistency Index (CI) = (Mean CV - No. Of criteria/ factor class) / (No. Of factor class - 1) =							**0.01472**
Consistency Ratio (CR) = CI/ RI = 0.034248 / 1.12 =							**0.01314**

Geofactor: Slope Curvature

Rank of Slope Curvature Classes

Sl No	Class Name	Code	Rank
1	< -0.1	Concave	**4**
2	-0.1 – 0.1	Flat	**2**
3	> 0.1	Convex	**6**

Matrix of Pairwise Ratings of Slope Curvature Class

Slope 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
Sum Column	**4.33**	**9.00**	**1.53**

Geofactor: Slope Curvature
Estimated Eigen values, fraction rate and LOFS for Slope Curvature classes

Slope Curvature	Concave	Flat	Convex	Sum Rows	Frac Weight	LOFS
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

Estimation of consistency vector (CV), consistency index(CI) and consistency ratio (CR) for Slope Angle classes

Slope Curvature	Concave	Flat	Convex	Sum Rows	CV
Concave	0.260498	0.318469	0.211115	0.790082	3.032969
Flat	0.086833	0.106156	0.126669	0.319658	3.011202
Convex	0.781494	0.530782	0.633346	1.945621	3.071973
				Sum CV	**9.116144**
				Mean Consistency Vector (Mean CV) = Total CV/ Nos. Of factor class (9.116144/3) =	**3.038715**
				Consistency Index (CI) = (Mean CV - No. Of criteria/ factor class) / (No. Of factor class - 1) =	**0.019357**
				Consistency Ratio (CR) = CI/ RI = 0.019357 / 0.58 =	**0.0334**

Factor Class
Rank of Factor Classes

Sl No	Factor Class Name	Code	Rank
1	Slope	SLP	**9**
2	Curvature	CUR	**2**
3	Slope Forming Material	SFM	**6**
4	Land Use Land Cover	LULC	**8**
5	Geomorphology	GEOM	**6**
6	Regolith Thickness	RT	**4**

Matrix of Pairwise Ratings of Factor Class

Factor Class	SLP	CUR	SFM	LULC	GEOM	RT
SLP	1.00	8.00	4.00	2.00	4.00	6.00
CUR	0.13	1.00	0.20	0.14	0.20	0.33
SFM	0.25	5.00	1.00	0.33	1.00	3.00
LULC	0.50	7.00	3.00	1.00	3.00	5.00
GEOM	0.25	5.00	1.00	0.33	1.00	3.00
RT	0.17	3.00	0.33	0.20	0.33	1.00
Sum Column	**2.29**	**29.00**	**9.53**	**4.01**	**9.53**	**18.33**

Factor Class
Estimated Eigen values, fraction rate and Weight for Factor classes

Factor Class	SLP	CUR	SFM	LULC	GEOM	RT	Sum Rows	Frac Weight	Weight
SLP	0.43636	0.27586	0.41958	0.49881	0.41958	0.32727	2.37747	0.396245271	12.86527835 ~ 13
CUR	0.05455	0.03448	0.02098	0.03563	0.02098	0.01818	0.18480	0.030799588	1 ~ 1
SFM	0.10909	0.17241	0.10490	0.08314	0.10490	0.16364	0.73807	0.123011111	3.993920696 ~ 4
LULC	0.21818	0.24138	0.31469	0.24941	0.31469	0.27273	1.61107	0.268510868	8.718001981 ~ 9
GEOM	0.10909	0.17241	0.10490	0.08314	0.10490	0.16364	0.73807	0.123011111	3.993920696 ~ 4
RT	0.07273	0.10345	0.03497	0.04988	0.03497	0.05455	0.35053	0.058422051	1.896845233 ~ 2

Estimation of consistency vector (CV), consistency index (CI) and consistency ratio (CR) for Factor classes

Factor Class	SLP	CUR	SFM	LULC	GEOM	RT	Sum Rows	CV
SLP	0.396245271	0.246396703	0.492044445	0.537021735	0.492044445	0.350532308	2.514284907	6.345274237
CUR	0.049530659	0.030799588	0.024602222	0.038358695	0.024602222	0.019474017	0.187367404	6.083438671
SFM	0.099061318	0.153997939	0.123011111	0.089503623	0.123011111	0.175266154	0.763851256	6.209611865
LULC	0.198122635	0.215597115	0.369033334	0.268510868	0.369033334	0.292110257	1.712407542	6.377423591
GEOM	0.099061318	0.153997939	0.123011111	0.089503623	0.123011111	0.175266154	0.763851256	6.209611865
RT	0.066040878	0.092398763	0.041003704	0.053702174	0.041003704	0.058422051	0.352571274	6.034900625
							Sum CV	**37.2603**
							Mean Consistency Vector (Mean CV) = Total CV/ Nos. Of factor class (37.2603/6) =	**6.210043**
							Consistency Index (CI) = (Mean CV - No. Of criteria/ factor class) / (No. Of factor class - 1) =	**0.042009**
							Consistency Ratio (CR) = CI/ RI = 0.042009 / 1.24 =	**0.033878**

ANNEXURE-II
42-Point Geo-Parametric Data Format for Landslides

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48N04/2019/01
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48N/04
5	Name of the slide	:	
6	NH/SH/Locality	:	Genasinakuni- Heggodu road
7	Latitude	:	14.056
8	Longitude	:	75.041
9	Length *(m)*	:	~22
10	Width *(m)*	:	~18
11	Height *(m)*	:	~18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~198
15	Run out distance *(m)*	:	~07
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive and Widening
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss and Quartz chlorite schist
26	Structure	:	Foliations trending WNW, dipping 45^{o}
27	Land use/ Land cover	:	Moderate vegetation. Slope cut for extending agriculture area.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes and increased groundwater levels within the mass. Also ground-water levels rising as a result of filling Linganamakki reservoir, that subsequently rises the level of

			stream, causing erosion at the base of slope.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land and agriculture destroyed due to mass fail.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. The soil slide has occurred at the litho contact between Granite gneiss and Qtz chlorite schist. The contact act as a path for facilitating the water infiltration & thus giving rise to increase in hydrostatic pressure leading to failure subsequently.
37	Recommendations	:	Easing of slope and proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining.
38	Remarks, if any		Date of occurrence: 9th August 2019, as conveyed by local.
39	Photos. Sketch of Plan & section of the slide	:	 **View of earth slide occurred in saturated Qtz chlorite schist**
40	Summary/Abstract	:	The landslide is an active earth slide having translational movement along a single rupture plane with approx. 7m run-out distance. The soil material has been moved along with trees and other vegetation destroying areca nut trees and Banana plants at downslope. This landslide has occurred on concave slope with 35°-40° gradient. Earth slide occurrence is due to anthropogenic activities i.e. diversion of streams for increase of agriculture area or for better irrigation. The first order stream is feeding the reservoir. Consequently, during high and sustained rainfall during August 2019 rainfall, ground-water levels rising as a result of filling of reservoir, that raised the stream level.

			This caused steepening of slope due to undercutting and thus faileddue to overloading and reduced shear strength. Another causative factor may be the litho contact of Granite gneiss and Qtz chlorite schist. The contact act as zone of ground water migration. Groundwater saturation may have increased the pore pressures within the weathering profile associated with these zones and thus reduced the shear strength. Crown of the slide is fractured that may lead to another failure during increased stress.
41	Date of Reporting	:	22/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/02
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagara- Mathimane road
7	Latitude	:	13.847
8	Longitude	:	74.998
9	Length *(m)*	:	~12
10	Width *(m)*	:	~25
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~150
15	Run out distance *(m)*	:	~06
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Confined
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Moderately dissected slope
25	Geology/Lithology	:	Quartz chlorite schist

26	Structure	:	Foliations trending E-W, dipping 60^{o} North
27	Land use/ Land cover	:	Dense mixed forest. Extensive slope cut along the road.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Removal of toe support due to road cutting, high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Forest
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail
37	Recommendations	:	The toe support should be given at the base contour line of slope (foot of slope) by construction of retaining wall with weep holes and minimize the slope gradient by benching and back filling. The drainage along the road side has to be cleared and should be provided with proper concrete lining, with plantations on the slope
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Debris slide along the Nagara- Mathimane road section**
40	Summary/Abstract	:	The debris slide is initiated as a planar failure. The debris is highly saturated with water. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during long spell of rain which increased its mass. Initially, high angel slope has been cut for road construction making the slope

			unstable. Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. Removal of debris exposing the underlying rocks below the crown.
41	Date of Reporting	:	23/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/03
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Hoshalli
7	Latitude	:	13.910
8	Longitude	:	74.934
9	Length *(m)*	:	~12
10	Width *(m)*	:	~50
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~180
15	Run out distance *(m)*	:	~08
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive and widening
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Gneissosity trends NNW-SSE dipping 50^{o} ENE.
27	Land use/ Land cover	:	Dense mixed forest. Extensive slope cut along the road.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Removal of toe support for road widening/construction,

			high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Forest
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail
37	Recommendations	:	The toe support should be given at the base contour line of slope (foot of slope) by construction of retaining wall with weep holes and minimize the slope gradient by benching and back filling. Plantations on the slope is also recommended. Proper drainage is to be developed to drain the water away from this area.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Multiple Debris slides near Hoshalli**
40	Summary/Abstract	:	Initially, north westerly high angle slope has been cut for road construction making the slope unstable. Multiple debris slides are initiated as a planar failure. Two debris slides are occurred within old slides. The old scars along with the active slides indicate that the slides are widening and the section is still unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass and reducedthe slope strength. Consequently the saturated debris material moved down the slope along a weak plane

			under the influence of gravity.
41	Date of Reporting	:	23/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/04
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Malekoppa
7	Latitude	:	13.9105
8	Longitude	:	74.9224
9	Length *(m)*	:	~08
10	Width *(m)*	:	~12
11	Height *(m)*	:	~07
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~28.8
15	Run out distance *(m)*	:	~03
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Widening.
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Moderately dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Gneissosity trends NNW-SSE dipping 50^{o} ENE.
27	Land use/ Land cover	:	Dense mixed forest. Extensive slope cut along the road.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Removal of toe support for road widening/construction, high slope gradient are the primary causes while heavy

			antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Forest
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength. The percolating water through soil hydrated the clay layer adding to the weight that reduced the slope material strength.
37	Recommendations	:	The toe support should be given at the base contour line of slope (foot of slope) by appropriate concrete measures and minimize the slope gradient by benching along with plantations on the slope.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Debris slide adjacent to an old slide scar near village Malekoppa**
40	Summary/Abstract	:	Debris slide initiated as a planar failure. The slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Initially, high angel slope has been cut for road construction making the slope unstable. Top of the hill bushes & sparse vegetation is observed with presence of weathered rock and thin soil cover. However highly weathered & soft soil is observed on the slope corresponding to soil thickness of 2m to 3m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	23/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/05
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Malekoppa
7	Latitude	:	13.9109
8	Longitude	:	74.9223
9	Length *(m)*	:	~12
10	Width *(m)*	:	~30
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~108
15	Run out distance *(m)*	:	~03
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive and Widening
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Moderately dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Gneissosity trends NNW-SSE dipping 50^{o} ENE.
27	Land use/ Land cover	:	Moderate vegetation and extensive slope cut for road construction and widening.
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Removal of toe support for road widening/construction, high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil

32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that reduced the shearing strength. The percolating water through soil hydrated the clay layer adding to the weight that reduces the slope strength.
37	Recommendations	:	Slope gradient should be eased by way of constructing benches. Proper drainage with concrete lining should be made at the foot of the slope along with plantations on the slope.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Debris slide along Belur- Malekoppa road section**
40	Summary/Abstract	:	Debris slide initiated as a planar failure. The slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Initially, slope has been cut for road construction making it unstable. Top of the hill bushes & sparse vegetation is observed with presence of weathered rock and thin soil cover. However highly weathered & soft soil is observed on the slope corresponding to soil thickness of 2m to 3m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	23/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/06
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Malekoppa- Sidalguni road section
7	Latitude	:	13.9158
8	Longitude	:	74.9206
9	Length *(m)*	:	~12
10	Width *(m)*	:	~30
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.2
14	Volume *(m3)*	:	~72
15	Run out distance *(m)*	:	~3
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Widening
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Moderately dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Gneissosity trends NNW-SSE dipping 50^{o} ENE.
27	Land use/ Land cover	:	Moderate vegetation and extensive slope cut for road construction and widening.
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Removal of toe support for road widening/construction, high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail along the road. Infiltration of water increases the pore pressure and thus reducedthe shear strength of the soil making a potential slide surface.
37	Recommendations	:	Grading of slope along with plantations and protecting the base of the slope from erosion or excavation.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide occurred along Malekoppa- Sidalguni road**
40	Summary/Abstract	:	Debris slide initiated as a planar failure. The slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Initially, slope has been cut for road construction making it unstable. Top of the hill bushes & sparse vegetation is observed with presence of weathered rock and thin soil cover. However highly weathered & soft soil is observed on the slope corresponding to soil thickness of 3m to 5m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	23/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/07
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sidalguni-Nittur road section / Milestone-Kollur:22 km
7	Latitude	:	13.9222
8	Longitude	:	74.9108
9	Length *(m)*	:	~07
10	Width *(m)*	:	~18
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~37.8
15	Run out distance *(m)*	:	~5
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not Known
24	Geomorphology	:	Moderately dissected slope
25	Geology/Lithology	:	Granite Gneiss
26	Structure	:	Gneissosity trends NNW-SSE dipping 45^{o} ENE.
27	Land use/ Land cover	:	Moderate vegetation and extensive slope cut for road construction and widening.
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Removal of toe support for road widening/construction, high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength. The percolating water through soil hydrated the clay layer adding to the weight that reduced the slope material strength.
37	Recommendations	:	Slope gradient should be eased by way of constructing benches. Proper drainage with concrete lining should be made at the foot of the slope along with planataions on the slope. Trench observed on other side of road is to be filled before next rain to avoid road subsidence or any mass failure down slope.
38	Remarks, if any		Trench on the other side of the road is observed & is running parallel to the road.
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide at Milestone-Kollur:22Km**
40	Summary/Abstract	:	Debris slide initiated as a planar failure. The slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Initially, slope has been cut for road construction making it unstable. Top of the hill bushes & sparse vegetation is observed with presence of weathered rock and thin soil cover. However highly weathered & soft soil is observed on the slope corresponding to soil thickness of 2m to 3m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	23/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

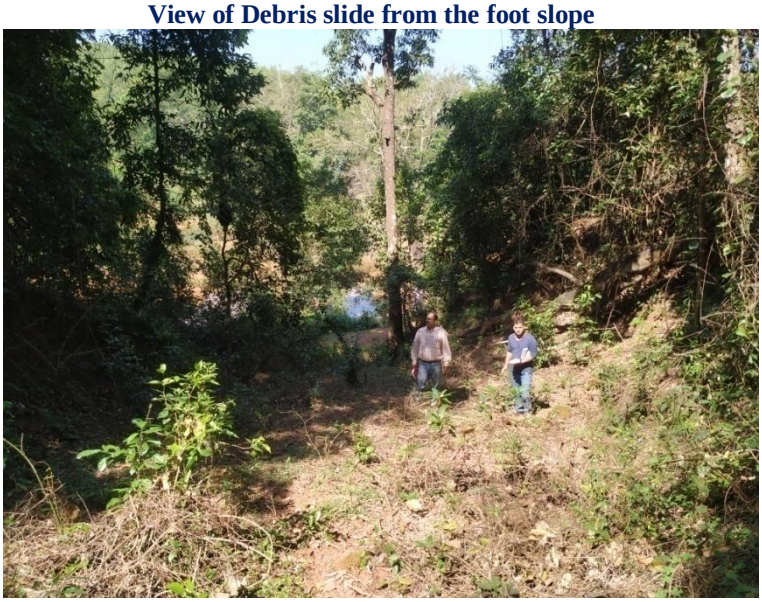
No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48N04/2019/08
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48N/04
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Mumbala
7	Latitude	:	14.1033
8	Longitude	:	75.2070
9	Length *(m)*	:	~16
10	Width *(m)*	:	~14
11	Height *(m)*	:	~12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~112
15	Run out distance *(m)*	:	~2
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Rainfall triggered the mass to fail
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while rainfall triggered the mass to fail along the road.
37	Recommendations	:	Slope gradient should be eased by way of constructing benches. Proper drainage with concrete lining should be made at the foot of the slope.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of old suspended Debris slide covered with vegetation**
40	Summary/Abstract	:	The slide is an old suspended slide that initiated as translational failure. Top of the hill moderate vegetation is observed with some bushes reflecting soil cover of 2 to 3m.The primary cause being the slope cut for road construction making the slope unstable. Consequently the soil saturated with rain water moved down the slope rapidly under the influence of gravity.
41	Date of Reporting	:	23/10/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/09
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sampekatte-Kollur road
7	Latitude	:	13.9079

8	Longitude	:	74.9412
9	Length *(m)*	:	~ 25
10	Width *(m)*	:	~ 10
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~250
15	Run out distance *(m)*	:	Not known
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Gneissosity trends NW-SE dipping 60^{o} NE
27	Land use/ Land cover	:	Thick forest
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Removal of toe support for road widening/construction, high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of forest land destroyed.
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength. The percolating water through soil hydrated the clay layer adding to the weight that reducedthe slope material strength.
37	Recommendations	:	Slope gradient should be eased by way of constructing

			benches. Proper drainage with concrete lining should be made at the foot of the slope.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide from the foot slope**  **View of Debris slide from the crown**
40	Summary/Abstract	:	An old suspended debris slide initiated as translational failure. The slide occurrence is due to slope cut for road construction making it unstable. However, highly weathered rock is observed on the slope corresponding to soil thickness of more than 5m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The debris flown over the road into other side approaching to back water of reservoir. According to a local, the slide occurred 02 years back i.e. in the year 2017. The crown is still wet, while the body of the slide is covered with bushes and vegetation. With increased rainfall, more percolation can lead to failure of the mass and reactivation.
41	Date of Reporting	:	15/11/2019
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/10
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kumbli-Sampekatte road, near village Ambiladi
7	Latitude	:	13.8976
8	Longitude	:	74.9108
9	Length *(m)*	:	~ 9
10	Width *(m)*	:	~ 14
11	Height *(m)*	:	~ 8
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.2
14	Volume *(m3)*	:	~25
15	Run out distance *(m)*	:	~6
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive and widening
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Removal of toe support for road widening/construction, high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength. The percolating water through soil hydrated the clay layer adding to the weight that reducedthe slope material strength.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining with plantations on the graded slope.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of debris slide occurred along the Kumbli-Sampekatte road**
40	Summary/Abstract	:	Debris slide initiated as a planar failure. The slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Initially, high angleslope has been cut for road construction making the slope unstable. Top of the hill is covered with thick vegetation. However highly weathered & soft soil is observed on the slope corresponding to soil thickness of 3m to 5m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/11

2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kumbli-Sampekatte road
7	Latitude	:	13.8972
8	Longitude	:	74.9111
9	Length *(m)*	:	~ 30
10	Width *(m)*	:	~ 15
11	Height *(m)*	:	~ 20
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~450
15	Run out distance *(m)*	:	~15
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of forest land is destroyed under debris slide.
36	Geo-scientific Causes	:	Regolith /Soil thickness greater than 15m corresponding to

			considerable depth of soil and weathered rock mass. Removal of toe support by second order stream, high slope gradient are the primary causes that tend to reduce the shearing strength. High angle slope cut left unsupported below the road bench, improper and inadequate drainage arrangements, lack of channelized runoff water network on slope, improper toe support measures.
37	Recommendations	:	The toe support should be given at the toe of slide (where slide material stopped) by appropriate concrete measures (Retaining wall with weep holes) before going for benching and back filling of slope. Strengthened concrete measures right from firm hard rock surface to provide lateral support to the road. Surface water is to be diverted from unstable slopes by ditches and pipes. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		Road leading to Sampekatte/Kodachadri is in grave danger, as the slide is retrograding and can lead to road subsidence. Soil pipe in the crown part revealing sub-surface erosion. Therefore, it requires an immediate attention.
39	Photos. Sketch of Plan & section of the slide	:	 **View of debris slide occurred along the Kumbli-Sampekatte road**  **View of debris slide from crown**
40	Summary/Abstract	:	Debris slide initiated on the downside of the road in highly weathered schistose rock. Toe erosion by heavily charged

			Markatke Hole (IInd order Stream) during heavy rain event of August 2019, undercut or scoured the slope making it steeper. Also, the slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Cumulative effect reducedthe shear strength that lead to mass failure down the road. Poor drainage network on upside of the road also contributed to seepage of water down the road. Presence of soil pipe on the crown part reveals the subsurface erosion and retrogressive nature of the slide. Therefore, an urgent attention requires safeguarding the road leading to Sampekatte or Kodachadri.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/12
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur
7	Latitude	:	13.9221
8	Longitude	:	74.9049
9	Length *(m)*	:	~10
10	Width *(m)*	:	~14
11	Height *(m)*	:	~8
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~70
15	Run out distance *(m)*	:	~6
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss

26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Cut-slope for making settlement
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Huge debris accumulated at the back side of Chandrashekhar Jogi's house.
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Unscientific way of cutting slope for making settlement thus removing toe support &which increased slope instability. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Retaining wall with weep holes is required for better protection. Drainage at the base of slope should be provided with concrete lining.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide at back of the house**

			 **Cut-slope failure occurred after constructing settlement**
40	Summary/Abstract	:	The slide initiated as a planar failure. The slide initiated after disturbance of the slope for making settlement. No support has been provided by the house owner. Highly weathered and saturated debris with soil thickness 2-5 m accumulated at the back of Chandrashekhar Jogi's house. The slide is still active and need immediate lateral support (concrete wall with weep holes).
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/13
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Nagodi road section
7	Latitude	:	13.9199
8	Longitude	:	74.8992
9	Length *(m)*	:	~13
10	Width *(m)*	:	~70
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~273
15	Run out distance *(m)*	:	~6

16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Extensive cut slope for road construction
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength.The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Retaining wall with weep holes is required for better protection. Drainage at the base of slope should be provided with concrete lining.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of Multiple debris slides at Nittur-Nagodi road**
40	Summary/Abstract	:	Multiple debris slides (03no's) initiated as a planar failure. The debris is highly saturated with water. The slope forming material (SFM) lying over the hard rock got saturated by percolation of water during heavy spell of rain which increased its mass. Initially, slope has been cut for road construction making the slope unstable. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/14
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Nagodi road section
7	Latitude	:	13.9197
8	Longitude	:	74.8988
9	Length *(m)*	:	~15
10	Width *(m)*	:	~25
11	Height *(m)*	:	~12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3

14	Volume *(m3)*	:	~112
15	Run out distance *(m)*	:	Data not available
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Extensive cut slope for road construction with sparse vegetation on upslope
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting is the primary cause that tends to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Retaining wall with weep holes is required for better protection. Drainage at the base of slope should be provided with concrete lining.
38	Remarks, if any		

39	Photos. Sketch of Plan &section of the slide	:	 **View of debris slide at Nittur-Nagodi road**
40	Summary/Abstract	:	Debris slide initiated as a planar failure and is retrogressive in nature. The debris is highly saturated with water. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during heavy spell of rain which increased its mass. Initially, slope has been cut for road construction making the slope unstable. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/15
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Nagodi road section
7	Latitude	:	13.9163
8	Longitude	:	74.8915
9	Length *(m)*	:	~10
10	Width *(m)*	:	~14
11	Height *(m)*	:	~8
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~42

15	Run out distance *(m)*	:	Data not available
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Extensive cut slope for road construction with sparse vegetation and bushes on upslope
28	Hydrological condition	:	dry
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail.
37	Recommendations	:	Easing of the slope with deep rooted plant has to be done.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	

			Debris flow downhill side of the road
40	Summary/Abstract	:	The debris slide is initiated as a planar failure. The debris is highly saturated with water. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during heavy spell of rain which increased its mass. Initially, the slope has been cut for road construction making the slope unstable. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/16
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Vatgod
7	Latitude	:	13.8106
8	Longitude	:	74.9817
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 16
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~200
15	Run out distance *(m)*	:	Not observed as it is an old slide
16	Type of Material	:	Debris
17	Type of movement	:	slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	Old Slide
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	NNW Orientation, dipping 65°WSW

27	Land use/ Land cover	:	Cultivation and sparse vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removing soil from hill slopefor increasing cultivation area results in a significant reduction in lateral support. Diversion of main stream channel towards hill side accelerates toe erosion. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Natural drainage should be left unaltered. Plantation/Cultivation on the nala/stream should be avoided for the free flow of water. Benching on the slope is advisable for easing the slope. The drainage should be lined with concrete to avoid any infiltration from the stream. Crown cracks to be sealed with impervious material. Monitoring of cracks should be done regularly during rain.
38	Remarks, if any		Main course of stream is converted into cultivation land. Foot track observed on the upside of crown part of Slide.
39	Photos. Sketch of Plan & section of the slide	:	 **Distant view of an old suspended debris slide**
40	Summary/Abstract	:	The landslide is an old suspended slide having translational movement along a single rupture plane. Debris slide occurrence is due to anthropogenic activities i.e. Slope cut and diversion of stream for increase of agriculture area or for better irrigation. Diversion of large stream towards foot of

			the slope into smaller area accelerates the toe erosion during rainfall. This causes steepening of slope due to undercutting and resulting in failure due to overloading and reduce the shear strength. Cracks and slight subsidence is observed on the crown part that may lead to another failure during event of heavy rain. Foot track on the crown part is also contributing for overburden weight and increased stress.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/17
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Vatgod
7	Latitude	:	13.8110
8	Longitude	:	74.9815
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 14
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~250
15	Run out distance *(m)*	:	Not observed as it is an old slide
16	Type of Material	:	Debris
17	Type of movement	:	slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	NNW Orientation, dipping 65°WSW

27	Land use/ Land cover	:	Cultivation and sparse vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removing soil from hill slope for increasing cultivation area results in a significant reduction in lateral support. Diversion of main stream channel towards hill side accelerates toe erosion. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Natural drainage should be left unaltered. Plantation/Cultivation on the nala/stream should be avoided for the free flow of water. Benching on the slope is advisable for easing of the slope. The drainage should be lined with concrete to avoid any infiltration from the stream.
38	Remarks, if any		Main course of the stream is converted into cultivation land. Foot track observed on the upside of crown part of Slide.
39	Photos. Sketch of Plan & section of the slide	:	 **Distant view of an old suspended debris slide**
40	Summary/Abstract	:	The landslide is an old suspended slide having translational movement along a single rupture plane. Debris slide occurrence is due to anthropogenic activities i.e. Slope cut and diversion of stream for increase of agriculture area or for better irrigation. Diversion of large stream towards foot of the slope into smaller area accelerates the toe erosion during rainfall. This causes steepening of slope due to undercutting

			and resulting in failure due to overloading and reduce the shear strength. Crown cracks observed that may lead to another failure during event of heavyrain. A local road on the crown part is also contributing for overburden weight and increased stress.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/18
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	1.2 km West of Vatgod
7	Latitude	:	13.8124
8	Longitude	:	74.9729
9	Length *(m)*	:	~ 8
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 5
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~29
15	Run out distance *(m)*	:	~ 2
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	NNW Orientation, dipping 65°WSW
27	Land use/ Land cover	:	Moderate vegetation
28	Hydrological condition	:	Damp

29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of an old debris slide**
40	Summary/Abstract	:	Debris slide initiated as a planar failure. The slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Initially, high angle slope has been cut for road construction making the slope unstable. Top of the hill is covered with thick vegetation. However highly weathered & soft soil is observed on the slope corresponding to soil thickness of 3m to 5m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/19
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Belur-Madvi road
7	Latitude	:	13.9067
8	Longitude	:	74.9267
9	Length *(m)*	:	~14
10	Width *(m)*	:	~40
11	Height *(m)*	:	~12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~198
15	Run out distance *(m)*	:	~05
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Laterite and Saprolite derived from Quartz chlorite schist
26	Structure	:	Foliation trending NW-SE
27	Land use/ Land cover	:	Moderate vegetation. Slope cut for extending agriculture area.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land destroyed due to mass failure.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by diverted stream undercut the slope making it steeper and madethe slope unstable. Laterite/Saprolite cover with thickness more than 5m added the weight on saturated material. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Blocked drainage at the foot slope should be clear for free flow of water. Drainage should be provided with concrete lining.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of earth slide occurred in laterite/saprolite**
40	Summary/Abstract	:	The landslide is an active earth slide having translational movement along rupture plane with approx. 5m run-out distance. Earth slide occurrence is due to anthropogenic activities i.e. Slope cut and diversion of stream for increase of agriculture area or for better irrigation. Diversion of stream towards foot of the slope accelerates the toe erosion during rainfall. This causes steepening of slope due to undercutting and thus fails due to overloading and reduced shear strength. Highly saturated lateritic soil with thickness correspondingto 5 to 10 m is observed, which is adding an extra overburden weight and percolation of water resulting in building up of pore water pressure and reducing the cohesive strength. The underlying rock exposed at the base after removal of soil. Foliations are well distinct in saprolite. The slide occurred at the back side of Narayana's house, and is partly affected his cultivation area.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description

1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/20
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Belur-Madvi road, Near Vill. Madvi
7	Latitude	:	13.9011
8	Longitude	:	74.9229
9	Length *(m)*	:	~14
10	Width *(m)*	:	~30
11	Height *(m)*	:	~12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~210
15	Run out distance *(m)*	:	~05
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation trending NW-SE
27	Land use/ Land cover	:	Moderate vegetation. Slope cut for extending agriculture area.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil

35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by diverted stream undercut the slope making it steeper and made the slope unstable. Soil/Weathered rock thickness is more than 5m added the weight on saturated material. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Blocked drainage at the foot slope should be clear for free flow of water. Drainage should be provided with concrete lining.
38	Remarks, if any		Slide occurred in the rainfall event of August 2019
39	Photos. Sketch of Plan & section of the slide	:	 **View of earth slide occurred in saturated weathered schist**
40	Summary/Abstract	:	The earth slide is observed to have occurred on the westerly slope. The inclination of failure slope is observed to be around 40°. The landslide is an active earth slide having translational movement failing along the interface of soil and weathered rock and consequential movement aided by water. Earth slide occurrence is due to anthropogenic activities i.e. Slope cut and diversion of stream for increase of agriculture area (paddy field) or for better irrigation. During incessant rainfall, the stream was unable to accommodate large volume of discharge. This accelerated the toe erosion of the hill slope and resulted in steepening of slope due to undercutting. Consequently, the slope faileddue to overloading and reduced shear strength. Highly saturated reddish brown soil with thickness correspondingto 5 to 10 m added an extra overburdenweight and percolation of water resulting in building up of pore water pressure and reducing the cohesive strength. The underlying rock exposed at the base after removal of soil.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/21
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Belur-Madvi road, Near Vill. Madvi
7	Latitude	:	13.8995
8	Longitude	:	74.9202
9	Length *(m)*	:	~22
10	Width *(m)*	:	~30
11	Height *(m)*	:	~18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~330
15	Run out distance *(m)*	:	~05
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation trending NW-SE
27	Land use/ Land cover	:	Moderate vegetation. Slope cut for extending agriculture area.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes and also aggravated toe erosion by IInd order stream.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by diverted stream undercut the slope making it steeper and made the slope unstable. Soil/Weathered rock thickness is more than 5m addedthe overburden weight on saturated material. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Natural flow of drainage should be unaltered.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of old earth slide covered with bushes and small trees**
40	Summary/Abstract	:	An old suspended earth slide is observed on the east facing slope. The slide initiated as a translational failure along the interface of soil and weathered rock. Earth slide occurrence is due to anthropogenic activities i.e. Slope cut and diversion of stream for increase of agriculture area (paddy field) or for better irrigation. During incessant rainfall, the N-S running stream (II^{nd} order stream) was unable to accommodate large volume of discharge. This accelerated the toe erosion of the hillslope and resulted in steepening of slope due to undercutting. Consequently the slope faileddue to overloading and reduced shear strength. The zone of accumulation is covered with shrubs and isolated small trees. The failure occurred at the convex bend of the stream.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/22

2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Markutka road
7	Latitude	:	13.9204
8	Longitude	:	74.8993
9	Length *(m)*	:	~12
10	Width *(m)*	:	~35
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~210
15	Run out distance *(m)*	:	~8
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Cut-slope for making settlement
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support for constructing settlement without

			giving any lateral support and thick saturated soil cover of 3 to 5m are the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading with deep rooted plantations on the graded slope, possibly reduce the hazard considerably.Surface water should be diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide due to extensive cut slope**
40	Summary/Abstract	:	The slide initiated after extensively cutting the slope for making settlement. No lateral support has been provided by the house owner. Highly weathered and saturated debris with soil thickness 3-5 m increased the pore pressure and thus reduced theshear strength of the soil. Presence of cracks in the crown part reveals that the slide is still active and retrograding. The excavated slope if left untreated is sure to pose threat during heavy rainfall.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/23
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Katkamadi road
7	Latitude	:	13.9151

8	Longitude	:	74.8813
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~250
15	Run out distance *(m)*	:	~5
16	Type of Material	:	Debris
17	Type of movement	:	slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz Chlorite schist
26	Structure	:	Not observed
27	Land use/ Land cover	:	Thick vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting together with thick soil cover are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail.
37	Recommendations	:	Benching on the slope is advisable for easing the slope. The drainage should be lined with concrete to avoid any infiltration from the stream.
38	Remarks, if any		.

39	Photos. Sketch of Plan & section of the slide	:	 **View of a reactivated debris slide (Crown is visible)**
40	Summary/Abstract	:	The landslide is reactivated slide having translational movement along a single rupture plane. Since the area already witnessed an old slide earlier, the old cracks formed by old slide may have played a key role for rainfall infiltration. The old slip zone with lower permeability was another important factor to cause the infiltrated water to accumulate and form a high pore water pressure zone above slip surface. The high pore water pressure decreased the shear strength of slip surface and triggered the reactivation of an old landslide again. The crown part is clearly visible, while the accumulation zone is partly covered with trees and bushes. The runoff material has been dumped beside the road.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/24
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Katkamadi road
7	Latitude	:	13.9145
8	Longitude	:	74.8792
9	Length *(m)*	:	~ 7
10	Width *(m)*	:	~ 16

11	Height *(m)*	:	~ 5
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~34
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of a road cut initiated debris slide**
40	Summary/Abstract	:	Debris slide initiated as a planar failure. The slope forming material (SFM) got saturated by percolation of water during heavy rains which increased its mass. Initially, slope has been cut for road construction making it unstable. Top of the hill is covered with moderate vegetation. However highly weathered & soft soil is observed on the slope corresponding to soil thickness of 3m to 5m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/25
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Katkamadi road
7	Latitude	:	13.9132
8	Longitude	:	74.8761
9	Length *(m)*	:	~ 7
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 5
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5

14	Volume *(m3)*	:	~42
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of a road cut initiated debris slide**
40	Summary/Abstract	:	The debris slide is observed to have occurred on the north-westerly slope. The inclination of planar failure slope is observed to be around 40°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 3m to 5m got saturated by percolation of water during heavy rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The landslide debris is accumulated at the road. Top of the hill is covered with moderate vegetation. The slide is adjacent to an old slide that reflects widening of the slide. Down the slope, below the road bench, NE-SW running stream of Ist order draining the area.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/26
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Yellurmane-Areshirur road
7	Latitude	:	13.8164
8	Longitude	:	74.7677
9	Length *(m)*	:	~ 7
10	Width *(m)*	:	~ 20

11	Height *(m)*	:	~ 5
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~70
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite
26	Structure	:	Foliation-SSE
27	Land use/ Land cover	:	Thick vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Side view of the debris slide covered with bushes**
40	Summary/Abstract	:	The debris slide is observed to have occurred on the north-westerly slope. The inclination of planar failure slope is observed to be around 25°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 3m to 5m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The landslide debris is accumulated at the road. Top of the hill is covered with thick vegetation. The slide is occurring at the bend of the road.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/27
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Muduru- Kundanabailu road
7	Latitude	:	13.7954
8	Longitude	:	74.8758
9	Length *(m)*	:	~9
10	Width *(m)*	:	~22
11	Height *(m)*	:	~8

12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~99
15	Run out distance *(m)*	:	~3
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Cut-slope for making settlement
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support for constructing settlement without giving any lateral support and thick saturated soil cover of 3 to 5m are the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. The toe erosion of slopes by water action should be stopped by appropriate strengthened concrete measures right from firm hard rock surface which may also act as toe support for slope material. Surface water is to be diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of Earth slide due to extensive cut slope**
40	Summary/Abstract	:	The slide initiated after removal of soil from hillslopefor making settlement. The Hb-actinolite-chlorite schist showing a high degree of alteration and development of reddish-brown, soft and friable material (saprolite). The percolating water through soil hydrated the clay layer adding to the weight that reducedthe slope strength. The slide occurred during heavy rainfall that caused infiltration of water which resulted in building up of pore water pressure and reducing the cohesive strength. Consequently the saturated debris material moved down the disturbed slope along a weak plane under the influence of gravity. No lateral support has been provided by the land owner. The excavated slope if left untreated is sure to pose threat during heavy rainfall.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/28
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Muduru-Kundanabailu road
7	Latitude	:	13.7950
8	Longitude	:	74.8735
9	Length *(m)*	:	~ 8
10	Width *(m)*	:	~ 5

11	Height *(m)*	:	~ 14
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~20
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Cashew plantation & bushes on upslope, Extensive cut slope for road
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Clogged road side drainage should be cleared. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of a road cut initiated debris slide**
40	Summary/Abstract	:	The debris slide is observed to have occurred on the north-westerly slope. The inclination of planar failure slope is observed to be around 45°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 3m to 5m got saturated by percolation of water during heavy rains which increased its mass. Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. Top of the hill is modified & is covered with cashew plantation with bushes. The drainage line along the road is blocked with debris material that should be removed before next rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/29
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	BC Road, NE of Tenkanamakki
7	Latitude	:	13.7568
8	Longitude	:	74.9087
9	Length *(m)*	:	~8
10	Width *(m)*	:	~25
11	Height *(m)*	:	~10

12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~100
15	Run out distance *(m)*	:	~4
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Foliation-NNW, dipping 60°ENE
27	Land use/ Land cover	:	Cut-slope for making settlement & sparse vegetation at upslope
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Run off debris accumulated at the back side of the house.
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Unscientific way of cutting slope for making settlement by way of removing toe support which increased slope instability. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	The slope around the house and the house situated near to the hill is deduced to be highly susceptible to failure, particularly in the event of heavy or prolonged rainfall. The residents are therefore advised to keep safe distance from the vulnerable slope and vacate the area, especially during heavy or prolonged rainfall. The toe support should be given at the foot of slope by construction of retaining wall with weep holes and minimize the slope gradient by benching and back filling. Surface water is to be diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Distant View of the slide on modified slope for making settlements**  **Debris accumulated at the back side of settlement**
40	Summary/Abstract	:	The active debris slide is observed to have occurred on the north-westerly slope. The inclination of failure slope is observed to be around 40°. There are number of settlements present along the foot of the hill & are constructed without giving any lateral support to the slope. Oversaturated weathered rock & soil is observed on the slope corresponding to soil thickness more than 5m.Plantation in the steep slopes has been practiced after removing the vegetation cover on the upper parts of the slope. The vegetation on upslope of the hill is therefore unable to hold the thick saturated soil against the gravity. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The excavated slope if left untreated is sure to pose threat during heavy rainfall.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/30
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	1.27 Km North of Kollur along Kollur-Nagodi road
7	Latitude	:	13.8750
8	Longitude	:	74.8122
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~350
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil

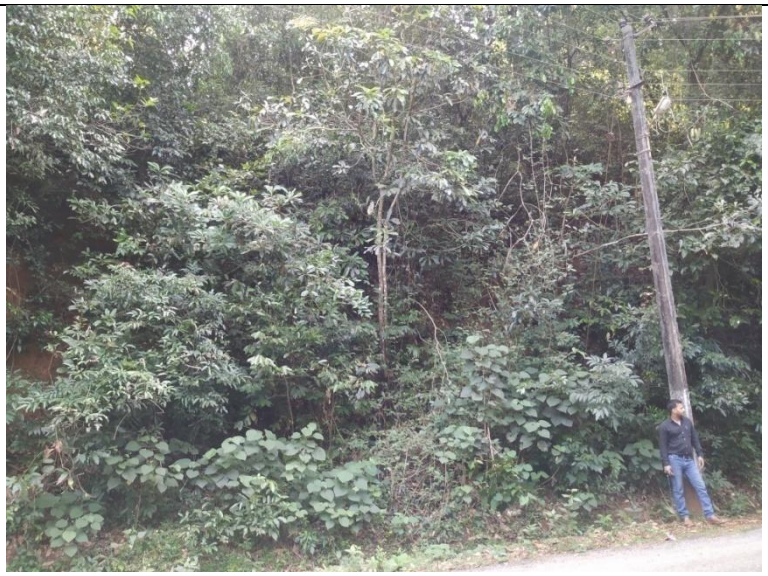
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 5m to 10m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. The subsurface seepage of water beneath the road is removing the soil from beneath & making other side of the slope also unstable.
37	Recommendations	:	The toe support should be given at the base contour line of slope (foot of slope) by construction of retaining wall with weep holes and also minimize the slope gradient by benching and back filling. Clogged road side drainage should be cleared. Drainage system along the road should be supported by concrete work. Road leading to Kollur should be strengthened as another slide below the road bench posing threat for it.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of a road cut initiated earth slide**  **Earth slide observed below the road bench**

40	Summary/Abstract	:	The slide is observed to have occurred on the north-westerly slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 10m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Opposite to this slide, below the road bench another slide occurred due to unsupported high angle slope cut for road construction. The slide is retrograding &may cause failure/subsidence of road with increased stress. The drainage line along the road is blocked with landslide debris material that should be removed before next rain to avoid sub surface erosion. Below the road bench, a higher order stream running almost parallel to the road is also responsible for removing toe support. The failure occurred at the convex bend of the stream.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/31
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	1.34 Km North of Kollur along Kollur-Nagodi road
7	Latitude	:	13.8755
8	Longitude	:	74.8127
9	Length *(m)*	:	~ 22
10	Width *(m)*	:	~ 32
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~700
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive

21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 5m to 10m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Clogged road side drainage should be cleared. Drainage system along the road should be supported by concrete work. Below the road bench, trench parallel to the road is posing problem and may destabilize the slope. This trench should be filled immediately before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended Earth slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the north-westerly slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 10m got saturated by percolation of water during heavy rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The drainage line along the road is blocked with landslide debris material that should be removed before next rain to avoid sub surface erosion. Down the slope a higher order stream is running with its convex bend towards the mass failure at road cut.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/32
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8887
8	Longitude	:	74.8200
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 10
11	Height *(m)*	:	~ 10

12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~60
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 5m to 10m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the south-easterly slope. The inclination of planar failure slope is observed to be around 45°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 10m got saturated by percolation of water during heavy rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Crown cracks observed that reveals retrogressive nature of slide. A NNW-SSE running first order stream is adjacent to the slide.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/33
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road (Ghat road)
7	Latitude	:	13.7950
8	Longitude	:	74.8191
9	Length *(m)*	:	~ 16
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 14
12	Area *(m2)*	:	

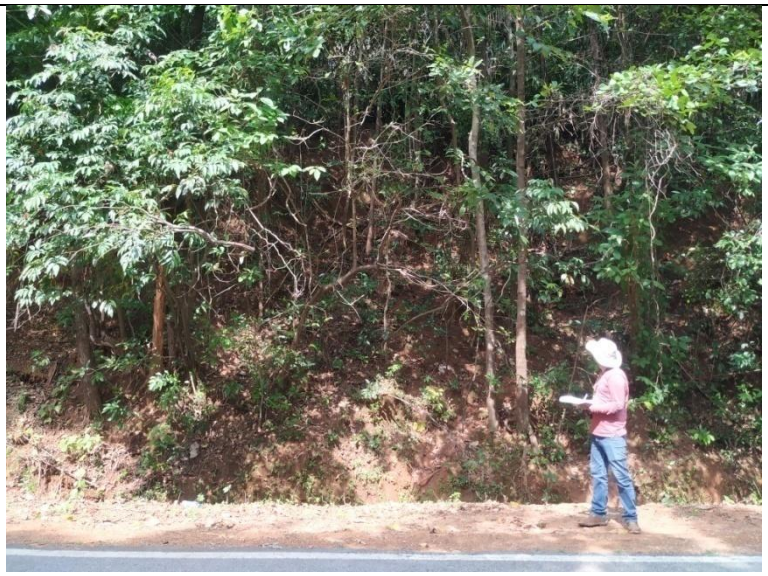
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~160
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt and Hornblende-actinolite-chlorite schist
26	Structure	:	Foliation trending N-S, dipping 30°E
27	Land use/ Land cover	:	Thick forest on upslope, Extensive cut slope for road
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail.The slide is occurring at the litho contact between Metabasalt and Hornblende-actinolite-chlorite schist. The contact zone act as a path for facilitating the water infiltration & thus giving rise to increase in hydrostatic pressure leading to failure subsequently.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Debris accumulated in the drainage line should be cleared. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of a road cut initiated debris slide**
40	Summary/Abstract	:	The debris slide is observed to have occurred on the north-westerly slope. The inclination of planar failure slope is observed to be around 45°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 3m to 5m got saturated by percolation of water during heavy rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The drainage line along the road is blocked with debris that should be removed before next rain. The slide is occurring close to different litho contact (Metabasalt and Hb-actinolite-chlorite schist) that provide way for the water to percolate easily and thus reduces shear strength of the slope facilitating the mass to fail.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/34
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8864
8	Longitude	:	74.8186
9	Length *(m)*	:	~ 16

10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 14
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.7
14	Volume *(m3)*	:	~224
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 5m to 10m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. Since the area already witnessed an old slide earlier, the old cracks so formed may have played a key role for rainfall infiltration
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide with partly vegetation cover at accumulation zone**
40	Summary/Abstract	:	A reactivated slide is observed to have occurred on high gradient north-westerly slope. The old slip zone with low permeability was an important factor to cause the infiltrated water to accumulate and form a zone of high pore water pressure above slip zone. Then the high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide material again.The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 10m got saturated by percolation of water during rains which increased its mass. Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation is partly covered with small trees and shrubs. The crown is very distinct with numerous fractures revealing its retrogressive nature.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/35
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi Ghat road
7	Latitude	:	13.8872
8	Longitude	:	74.8183
9	Length *(m)*	:	~ 16

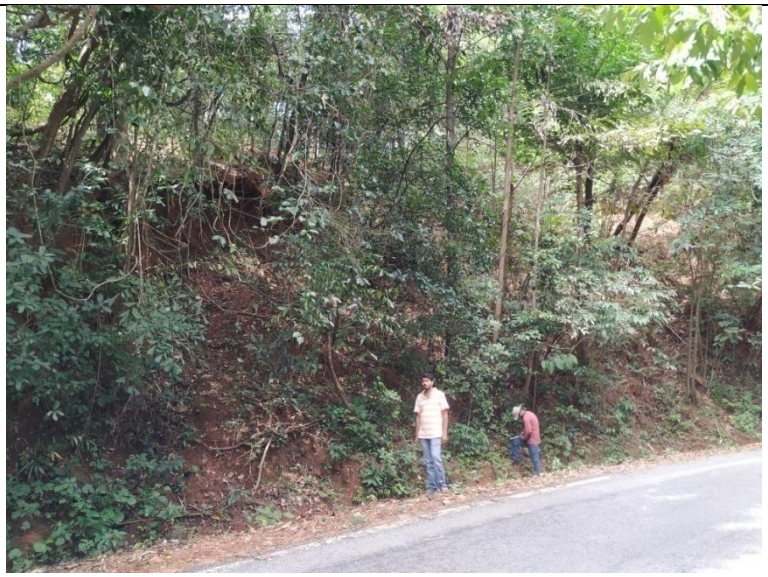
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 14
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.7
14	Volume *(m3)*	:	~224
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 5m to 10m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. Since the area already witnessed an old slide earlier, the old cracks so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide with fresh crown face covered with vegetation**
40	Summary/Abstract	:	A reactivated slide is observed to have occurred on the north-westerly slope. The old slip zone with low permeability was an important factor to cause the infiltrated water to accumulate and form a zone of high pore water pressure above slip zone. Then the high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide deposit again.The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 10m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation is partly covered with small trees and shrubs. The crown is very distinct with numerous fractures revealing its retrogressive nature.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/36
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8878
8	Longitude	:	74.8181
9	Length *(m)*	:	~ 20

10	Width *(m)*	:	~ 28
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~560
15	Run out distance *(m)*	:	~ 3
16	Type of Material	:	Earth
17	Type of movement	:	Slide , Creeping is also observed on accumulation zone
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist and Metabasalt
26	Structure	:	3 set of Joints. J1-035/45°NW, J2-330/70°SW and J3-335/85°NE
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Well observed litho contacts of Metabasalt (competent) and Hb-actinolite-chlorite schist (highly weathered) facilitating percolation of water that increased hydrostatic pressure and reduced theshear strength. While Removal of toe support after road cutting and antecedent rainfall are the primary causes that tend to reduce the shearing strength. Since the area has already witnessed an old slide earlier, the old cracks so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope withproper grading with plantation of deep rooted trees will increase the slope stability. Drainage system along the road should be supported by concrete work.

38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide with partly vegetation cover at accumulation zone**  **Creep indicated by curved tree trunks grown in zone of accumulation**
40	Summary/Abstract	:	A reactivated slide is observed to have occurred along the bend of the road. The crown part is exposed and soil accumulated at main body of the slide is partly covered with trees and shrubs. Creeping at the zone of accumulation is evident as tree trunks are tilting. The old slip zone with low permeability was an important factor to cause the infiltrated water to accumulate and form a zone of high pore water pressure above slip zone. Then the high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide deposit again.The failure occurred at the contact of competent (Metabasalt) and incompetent oversaturated soil/weathered rock (Schist). Whereas the water lubricates the contact between Metabasalt and soil/weathered schist debris thereby increasing shearing forces. Consequently, the thick saturated earth material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	

42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/37
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8911
8	Longitude	:	74.8198
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~500
15	Run out distance *(m)*	:	not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist and Metabasalt
26	Structure	:	3 set of Joints. J1-035/45°NW, J2-330/70°SW and J3-335/85°NE
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil

32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Well observed lithology contacts of Metabasalt (competent) and Hb-actinolite-chlorite schist (highly weathered) facilitating percolation of water that increased hydrostatic pressure and reduced theshear strength. While Removal of toe support after road cutting and antecedent rainfall are the primary causes that tend to reduce the shearing strength. Since the area already witnessed an old slide earlier, the old cracks so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope withproper grading with plantation of deep rooted trees will increase the slope stability. Drainage system along the road should be supported by concrete work. Soil has blocked the road side drainage that should be removed immediately. A Stream adjacent to the slide area is blocked after road construction. It should be made free by constructing proper dimension culvert.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide with exposed fractured crown**
40	Summary/Abstract	:	A reactivated slide is observed to have occurred along the bend of the road. The crown part is exposed and soil accumulated at main body of the slide is partly covered with shrubs. The old slip zone with lower permeability was an important factor to cause the infiltrated water to accumulate and form a zone of high pore water pressure above slip zone. The high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide deposit again.The failure occurred at the contact of competent (Metabasalt) and incompetent oversaturated soil/weathered rock (Schist). Whereas the water lubricates the contact between Metabasalt and soil/weathered schist debris

			thereby increasing shearing forces. The exposed rock is massive and highly jointed. Consequently, the thick saturated debris material moved down the slope along a weak plane under the influence of gravity. NW-SE running stream running adjacent to the slide has been interrupted after road construction
41	Date of Reporting	:	
42	Landslide Category	:	II

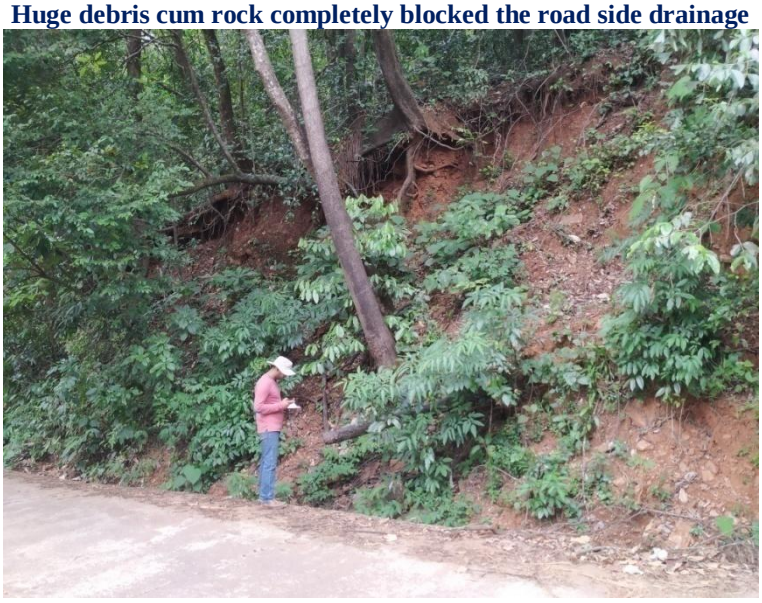
GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/38
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8929
8	Longitude	:	74.8214
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 15
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~54
15	Run out distance *(m)*	:	~ 2
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist
26	Structure	:	Foliation-NW, dipping 50°NE
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road

28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Debris slide exposing rock at the base of the slope**
40	Summary/Abstract	:	The slide is observed to have occurred along the bend of the road. Initially, high angel slope has been cut for road construction making the slope unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass. Slip zone within soil and rock interface created high pore water pressure zone that decreased the shear strength and triggered the landslide. Along with the debris, rock failure also observed along the foliation.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/39
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8953
8	Longitude	:	74.8229
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 35
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~420
15	Run out distance *(m)*	:	~ 3
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Orientation-NW, dipping 50°NE
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength. Since the area already witnessed an old slide earlier, the old cracks and slip plane so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Huge debris cum rock completely blocked the road side drainage**  **Reactivated debris slide adjacent to active slide**
40	Summary/Abstract	:	Multiple slides are observed in South-easterly directed steep slope along the bend of the road. The slides are occurring within a large old slide scar. There are two slides adjacent to each other, which are reactivated after the spell of rain in

			August 2019. Initially, high angleslope has been cut for road construction making the slope unstable. The old slip zone with low permeability was an important factor to cause the infiltrated water to accumulate and form a zone of high pore water pressure above slip zone. The high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of both slides. The debris along with rock boulders also observed at the toe of slide reflecting the break-up of jointed & fractured rock due to built up of pore water pressure. Relatively fresh rock isexposed at the base and soft/weathered rock isexposed near crown part.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/40
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8957
8	Longitude	:	74.8234
9	Length *(m)*	:	~ 22
10	Width *(m)*	:	~ 40
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~880
15	Run out distance *(m)*	:	~ 3
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope

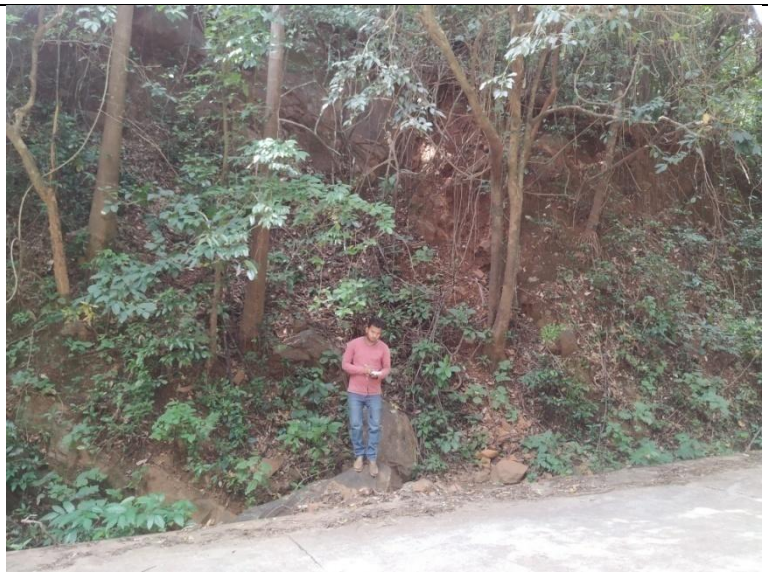
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist
26	Structure	:	Foliation-NW, dipping 50°NE
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength. Since the area has already witnessed an old slide earlier, the old cracks and slip plane so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Huge debris cum rock completely blocked the road side drainage**

			 **Reactivated debris slide adjacent to old slides**
40	Summary/Abstract	:	Multiple slides are observed in South-easterly directed steep slope along the bend of the road. There are three slides adjacent to one another, which are reactivated after the spell of rain in August 2019. Initially, high angle slope has been cut for road construction making the slope unstable. Regolith thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. The old slip zone with lower permeability was an important factor to cause the infiltrated water to accumulate and form a zone of high pore water pressure above slip zone. The high pore water pressure zone then decreased the shear strength of slip zone and triggered the reactivation of slides. The debris along with rock boulders also observed at the toe of slide reflecting the break-up of jointed & fractured rock due to built up of porewater pressure. Relatively jointed/fractured fresh rock isexposed at the base and soft/weathered rock isexposed near crown part.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/41
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8966

8	Longitude	:	74.8236
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 30
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.3
14	Volume *(m3)*	:	~180
15	Run out distance *(m)*	:	Not known
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Slow
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	3 set of Joints. J1-035/45°NW, J2-330/70°SW and J3-335/85°NE
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggeredthe mass to fail. Highly weathered rock/soil facilitating percolation of water that increased hydrostatic pressure and reduced the shear strength.
37	Recommendations	:	Easing of slope withproper grading will increase the slope stability. Drainage system along the road should be supported by concrete work. Blocked drainage should be cleared immediately.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old slide with vegetation cover at accumulation zone**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred along the south-easterly steep slope. The slide occurrence is due to slope cut for road construction making it unstable. However, highly weathered rock is observed on the slope corresponding to soil thickness that varies from 1 to 2m. Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. The rocks are exposed at the crown part, while the body of the slide is covered with bushes and vegetation.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/42
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill.Holegaru; Nittur-Nagodi road
7	Latitude	:	13.8953
8	Longitude	:	74.8649
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 35
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1

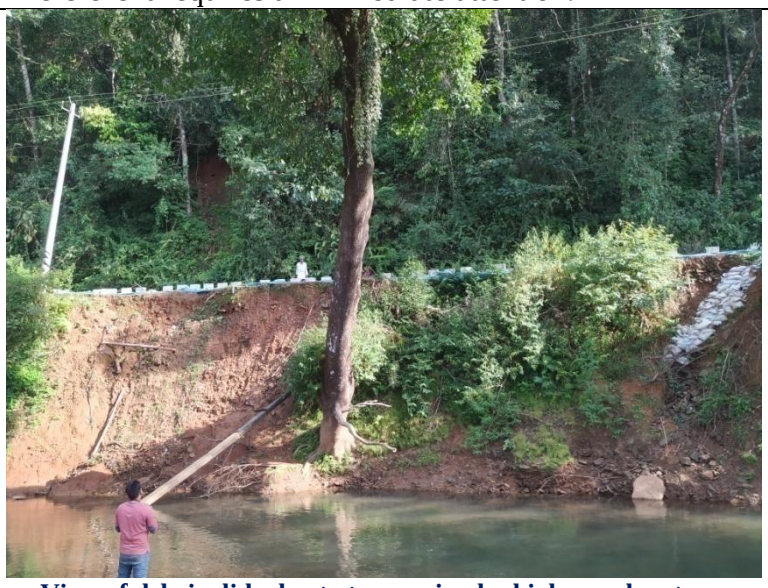
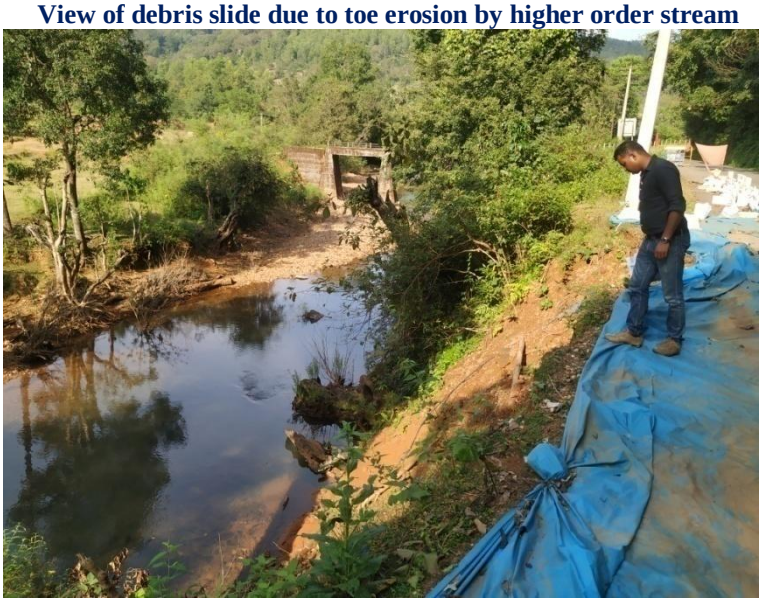
14	Volume *(m3)*	:	~700
15	Run out distance *(m)*	:	~ 5
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Sparse vegetation, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength. Since the area has already witnessed an old slide earlier, the old cracks and slip plane so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Deep rooted plants should be grown on upslope to strengthen the soil. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated debris slide within a large old slide scar**
40	Summary/Abstract	:	Debris slide initiated as a planar failure and is occurring within a large old slide scar. Initially, slope has been cut for road construction making the slope unstable. The thick soil cover over the hard rock got saturated by percolation of water during heavy rains which increased pore water pressure and reduced the cohesive strength. The old slip zone with lowr permeability was an important factor to cause the infiltrated water to accumulate and form a high pore water pressure zone above slip zone. The high pore water pressure zone then decreased the shear strength of slip zone and triggered the reactivation of both slides. The debris along with uprooted shrubs &trees are lying at the base of the slope. Sparse vegetation and bushes seen on upslope are unable to hold the thick soil (5 to 7m) firmly making the slope more vulnerable.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/43
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Holegaru ; Nittur-Nagodi road
7	Latitude	:	13.9122
8	Longitude	:	74.8624
9	Length *(m)*	:	~ 8

10	Width *(m)*	:	~ 30
11	Height *(m)*	:	~ 5
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~240
15	Run out distance *(m)*	:	Debris terminated at the stream and follows its course.
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Top of the hill is Barren while mid slope is thickly vegetated. Slope has been cut and modified for road construction
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Road leading to Kollur is damaged
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support by higher order stream, high slope gradient are the primary causes that tend to reduce the shearing strength. Road was constructed on soil and weathered schist material excavated from the road cut having poor geotechnical properties. High angle slope cut left unsupported below the road bench, improper and inadequate drainage arrangements, lack of channelized runoff water network on slope, improper toe support measures.
37	Recommendations	:	The toe support should be given at the toe of slide (where slide material stopped) by appropriate concrete measures (Retaining wall with weep holes) before going for back

			filling of slope. Strengthened concrete measures right from firm hard rock surface to provide lateral support to the road. Material suitable for embankment fill should preferably consist of granular permeable material that doesn't weather in the environment. Drainage system along the road should be supported by concrete work. Surface water should bediverted from unstable slopes by ditches and pipes.
38	Remarks, if any		Road leading to Kollur is in grave danger, as the slide is retrograding and can further lead to road subsidence. Therefore it requires an immediate attention.
39	Photos. Sketch of Plan & section of the slide	:	 **View of debris slide due to toe erosion by higher order stream**  **View of debris slide from crown; Road is partly damaged and covered with tarpaulin and sand bags as a temporary measure**
40	Summary/Abstract	:	Debris slide initiated on the downside of the road in highly weathered schistose rock. Toe erosion by heavily charged Nagodi Hole (High order Stream) during heavy rain event of August 2019 leading to flash flood, undercut or scours the slope making it steeper. The slope forming material (SFM) and the filled material for road construction got saturated by percolation of water during rains increased its mass. Cumulative effect reduce the shear strength and leadto mass failure down the road. The failure hasoccurred on the convex part of the NE-SW flowing stream. Poor drainage network

			on upside of the road also contributed to seepage of water down the road. The run off debris has been flown with the highly charged running stream. Cracks on the crown part and on the road are giving proof of the retrogressive nature of slide. Therefore an urgent attention requires safeguarding the road leading to Kollur.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/44
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill.Holegaru; Nittur-Nagodi road
7	Latitude	:	13.9119
8	Longitude	:	74.8618
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 14
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~168
15	Run out distance *(m)*	:	~ 7
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Top of the hill is Barren while mid slope is thickly vegetated. Slope has been cut and modified for road

			construction.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide with regolith thickness of 3 to 5m**
40	Summary/Abstract	:	Debris slide initiated as a planar failure on a high angle slope. Initially, slope has been cut for road construction making the slope unstable. Highly weathered soil got saturated by percolation of water during rains which increased pore water pressure and reduced the cohesive strength. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Huge debris material is seen accumulated on either side of the road. Downslope side (below the road bench) Nagodi Hole (higher order stream) is running north-easterly.
41	Date of Reporting	:	

42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/45
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill.Holegaru; Nittur-Nagodi road
7	Latitude	:	13.9111
8	Longitude	:	74.8569
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~300
15	Run out distance *(m)*	:	~ 3
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Thick forest on upslope. Slope has been cut and modified for road construction.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil

32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slides occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide occurred due to road cut**
40	Summary/Abstract	:	Multiple slides (03 No's) are observed in northerly directed high angle slope. There are three slides adjacent to one another, which are reactivated after the spell of rain in August 2019. Regolith thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass. Highly weathered soil got saturated by percolation of water during heavy rains which increased pore water pressure and reduced the cohesive strength. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Huge debris material are seen accumulated on either side of the road. The failure is occurring on the convex bend of Nagodi Hole (higher order stream) running on the downslope side, below the road bench.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/46
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur -Nagodi road
7	Latitude	:	13.9111
8	Longitude	:	74.8560
9	Length *(m)*	:	~ 22
10	Width *(m)*	:	~ 30
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~330
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 5m to 10m correspond to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the north-eastery slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 10m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Huge debris material accumulated on either side of the road. Down the slope, below the road bench a higher order stream is running with its convex bend towards the mass failure at road cut.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/47
2	State	:	Karnataka

3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Nagodi road
7	Latitude	:	13.9112
8	Longitude	:	74.8554
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 15
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~84
15	Run out distance *(m)*	:	~ 3
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Thick forest on upslope. Slope has been cut and modified for road construction.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slides

			occurred during heavy rainfall that caused infiltration of
	GEOPARAMETRIC DATA SHEET (42 POINTS)		sure and reducing the conesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide occurred due to road cut**
40	Summary/Abstract	:	Debris slide is observed in northerly directed high angle slope. Regolith thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass. Highly weathered soil got saturated by percolation of water during rain event of August 2019, which increased pore water pressure and reduced the cohesive strength. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Huge debris material is seen accumulated on either side of the road. Down the slope, below the road bench a higher order stream is running westerly.
41	Date of Reporting	:	
42	Landslide Category	:	III

No	**Field**		**Description**
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/48
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Nagodi road

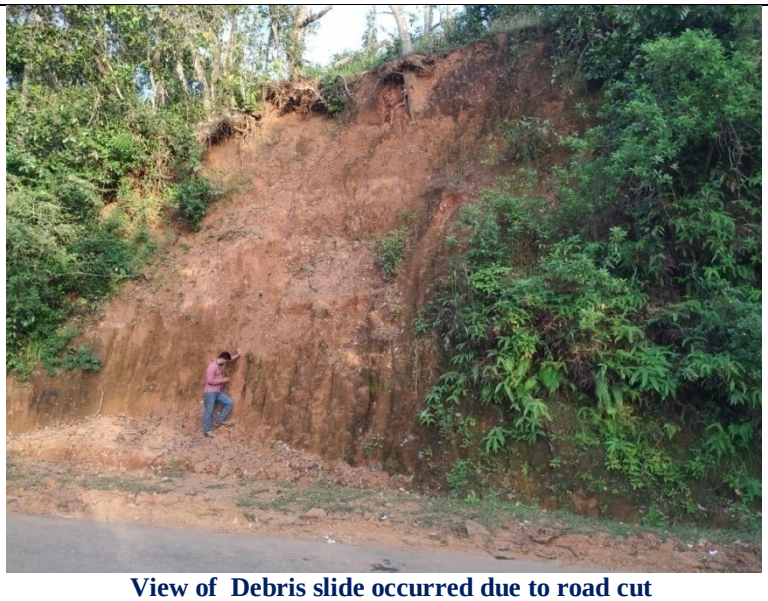
7	Latitude	:	13.9115
8	Longitude	:	74.8552
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 17
11	Height *(m)*	:	~ 15
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~340
15	Run out distance *(m)*	:	~ 7
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Thick vegetation on upslope, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. Laterite/Saprolite cover thickness is more than 10m adding the overburden weight on saturation. Infiltration of water made their way inside the slope resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	The toe support should be given at the base contour line of slope (foot of slope) by appropriate concrete measures and minimize the slope gradient by benching and back filling

			process. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of an Earth slide near the road bend**
40	Summary/Abstract	:	An earth slide initiated as a rotational failure in moderate slope. The landslide is an active earth slide having rotational movement along rupture plane with approx. 7m run-out distance. Earth slide occurrence is due to anthropogenic activities i.e. slope cut for road construction left unsupported. Highly saturated lateritic soil with thickness correspondingto 7 to 10 m added an extra overburden weight and percolation of water resulting in building up of pore water pressure and reducing the cohesive strength. Crown of the slide is saturated &retrograssivein nature. The soil along with uprooted shrubs & trees are seen at the base of the slope. 60 m West of this location (13.9116, 74.8547) towards Kollur, 02 no's of old slide scars observed, which are adjacent to each other and are suspended. Down the slope, below the road bench a higher order stream is running westerly.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/49
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	

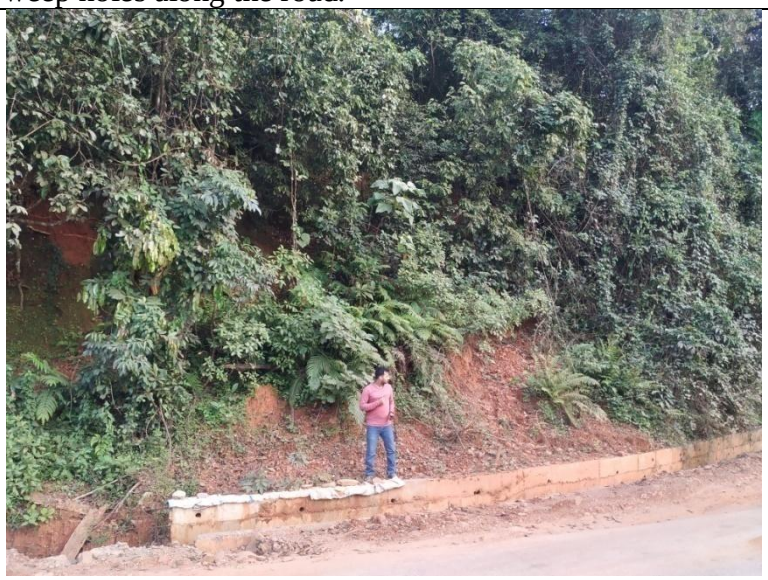
6	NH/SH/Locality	:	Nittur-Nagodi road
7	Latitude	:	13.9092
8	Longitude	:	74.8495
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 16
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~192
15	Run out distance *(m)*	:	~ 3
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Sparse vegetation and shrubs on upslope. Slope has been cut and modified for road construction.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slides occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be

			provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide occurred due to road cut**
40	Summary/Abstract	:	Debris slide is observed in north-westerly directed high angle slope. Regolith thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass. Highly weathered soil got saturated by percolation of water during rain event of August 2019, which increased pore water pressure and reduced the cohesive strength. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Huge debris material is seen accumulated on either side of the road. Down the slope, below the road bench a higher order stream is running north-easterly. Sparse vegetation and bushes on upslope are unable to hold the thick soil (5 to 7m) firmly making the slope more vulnerable.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/50
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Nagodi; Nagodi- Kollur road
7	Latitude	:	13.9077

8	Longitude	:	74.8465
9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 16
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~180
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Moderate vegetation, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Concrete lining for drainage should be extended more in length.

38	Remarks, if any		Good practice of constructing concrete lined drainage with weep holes along the road.
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation;** ***Drainage supported by concrete lining***
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the north-westerly slope. The inclination of planar failure slope is observed to be around 40°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 7m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Road widening work is carried out and below the road bench a higher order stream is running with its convex bend towards the mass failure.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/51
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8951

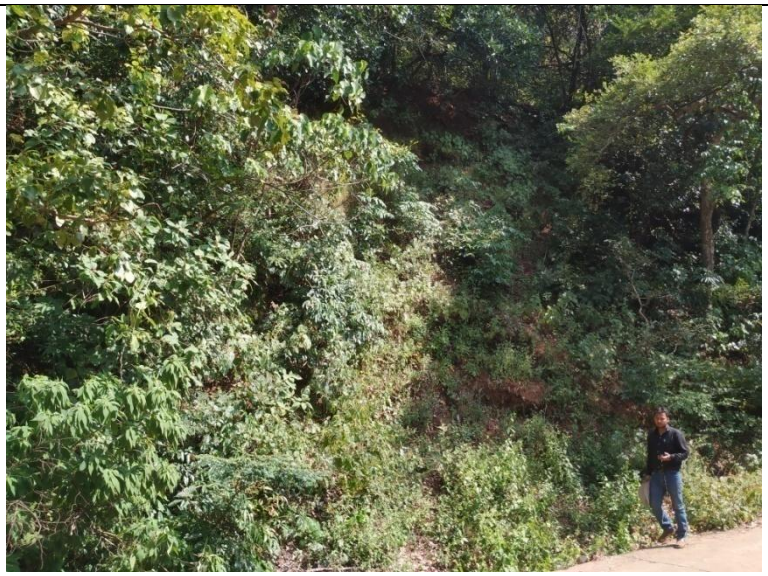
8	Longitude	:	74.8385
9	Length *(m)*	:	~ 15
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~190
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the steep slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 7m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is covered with vegetation & is saturated.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/52
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8975
8	Longitude	:	74.8243
9	Length *(m)*	:	~ 22
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	

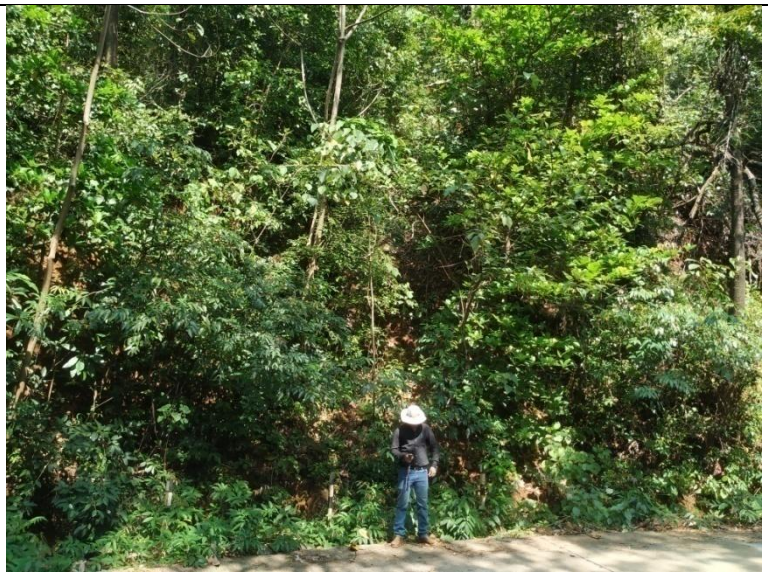
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~220
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Moderate vegetation & shrubs on upslope, Extensive cut slope for construction of road.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the steep slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 3m to 5m got saturated by percolation of water during rains which increased its mass. Shallow rooted plants and bushes observed on upslope are unable to withhold the soil and easy to erode during rain. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is covered with vegetation & is saturated.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/53
2	State	:	Karnataka
3	District		Udupi
4	Toposhe		
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8970
8	Longitude	:	74.8260
9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 40
11	Height *(m)*	:	~ 16

12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~360
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	Multiple (03no's) old suspended slides are observed to have occurred on the steep slope. The inclination of planar failure slope is observed to be around 60°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 7m got saturated by percolation of water during heavy rains which increased its mass. Shallow rooted plants and bushes observed on upslope are unable to withhold the soil and easy to erode during rain. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is covered with vegetation & is saturated.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	**Field**		**Description**
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/54
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8979
8	Longitude	:	74.8274
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 12

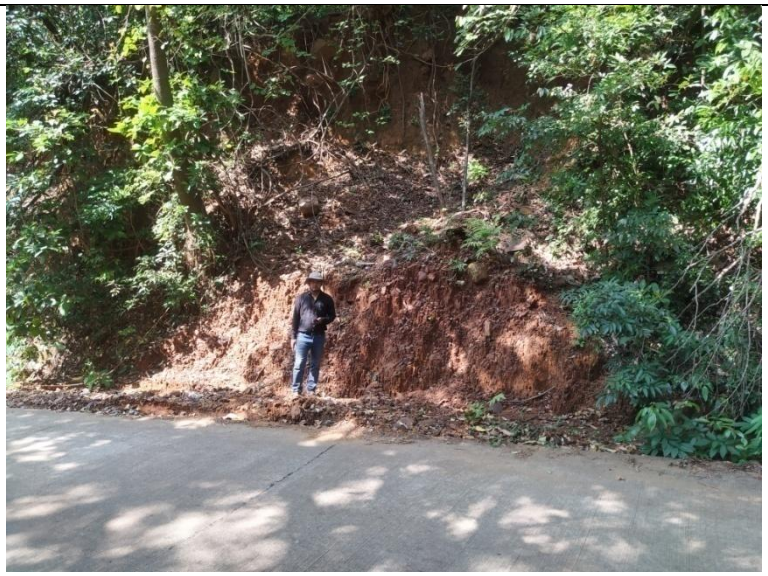
11	Height *(m)*	:	~ 8
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~72
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Orientation NNW-SSE, dipping 25° NNE
27	Land use/ Land cover	:	Moderate vegetation & shrubs on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 5m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the steep slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 3m to 5m got saturated by percolation of water during rains which increased its mass. Shallow rooted plants and bushes observed on upslope are unable to withhold the soil and easy to erode during rain. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is covered with vegetation & is saturated. Rocks are seen exposed at the toe part after removal of soil layer.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/55
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8981
8	Longitude	:	74.8279
9	Length *(m)*	:	~ 10

10	Width *(m)*	:	~ 22
11	Height *(m)*	:	~ 8
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~110
15	Run out distance *(m)*	:	~ 2
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt and Hornblende-actinolite-chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Litho contacts between Metabasalt (competent) and Hb-actinolite-chlorite schist (highly weathered) facilitating percolation of water that increased hydrostatic pressure and reduced theshear strength. While Removal of toe support after road cutting and antecedent rainfall are the primary causes that tend to reduce the shearing strength.
37	Recommendations	:	Easing of slope withproper grading with plantation of deep rooted trees will increase the slope stability. Drainage system along the road should be supported by concrete work. Blocked drainage along the road should be clear before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of the slide with regolith thickness of 1 to 2 m**
40	Summary/Abstract	:	Multiple debris slides are observed due to road-cut occurred along the bend of the road. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasedthe shear strength. The failure occurred at the contact of competent (Metabasalt) and incompetent oversaturated soil/weathered rock (Schist). Whereas the water lubricates the contact between Metabasalt and soil/weathered schist debris thereby increasing shearing forces. Consequently the thick saturated earth material moved down the slope along a weak plane under the influence of gravity. The crown part is seen exposed with little or no soil cover. Debris mixed with rock is seen accumulated at the main body of slide. A Second order stream is running NE-SW, adjacent to the mass failure. Parapet wall is constructed on either side of the road. Shallow rooted plants and bushes observed on upslope are unable to withhold the soil and easy to erode during rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/56
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8938
8	Longitude	:	74.8286

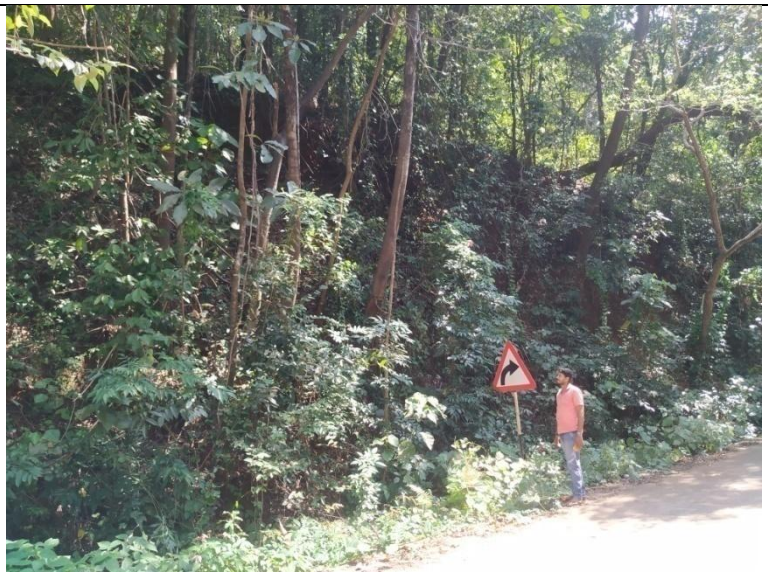
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 15
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~210
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with dense vegetation**
40	Summary/Abstract	:	An old suspended slide is observed in south-westerly steep slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasedthe shear strength. Consequently the saturated material moved down the slope along a weak plane under the influence of gravity. Debris mixed with rock is seen accumulated at the main body of slide and is covered with shrubs and trees.Shallow rooted plants and bushes observed on upslope are unable to withhold the soil and easy to erode during rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/57
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8932
8	Longitude	:	74.8289
9	Length *(m)*	:	~ 17
10	Width *(m)*	:	~ 24
11	Height *(m)*	:	~ 15

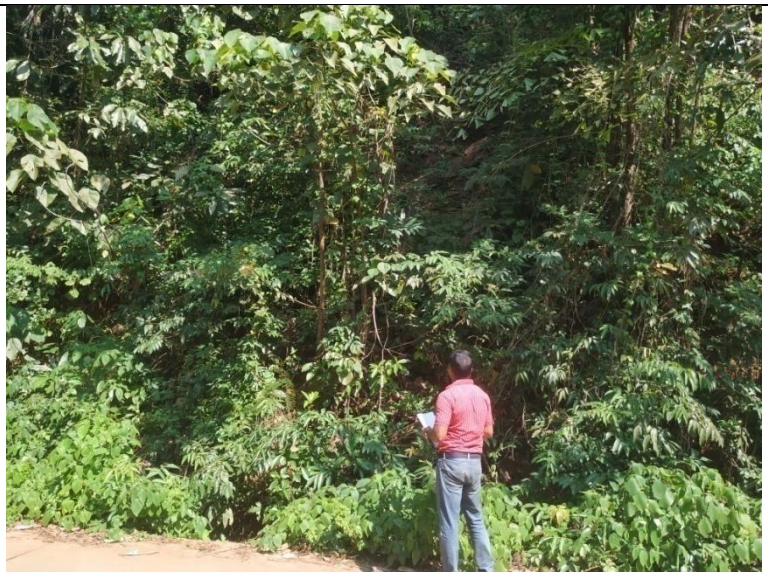
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~408
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Thick forest, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the steep slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 7m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is covered with vegetation & is saturated.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/58
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8929
8	Longitude	:	74.8291
9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 16
12	Area *(m2)*	:	

13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~450
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Moderate vegetation, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the steep slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 7m got saturated by percolation of water during rains which increased its mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is seen covered with vegetation & is saturated. Shallow rooted plants and bushes observed on upslope are unable to withhold the soil and easy to erode during rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	**Field**		**Description**
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/59
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8914
8	Longitude	:	74.8299
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 16

12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~240
15	Run out distance *(m)*	:	~5, Soil terminated on the other side of road.
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive and widening
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Moderate vegetation, cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength. Since the area already witnessed an old slide earlier, the old crown cracks and slip plane so formed may have played a key role for widening of the slide.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Deep rooted plants should be grown on upslope to strengthen the soil. Soil accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide adjacent to a large old slide scar**
40	Summary/Abstract	:	The slide initiated as a planar failure at the head and in the central toe zone the landslide slides up and out and out on the foliation. The failure reactivated the earlier old slip plane and crown crack of an adjacent old slide. The older slide widened its crown and initiated the failure. Initially, slope has been cut for road construction making the slope unstable. The thick soil cover over the hard rock got saturated by percolation of water during rains which increased pore water pressure and reduced the cohesive strength. The soil along with uprooted shrubs & trees is een lyingat the base of the slope. Moderated vegetation (shallow rooted trees) and shrubs on upslope are unable to hold the thick soil (5 to 7m) firmly making the slope more vulnerable. East of the road Metabasalt rock is observed having sharp contact with schistose rock.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/60
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8915
8	Longitude	:	74.8312
9	Length *(m)*	:	~ 22

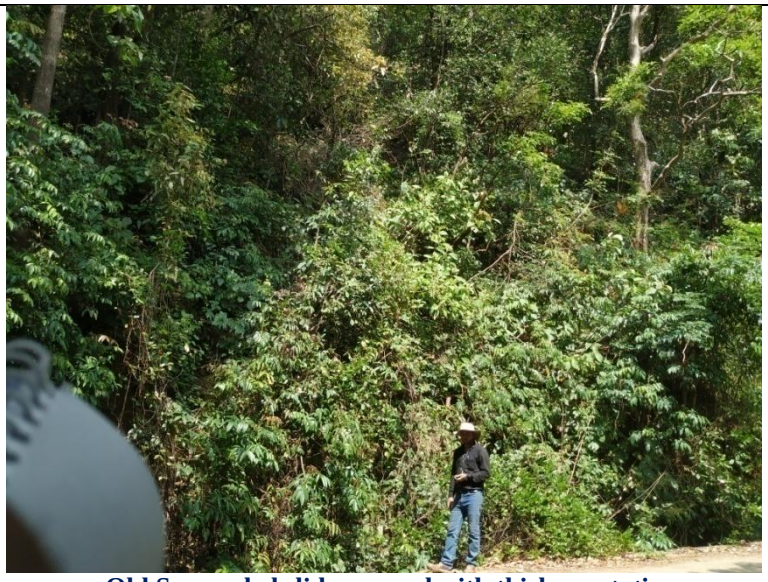
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~550
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with dense vegetation**
40	Summary/Abstract	:	Multiple suspended slides (03no's) are observed in southerly steep slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreases the shear strength. The top soil was removed exposing beneath fractured and jointed rock. Consequently the saturated debris with rock fragments moved down the slope along a weak plane under the influence of gravity. Debris mixed with rock are seen accumulated at the main body of slide and is covered with shrubs and trees. Shallow rooted plants and bushes observed on upslope are unable to withhold the soil and easy to erode during rain. The layered rock exposed after removal of soil along the toe of the slide reveals that soft soil and rock interface acted as another way of facilitating water into it thus increased thehydrostatic pressure. The break-up of jointed & fractured rock due to built up of porewater pressure makes a small proportion of rock fragment along with debris.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/61
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road

7	Latitude	:	13.8922
8	Longitude	:	74.8322
9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 15
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~216
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should

			be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with thick vegetation**
40	Summary/Abstract	:	An old suspended slide is observed in southerly steep slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasedthe shear strength. The top soil was removed exposing beneath fractured and jointed rock. Consequently the saturated debris with rock fragments moved down the slope along a weak plane under the influence of gravity. However along the flank of the slide, jointed/fractured rock is exposed. The soil /weathered rock has failed & seen accumulated in the zone of accumulation, which is covered with shrubs and trees. The layered rock exposed after removal of soil is seen along the toe of the slide reveals that soft soil and rock interface act as another way of facilitating water into it, thus increasing shearing forces. The break-up of jointed & fractured rock due to built up of porewater pressure makes a small proportion of rock fragment along with debris.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/62
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road

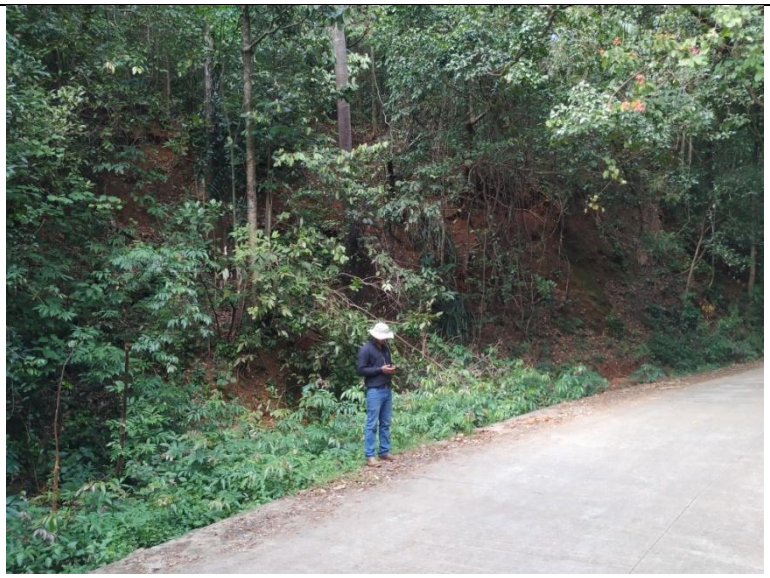
7	Latitude	:	13.8919
8	Longitude	:	74.8328
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~120
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Orientation NNW-SSE, dipping 30°NE
27	Land use/ Land cover	:	Thick vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should

			be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with thick vegetation**
40	Summary/Abstract	:	An old suspended slide is observed in southerly steep slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasedthe shear strength. The top soil was removed exposing beneath fractured and jointed rock. Consequently the saturated debris with rock fragments moved down the slope along a weak plane under the influence of gravity. The soil /weathered rock has failed & seen accumulated in the zone of accumulation, which is covered with shrubs and trees.However along the bend of the road, jointed/fractured rock is exposed.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/63
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8924
8	Longitude	:	74.8329
9	Length *(m)*	:	~ 15

10	Width *(m)*	:	~ 24
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~180
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with shrubs and trees**
40	Summary/Abstract	:	An old suspended slide is observed in south-westerly steep slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasedthe shear strength. The top soil is removed exposing beneath fractured and jointed rock. Consequently the saturated debris with rock fragments moved down the slope along a weak plane under the influence of gravity. However along the flank of the slide, jointed/fractured rock is exposed. The soil /weathered rock has failed &seen accumulated in the zone of accumulation, which is covered with shrubs and trees. The layered rock exposed after removal of soil along the toe of the slide reveals that soft soil and rock interface act as another way of facilitating water into it, thus increasingshearing forces. Shallow rooted trees and shrubs on upslope unable to hold the soil and increasing the soil erosion during heavy rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/64
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kollur-Nagodi road
7	Latitude	:	13.8912
8	Longitude	:	74.8343

9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 50
11	Height *(m)*	:	~ 14
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~450
15	Run out distance *(m)*	:	~ 2
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt and Quartz-sericite-schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Litho contacts between Metabasalt (competent) and quartz-sericite-schist (highly weathered) facilitating percolation of water that increased hydrostatic pressure and reducingshear strength. While Removal of toe support after road cutting and antecedent rainfall are the primary causes that tend to reduce the shearing strength.
37	Recommendations	:	Easing of slope withproper grading with plantation of deep rooted trees will increase the slope stability. Drainage system along the road should be supported by concrete work. Blocked drainage along the road should be clear before next rain.

38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slideswithin a large old slide scar**
40	Summary/Abstract	:	Multiple debris slides are observed due to road-cut occurred on moderate slope.The failure reactivated the earlier old slip plane and crown crack of an adjacent old slide. Initially, slope has been cut for road construction making the slope unstable. The failure occurred at the contact of competent (Metabasalt) and incompetent oversaturated soil/weathered rock (Schist). Whereas the water lubricates the contact between Metabasalt and soil/weathered schist debris thereby increasing shearing forces. Consequently the thick saturated debris material moved down the slope along a weak plane under the influence of gravity. The soil along with uprooted shrubs & trees are seenat the base of the slope. Moderate vegetation (shallow rooted trees) and shrubs on upslope are unable to hold the thick soil (5 to 7m) firmly making the slope more vulnerable.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/65
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8916
8	Longitude	:	74.8348
9	Length *(m)*	:	~ 15

10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~150
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation and shrubs on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 1m to 2m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.Deep rooted plants should be grown on upslope to strengthen the soil.

38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with shrubs**
40	Summary/Abstract	:	An old suspended slide is observed in south-westerlymoderate slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasedthe shear strength.Consequently the saturated debris moved down the slope along a weak plane under the influence of gravity. The soil /weathered rock has failed &seen accumulated at the zone of accumulation, which is covered with shrubs and trees. Crown is highly saturated and fractured tending to retrograde. Shallow rooted trees and shrubs on upslope are unable to hold the soil and increasing the soil erosion during heavy rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/66
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8949
8	Longitude	:	74.8332
9	Length *(m)*	:	~ 13
10	Width *(m)*	:	~ 12

11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~78
15	Run out distance *(m)*	:	~ 3
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-sericite-schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Thick vegetation, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.Schist is characterized by flaky minerals which weather quickly and promote instability.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Earth slide along the Nagodi-Kollur road**
40	Summary/Abstract	:	Earth slide initiated as a planar failure and is occurring at the bend of the road. Initially, slope has been cut for road construction making the slope unstable. The thick soil cover over the hard rock got saturated by percolation of water during rains that added the overburden weight and increased pore water pressure therebyreducingthe cohesive strength.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/67
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi-Kollur road
7	Latitude	:	13.898
8	Longitude	:	74.8309
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~700
15	Run out distance *(m)*	:	~ 120

16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt, Intrusion of Dolerite dyke in Metabasalt
26	Structure	:	3 set of Joints. J1-035/45°NW, J2-330/70°SW and J3-335/85°NE
27	Land use/ Land cover	:	Sparse vegetation, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The contact between dolerite dyke and Metabasalt providing passage for water and increased the hydrostatic pressure. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength. Since the area also witnessed an old slide earlier, the old cracks and slip plane so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Deep rooted plants should be grown on upslope to strengthen the soil. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated debris slide adjacent to large old slide scar**  **Dolerite dyke intruded in Metabasalt inducing mass failure**
40	Summary/Abstract	:	Debris slide initiated as a planar failure and is occurring within a large old slide scar in south-easterly slope. Initially, steep slope has been cut for road construction making the slope unstable.Metabasalt have been intruded by NW-SE trending dolerite dyke that weather it and created steep topography and high relief. The contact zone between closely spaced jointed dolerite and country rock act as zone of groundwater infiltration. Groundwater saturation may increase pore pressures within the weathering profile associated with these zones and thus reducingthe strength. Increased moisture/water can easily percolate and reduce friction along zone of weakness causing material above that particular plane to slide along the lubricated surface. The failure slope is partly covered with shrubs.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/68
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8945
8	Longitude	:	74.8308
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 11
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~280
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Fractured rock exposed at the crown of the slide**
40	Summary/Abstract	:	An old suspended slideis observed in southerly steep slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasingthe shear strength. Consequently the saturated debris with rock fragments moved down the slope along a weak plane under the influence of gravity. The layered Metabasalt exposed after removal of soil at the crown of the slide reveals thatthe soil actedas a conditioning factor for landslides and the hard rock acts as the slip plane.The crown is jointed/ fractured and therefore slide is tending to retrograde. The break-up of jointed & fractured rock due to built up of porewater pressure makes a small proportion of rock fragment along with debris. Debris mix with rock is seen accumulated at the main body of slide and is covered with shrubs and trees.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/69
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8967
8	Longitude	:	74.8320
9	Length *(m)*	:	~ 8
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 6
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~48
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-sericite-schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Thick vegetation, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary causes that tend to reduce the shearing strength. Highly weathered & soft soil is observed on the slope corresponding to soil thickness of 3m to 5m. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.Schist is characterized by flaky minerals which weather quickly and promote instability.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		The slide occurred near the litho contact of Quartz-sericite-schist and Metabasalt.
39	Photos. Sketch of Plan & section of the slide	:	 **Earth slide along the Nagodi-Kollur road**
40	Summary/Abstract	:	Earth slide initiated as a planar failure and is occurring on north-westerly slope. Initially, steep slope has been cut for road construction making the slope unstable. The thick soil cover over the hard rock got saturated by percolation of water during rains that added the weight and increased pore water pressure thereby reduced the cohesive strength. The nearby litho-contact of Quartz-sericite-schist and Metabasalt may have also played an important role in infiltration of water and increased ground water saturation. This may increase pore pressures within the weathered profile associated with this zone and thus reducedshear strength. Parapet wall is constructed on other side of the road.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/70
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8976
8	Longitude	:	74.8327
9	Length *(m)*	:	~ 16
10	Width *(m)*	:	~ 50
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~800
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes. Reduction of shear strength of soil on super-saturation due to heavy raintriggeredthe mass to fail. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Soil washed away after the slide and exposing rock at the crown**
40	Summary/Abstract	:	Multiple debris slides are observed due to road-cut occurred on steep slope. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreasedthe shear strength. Consequently, the saturated debris moved down the slope along a weak plane under the influence of gravity. The layered Metabasalt exposed after removal of soil at the crown of the slide reveals thatthe soil actedas a conditioning factor for landslides and the hard rock acted as the slip plane.The crownportion isfractured and therefore slides are tending to retrograde. Debris accumulated at the main body of slidesare covered with shrubs and trees.
41	Date of Reporting	:	
42	Landslide Category	:	III

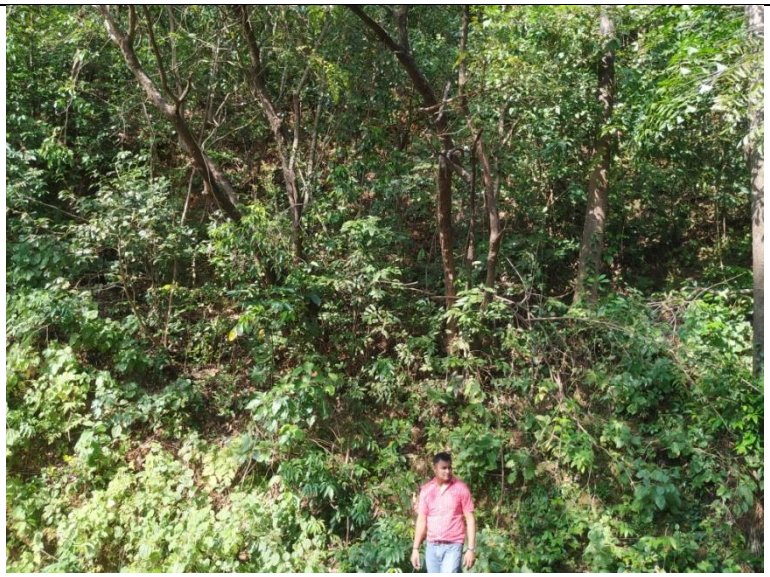
GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/71
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8951
8	Longitude	:	74.8358
9	Length *(m)*	:	~ 22
10	Width *(m)*	:	~ 28
11	Height *(m)*	:	~ 19
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~616
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-sericite-schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Thick vegetation, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting on steep slopeis the primary cause that tend to reduce the shearing strength. Highly weathered & soft soil is observed on the slope corresponding to soil thickness of 3m to 5m. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.Schist is characterized by flaky minerals which weather quickly and promote instability.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		The slide occurred near the litho contact of Quartz-sericite-schist and Metabasalt.
39	Photos. Sketch of Plan & section of the slide	:	 **View of old debris slide covered with shrubs**
40	Summary/Abstract	:	An old suspended slide initiated as a planar failure and is occurring on south-westerly slope. Initially, steep slope has been cut for road construction making the slope unstable. The thick soil cover over the hard rock got saturated by percolation of water during rains that added the weight and increased pore water pressure thereby reduced the cohesive strength. The nearby litho-contact of Quartz-sericite-schist and Metabasalt may have also played an important role in infiltration of water and increased ground water saturation. This increased pore pressure within the weathered profile associated with this zone and thus reducedshear strength.
41	Date of Reporting	:	
42	Landslide Category	:	III

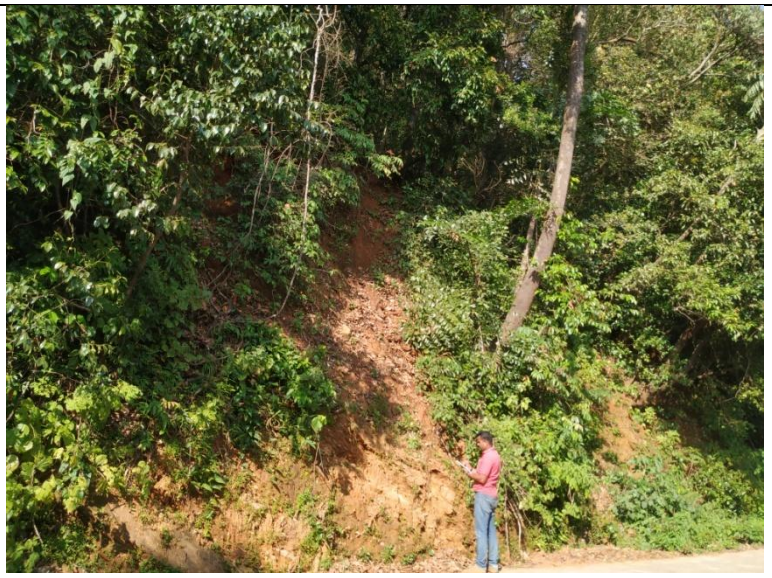
GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/72
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8948
8	Longitude	:	74.8363
9	Length *(m)*	:	~ 22
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 18
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~440
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation and shrubs on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 1m to 2m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.Deep rooted plants should be grown on upslope to strengthen the soil.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with shrubs and tilted trees**
40	Summary/Abstract	:	An old suspended slide is observed in southerly facing slope. Initially, steep slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreased the shear strength.Consequently the saturated debris moved down the slope along a weak plane under the influence of gravity. The soil /weathered rock has failed & accumulated at the zone of accumulation, which is covered with shrubs and trees. The trees grown on the zone of accumulation are showing creeping naturereflecting imperceptible movement of saturated soil downslope.Crown is prominent, well distinct from the road and is highly saturated. Fractures are observed at the crown part showing retrogressive nature of slide. Shallow rooted trees and shrubs on upslope unable to hold the soil and increased the soil erosion during heavy rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/73
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8947
8	Longitude	:	74.8368
9	Length *(m)*	:	~ 16
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~320
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes. Reduction of shear strength of soil on super-saturation due to heavy raintriggeredthe mass to fail. Regolith /Soil thickness varies from 1m to 2m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be cleaned.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide partly covered with shrubs and trees**
40	Summary/Abstract	:	Multiple debris slides are reactivated and observed due to road-cut occurred on steep slope. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreased the shear strength. Since the area has already witnessed an old slide earlier, the old cracks, so formed may have played a key role for rainfall infiltration. The old slip zone with lower permeability was another important factor to cause the infiltrated water to accumulate and form a high pore water pressure zone above slip zone.This high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide to fail again. Metabasalt exposed after removal of soil at the toe and central part of the slide reveals thatthe soil acts as a conditioning factor for landslides and the hard rock acts as the slip plane.The crown part is saturated and fractured tending to retrograde. Debris accumulated at the main body of slide is covered with shrubs and trees.
41	Date of Reporting	:	
42	Landslide Category	:	III

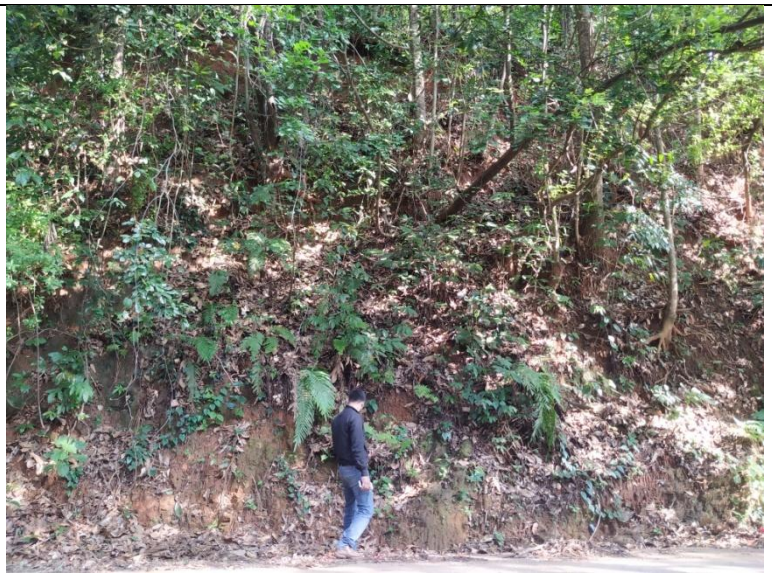
GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/74
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8945
8	Longitude	:	74.8376
9	Length *(m)*	:	~ 10
10	Width *(m)*	:	~ 18
11	Height *(m)*	:	~ 7
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~180
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation and shrubs on upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil

32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primarycause that tends to reduce the shearing strength while heavy antecedent rainfall resulting in building up of pore water pressure and reducing the cohesive strength. There is no lateral support along the road. Regolith /Soil thickness varies from 1m to 2m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be cleaned.Deep rooted plants should be grown on upslope to strengthen the soil.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with shrubs and trees**
40	Summary/Abstract	:	An old suspended slide is observed in south-easterly facing slope. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreased the shear strength.Consequently the saturated debris moved down the slope along a weak plane under the influence of gravity. The soil /weathered rock has failed & accumulated at the zone of accumulation, which is covered with shrubs and trees. Crown is prominent, well distinct from the road and is highly saturated. Fractures observed at the crown part showing retrogressive nature of slide. Shallow rooted trees and shrubs on upslope was unable to hold the soil and increasing the soil erosion during heavy rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/75
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8936
8	Longitude	:	74.8382
9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 40
11	Height *(m)*	:	~ 16
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~360
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Metabasalt
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Thick vegetationon upslope, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primarycause that tends to reduce the shearing strength while heavy antecedent rainfall resulting in building up of pore water pressure and reducing the cohesive strength. There is no lateral support along the road. Regolith /Soil thickness varies from 2m to 3m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be clean.
38	Remarks, if any		Massive rock body is exposed at the road bend, adjacent to the slide.
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with shrubs and trees**
40	Summary/Abstract	:	An old suspended slide is observed in south-easterly facing slope. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreased the shear strength.Consequently, the saturated debris moved down the slope along a weak plane under the influence of gravity. The soil /weathered rock has failed & accumulated at the zone of accumulation, which is covered with shrubs and trees. Crown is prominent, well distinct from the road and is highly saturated. Fractures observed at the crown showing retrogressive nature of slide.
41	Date of Reporting	:	
42	Landslide Category	:	III

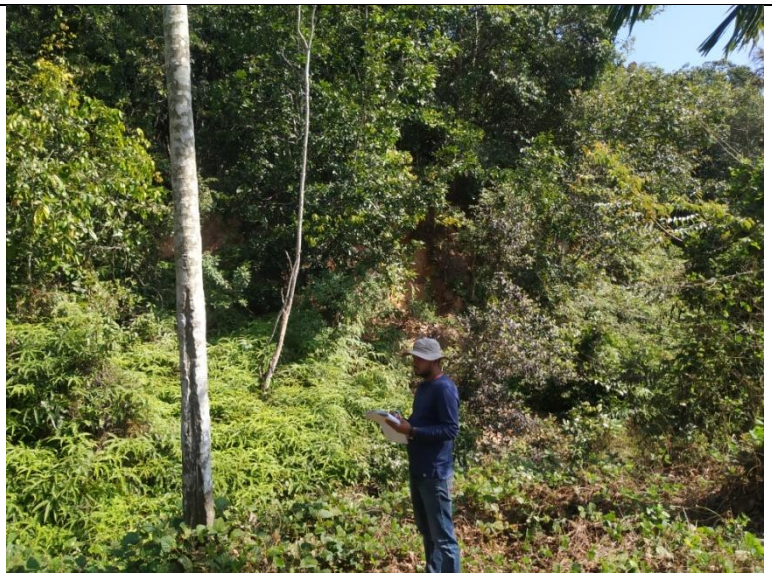
GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/UDUPI/48K13/2019/76
2	State	:	Karnataka
3	District		Udupi
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kollur road
7	Latitude	:	13.8948
8	Longitude	:	74.8384
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~240
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-chlorite-schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Moderate vegetation, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting in a steep slope is the primary causes that tend to reduce the shearing strength. Highly weathered & soft soil is observed on the slope corresponding to soil thickness of 3m to 5m. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.Schist is characterized by flaky minerals which weather quickly and promote instability.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining.
38	Remarks, if any		The slide occurred near the litho contact of Quartz-chlorite-schist and Metabasalt.
39	Photos. Sketch of Plan & section of the slide	:	 **Earth slide along the Nagodi-Kollur road**
40	Summary/Abstract	:	Earth slide initiated as a planar failure and is occurring on moderate slope. Initially, slope has been cut for road construction making the slope unstable. The thick soil cover over the hard rock got saturated by percolation of water during rains that added the weight and increased pore water pressure thereby reduced the cohesive strength. The nearby litho-contact of Quartz-chlorite-schist and Metabasalt may have also played an important role in infiltration of water and increased ground water saturation. This hasincreased the pore pressures within the weathered profile associated with this zone and thus reducedshear strength. Crown is prominent and is highly saturated. Creeping of trees in the crown part is observed indicative of imperceptible movement down the slope.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

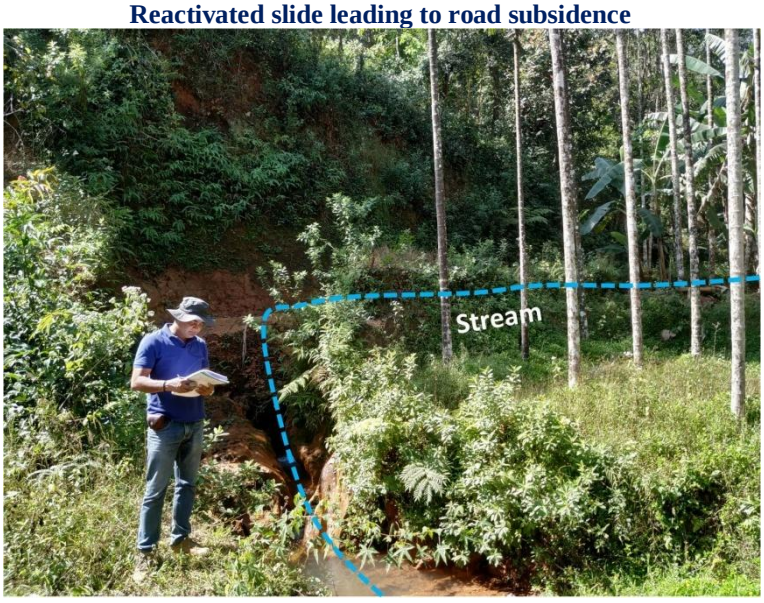
No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48N04/2019/77
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48N/04
5	Name of the slide	:	
6	NH/SH/Locality	:	Avinahalli-Chikkamattur road
7	Latitude	:	14.0892
8	Longitude	:	75.0007
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~120
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	Old slide
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Foliation: WNW, dipping 45°NNE
27	Land use/ Land cover	:	Cultivation and thick vegetation
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removing soil from hillsides for increasing cultivation area results in a significant reduction in lateral support. Diversion of main stream channel towards hill side accelerates toe erosion. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Benching on the slope is advisable for easing the slope. The drainage should be lined with concrete to avoid any infiltration from the stream.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of an old suspended debris slide covered with shrubs and trees**
40	Summary/Abstract	:	The landslide is an old suspended slide having translational movement along a single rupture plane. Debris slide occurrence is due to anthropogenic activities i.e. Slope cut and diversion of stream for increase of agriculture area or for better irrigation. Diversion of higher order stream towards foot of the slope into smaller stream area accelerates the toe erosion during rainfall. This causes steepening of slope due to undercutting and thus fails due to overloading and reduced shear strength.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/78
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13

5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Deviyaramane
7	Latitude	:	13.8970
8	Longitude	:	74.9366
9	Length *(m)*	:	~ 15
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~320
15	Run out distance *(m)*	:	~10
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Slide occurred in the year 2018
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz-chlorite-schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Plantation on downside of the road, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Debris of the slide consumed part of Areca nut plantation
36	Geo-scientific Causes	:	Regolith /Soil thickness greater than 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support by second order stream, high slope gradient are the primary causes that tend to reduce the shearing strength. High angle slope cut left unsupported

			below the road bench, improper and inadequate drainage arrangements, lack of channelized runoff water network on slope, improper toe support measures.
37	Recommendations	:	The toe support should be given at the toe of slide (where slide material stopped) by appropriate concrete measures (Retaining wall with weep holes) before going for benching and back filling of slope. Strengthened concrete measures right from firm hard rock surface to provide lateral support to the road. Surface water is to be diverted from unstable slopes by ditches and pipes. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		Road leading to Sampekatte is in grave danger, as the slide is retrograding and can lead to road subsidence. Therefore it requires an immediate attention.
39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide leading to road subsidence**  **Stream running at the toe of the slide abruptly bend**
40	Summary/Abstract	:	An old slide isreactivated and observed on the downside of road bench in highly weathered schistose rock.Toe erosion by heavily charged Stream during heavy rain event in the year 2018, undercut or scoured the slope making it steeper. Also, the slope forming material (SFM) got saturated by percolation of water during rains which increased its mass. Cumulative effect reduced the shear strength that lead to

			mass failure down the road in the year 2018. Poor drainage network on upside of the road also contributed to seepage of water down the road. The stream running south-easterly down the slope is immediately bend in north-easterly direction due to blockage of stream path with landslide debris. Since the area already witnessed an old slide earlier (Year 2018), the old cracks, so formed may have played a key role for rainfall infiltration. The old slip zone with lower permeability was another important factor to cause the infiltrated water to accumulate and form a high pore water pressure zone above slip zone.This high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide to fail again in the year 2019.A dugwell is observed at the toe of the slide with shallow water level. The crown is saturated and fractured tending to retrograde. Therefore an urgent attention requires safeguarding the road leading to Sampekatte.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/79
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Deviyaramane
7	Latitude	:	13.8973
8	Longitude	:	74.9382
9	Length *(m)*	:	~15
10	Width *(m)*	:	~25
11	Height *(m)*	:	~12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~375
15	Run out distance *(m)*	:	~08
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Reactivated

20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Earlier, the slide occurred in Year 2018 (as per local resident)
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Laterite and Saprolite derived from Granite gneiss
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Modification of forest into Acacia Plantation on upslope. Cultivation land downslope.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Stream used for irrigation is blocked with lateritic soil derived from the failed surface.
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land and Acacia plants destroyed due to mass fail.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by diverted stream undercut the slope making it steeper &made the slope unstable. Laterite/Saprolite cover thickness is more than 5m adding the weight on saturation. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Blocked drainage at the foot slope should be clear for free flow of water. The toe erosion of slopes by water action should be stopped by appropriate strengthened concrete measures right from firm hard rock surface which may also act as toe support for slope material. Surface water is to be diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		Landslide occurred in August, 2018, which recurred in August, 2019.

39	Photos. Sketch of Plan & section of the slide	:	 **View of earth slide occurred due to toe erosion by stream**
40	Summary/Abstract	:	A reactivated old slide having translational movement along rupture plane observed on north-westerly steep slope.Earth slide occurrence in the year 2018 is due to anthropogenic activities i.e. Slope cut and diversion of stream for increasing agriculture area or for better irrigation. Diversion of stream towards foot of the slope accelerated the toe erosion during rainfall. This causes steepening of slope due to undercutting and thus faileddue to overloading and reduced shear strength.Highly saturated lateritic soil with thickness correspondingto 5 to 10 m added an extra weight.Percolation of water resulting in building up of pore water pressure and reducedthe cohesive strength.This cumulatively led to mass failure in the year 2018. Modifying the forest into Acacia plantation reduced the soil strength on upslope also contributed to failure. The slide was temporarily stabilized. The slide subsequently recurred in the rain event of August, 2019. Since the area already witnessed an old slide earlier (Year, 2018), the old cracks, so formed may have played a key role for rainfall infiltration. The old slip zone with lower permeability was another important factor to cause the infiltrated water to accumulate and form a high pore water pressure zone above slip zone. This high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide deposit again in the year 2019.The body of the slide is wet with water seepage. Surface water should be diverted from unstable slopes by ditches and pipes.A ground water well present in the area reflecting shallow water level. Therefore, keeping in mind, any excavation on the hill slope should be avoided. Geological map showing presence of the litho-contact of Granite gneiss and Quartz-chlorite-schist adjacent to the slide. The contact may have also played an important role in infiltration of water and increased ground water saturation.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/80
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Deviyaramane
7	Latitude	:	13.8970
8	Longitude	:	74.9374
9	Length *(m)*	:	~ 15
10	Width *(m)*	:	~ 30
11	Height *(m)*	:	~ 13
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~450
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide occurred in the year 2018
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz-chlorite schist
26	Structure	:	Foliation: WNW, dipping 35° NNE
27	Land use/ Land cover	:	Modification of forest into Acacia Plantation on upslope. Cultivation land downslope.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Stream used for irrigation is blocked with lateritic soil derived from the failed surface of landslide no.79
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land and Acacia plants destroyed due to mass fail.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by diverted stream which has undercut the slope making it steeper & made the slope unstable. Soil thickness of more than 5m adding the overburden weight on saturation. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Blocked drainage at the foot slope should be made clear for free flow of water. The drainage should be supported by concrete works to restrict infiltration of water.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with bushes**
40	Summary/Abstract	:	An old suspended slide is observed in north-westerly slope. The slope has been modified (slope cut) for increasing agriculture area. Simultaneously, the stream has been diverted along the toe cut of the slope for irrigation purpose. During high rain, heavily charged stream undercut the slope and making the slope much steeper. The saturated soil with its increased mass decreased the shear strength. Consequently the saturated debris moved down the slope along a weak plane under the influence of gravity. The soil /weathered rock has failed &seen accumulated at the zone of accumulation, which is covered with bushes. Crown is prominent and retrograding. The slide has occurred 85m WSW of earlier observed slide no.79. Geological map showing presence of the litho-contact of Granite gneiss and Quartz-chlorite-schist which is adjacent to the slide. The contact may have also played an important role in infiltration of water and increased ground water saturation. This may increase pore pressure within the

			weathered profile associated with this zone and thus reduced theshear strength.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/81
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Ambiladi-Sampekatte road; Milestone**:** Sampekatte-3Km
7	Latitude	:	13.8829
8	Longitude	:	74.9320
9	Length *(m)*	:	~ 10
10	Width *(m)*	:	~ 18
11	Height *(m)*	:	~ 8
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~90
15	Run out distance *(m)*	:	~ 5
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist altered into Laterite and Saprolite
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Moderate vegetation on upslope. Slope has been cut and modified for road construction.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.

30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary causethat tend to reduce the shearing strength. The slides occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Soil blocked the drainage line should be removed before next rain.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of slide occurred due to extensive road cut**
40	Summary/Abstract	:	An Earth slide is observed in north-easterly directed moderate slope. Highly saturated lateritic soil with thickness correspondingto 5 to 7 m added an extra weight.Percolation of water during rain event of August 2019resulting in building up of pore water pressure and reducing the cohesive strength. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Huge soil accumulated on either side of the road.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/82
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Government high school, Sampekatte
7	Latitude	:	13.8867
8	Longitude	:	74.9543
9	Length *(m)*	:	~20
10	Width *(m)*	:	~30
11	Height *(m)*	:	~15
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~600
15	Run out distance *(m)*	:	~5 (Debris interrupted by School building)
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Foliation-NNW, dipping 50°ENE
27	Land use/ Land cover	:	Cut-slope for making school building&Moderate vegetation at upslope
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Debris rushed and terminated at the back side of the School, damaged the walls of chemistry lab.
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Unscientific way of cutting slope for making school building thus removing toe support &increasedslope instability. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	The toe support should be given at the foot of slope by construction of retaining wall with weep holes and minimize the slope gradient by benching and back filling. Surface water is diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		A note is submitted on 28th Feb, 2020 to the Deputy Commissioner, Shimoga for giving an urgent attention and take precautionary measures.
39	Photos. Sketch of Plan & section of the slide	:	 **Distant View of the slide on modified slope for school construction**  **Debris rushed inside the backside of school (Chemistry lab)**
40	Summary/Abstract	:	The active debris slide is observed to have occurred on the southerlygentle slope. The debris slide was occurred on 08th August 2019, as conveyed by School Headmaster Shri Prakash K.R. Initially, extensive cutting of slope for

			construction of school without providing any lateral support made the slope unstable. The debris slide initiated as rotational failure & the debris further descending down hasintruded into the school building damaging a classroom.The granite showing a high degree of alteration and development of reddish-brown, soft and friable materials (saprolite).Highly saturated lateritic soil with thickness corresponds to 5 to 10 m is adding an extra weight and percolation of water resulting in building up of pore water pressure and reducing the cohesive strength. The weathered rock exposed after removal of soil along the top and mid of the slide reveals that soft soil and rock interface act as another way of facilitating water into it, thus increases shearing forces. Clay layer (white in color) is observed on the sliding surface. The vegetation on upslope of the hill is unable to hold the thick saturated soil against the gravity. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.A small 1.2m height wall is constructed earlier; but the wall needs to be extended with more height and weep holes. The saturated debris crossed the wall and entered into the premises. The excavated slope if left untreated is sure to pose threat during heavy rainfall.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/83
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sampekatte- Ambiladi road
7	Latitude	:	13.8827
8	Longitude	:	74.9294
9	Length *(m)*	:	~14
10	Width *(m)*	:	~20
11	Height *(m)*	:	~12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~140
15	Run out distance *(m)*	:	~4

16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz-chlorite schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Cut-slope for making settlement
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support for constructing settlement without giving any lateral support and thick saturated soil cover of 3 to 5m are the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope and proper grading, possibly reduce the hazard considerably.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide due to extensive cut slope**
40	Summary/Abstract	:	The slide initiated after removal of soil from hillside for making settlement. The Quartz-chlorite schist showing a high degree of alteration and development of reddish-brown, soft and friable materials (saprolite). The percolating water through soil hydratedthe clay layer adding to the weight that reducedthe slope strength. The slide occurred during heavy rainfall that causes infiltration of water resulted in building up of pore water pressure and reducing the cohesive strength. Consequently the saturated debris material moved down the disturbed slope along a weak plane under the influence of gravity. No lateral support has been provided by the land owner. Upslope is barren and therefore unable to hold the soil, that may led to fail during high rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/84
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sampekatte-Ambiladi road
7	Latitude	:	13.8809
8	Longitude	:	74.9253
9	Length *(m)*	:	~ 9
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 7

12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~108
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-chlorite schist and Banded magnetite quartzite
26	Structure	:	Foliation trending NNW, dipping 28°ENE
27	Land use/ Land cover	:	Barren slope covered partly with bushes and occasionally small trees , Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 1m to 2m corresponding to soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail.The slide is occurring at the litho contact between Quartz-chlorite schist and Banded magnetite quartzite. The contact act as a path for facilitating the water infiltration & thus giving rise to increase in hydrostatic pressure leading to failure subsequently.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Debris accumulated in the drainage line should be cleared. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of a road cut initiated debris slide**
40	Summary/Abstract	:	The debris slide is observed to have occurred on the easterly slope. Initially, slope has been cut for road construction making it unstable. Along the Quartz-chlorite schist and Banded magnetite quartzite lithology contact, the schist is showing a high degree of alteration and development of reddish-brown, coarse-grained sandy matrix. The percolating water through soil adding to the weight that reducedthe slope strength.The litho contact also played an important role in infiltration of water and increased ground water saturation. This may have increased pore pressure within the weathered profile associated with this zone and thus reducedshear strength.Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Top of the hill is barren and sporadic sparse vegetation is observed reflecting presence of rock and thin soil cover.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/85
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sampekatte- Ambiladi road
7	Latitude	:	13.8772
8	Longitude	:	74.9244
9	Length *(m)*	:	~ 13

10	Width *(m)*	:	~ 22
11	Height *(m)*	:	~ 11
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~143
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Slow
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation trending NNW, dipping 28°ENE
27	Land use/ Land cover	:	Barren slope covered partly with bushes and occasionally small trees , Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slides occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Soil blockingthe drainage line should be removed before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide occurred due to road cut**
40	Summary/Abstract	:	Debris slide is observed in easterly directed moderate slope. The slide occurred in less weathered soil cover corresponding to 0.5 to 1m thickness. The slide movement is low and suspended. Percolation of water during rain resulting in building up of pore water pressure and reducing the cohesive strength. Barren and sporadic vegetation on upslope unable to withhold the soil. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Along 30 m west of the road, nala section showing the litho-contact between Quartz chlorite schist and banded magnetite quartzite. Debris accumulated on the drainage line should be removed.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/86
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sampekatte- Ambiladi road
7	Latitude	:	13.8768
8	Longitude	:	74.9241
9	Length *(m)*	:	~ 10
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 8
12	Area *(m2)*	:	

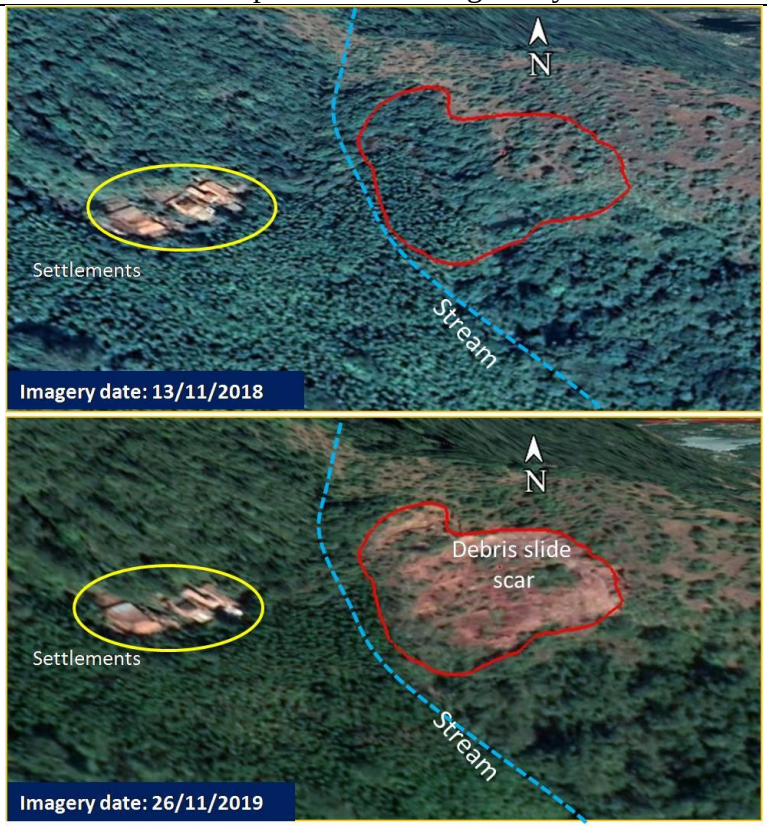
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~60
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Slow
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz-chlorite-schist
26	Structure	:	Foliation trending NNW, dipping 28°ENE
27	Land use/ Land cover	:	Barren slope covered partly with bushes and occasionally small trees , Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slides occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Soil blockingthe drainage line should be removed before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide occurred adjacent to litho-contact**
40	Summary/Abstract	:	Debris slide is observed in easterly directed moderate slope. The slide occurred in less weathered soil cover corresponding to 0.5 to 1m thickness. The slide movement is low and suspended. Percolation of water during rain resulting in building up of pore water pressure and reducing the cohesive strength. The litho-contact between Quartz chlorite schist and banded magnetite quartzite is observed along the nala, adjacent to the slide. This contact played an important role in infiltration of water and increased ground water saturation. This may increase pore pressure within the weathered profile associated with this zone and thus reduce shear strength. Barren and sporadic vegetation on upslope unable to withhold the soil. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. Debris accumulated on the drainage line should be removed.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/87
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Sunkadavaramane
7	Latitude	:	13.8885
8	Longitude	:	74.9290
9	Length *(m)*	:	~80

10	Width *(m)*	:	~160
11	Height *(m)*	:	~40
12	Area *(m2)*	:	
13	Depth *(m)*	:	~2
14	Volume *(m3)*	:	~25,600
15	Run out distance *(m)*	:	~50
16	Type of Material	:	Debris
17	Type of movement	:	Flow
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Deep rotational failure
23	History	:	
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-chlorite-schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation with bushes on upslope. Acacia Plantation, Areca nut and pepper plantation on downslope.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Around 1 acres agriculture land (Survey no. 29, 30 & 31) of S.R Manjunath, S.R Ravi, S.R Radhakrishna and M.P Vedawati has been destroyed by the debris.
32	Livestock Loss	:	Nil
33	Communication	:	Stream used for irrigation is blocked with debris derived from the failed surface.
34	Infrastructure	:	House wall and floor of Shri S.R Radhakrishna is partly damaged with cracks as heavy infiltration of rainfall increased ground water level and created hydrostatic pressure that forced water through openings in the foundation and created cracks.
35	Agriculture/forest/Barren	:	Part of Forest landis destroyed under debris flow.Areca nut and peeper plantation of all above mentioned land owners also damaged during the event of sliding.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by stream has undercut the slope making it steeper &made the slope instable. Laterite/Saprolite cover thickness is more than 5m adding the weight on saturation. Infiltration of water made their way inside the slope making a seepage path thereby

			making a potential slide surface.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. The debris accumulated at the body of slide should be covered with deep rooted plants. Crown cracks to be sealed with some impervious material & covered with tarpaulin to avoid any water infiltration. Blocked drainage at the foot slope should be made clear for free flow of water. Surface water is to be diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		A note is submitted on 28th Feb, 2020 to the Deputy Commissioner, Shimoga for giving an urgent attention and take precautionary measures. The excavated slope if left untreated is sure to pose threat during heavy rainfall.
39	Photos. Sketch of Plan & section of the slide	:	 **View of the terrain (Google imageries of year 2018 and 2019)** ***(Slide occurred on 09th august,2019)***  **Distant view of the debris slide (*Sparse vegetation on upslope*)**

			 **Debris flow initiated as rotational failure showing subsidence near the crown**  **View of the failure surface from foot of the slope**
40	Summary/Abstract	:	Massive debris slide initiated on the upper slope of the ridge as rotational failure & is further came down as debris flow collecting material from upper catchment area. The slide occurred on south-westerly slope during rain event of August 2019. Debris slide on 09th August 2019 occurreddue to slope cut and diversion of stream for increasing agriculture area and for better irrigation. The south-east flowing stream accelerated the toe erosion during heavy incessant rainfall. This caused steepening of slope due to undercutting and thus faileddue to overloading and reduced shear strength.The ridge part of the hill is having sparse vegetation with thin slope wash, whereas in the mid slope & downslope the thickness of the regolith increases and attains a thickness >5m.Highly saturated lateritic soil with thickness correspondingto 5 to 10 m added an extra weight.Percolation of water resulting in building up of pore water pressure and reducing the cohesive strength. Rapidly running water and gravity driven movement induced by lubricating action of ground water thus derived the debris down slope at fast pace consumed much of the forest area

			and destroyed plantationof Areca nut, Acacia and Black pepper. Huge debris blocked the stream flow, resulting in diversion of water into the agriculture land. The Litho contact between Quartz-chlorite-schist and Banded haematite quartzite is observed in the landslide area. The hard and competent BMQ on both sides of the slide remains intact, while the schist present in between the BMQ's altered to laterite/saprolite, gets failed. Such discontinuities provide storage space and pathway for ground water migration. Groundwater saturation may increase pore pressures within the weathering profile associated with these zones and thus reduce strength. Subsidence and crown cracks observed on the upper part of the slide shows that the slide is still active and retrograding. Huge debris mass is accumulated in the zone of accumulation. This could surely impose another threat during heavy rain. It is observed that residents of this village are disturbing the natural course of stream. A water storage tank is constructed on slope behind the house of S.R Manjunath. These types of practices could trigger huge mass failure and harm the life and property. The area is not suitable for living as the slopes are highly dissected and are vulnerable. People living around these slopes should remain vigilant, particularly during themonsoon period and any physical change in the slope or widening of the landslide crack should immediately bring into the notice of authorities.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/88
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Belur-Nittur road
7	Latitude	:	13.9156
8	Longitude	:	74.9208
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 13
11	Height *(m)*	:	~ 11
12	Area *(m2)*	:	

13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~182
15	Run out distance *(m)*	:	~8
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Slide occurred in the past
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Plantation on downside of the road, Extensive cut slope for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Debris of the slide consumed part of Areca nut plantation down side of road bench.
36	Geo-scientific Causes	:	Removal of toe support by stream, high angle slope cut below the road benchwithout providing any lateral support arethe primary causes that tend to reduce the shearing strength. Regolith /Soil thickness of 3-5m corresponding to considerable depth of soil and weathered rock mass.
37	Recommendations	:	The toe support should be given at the toe of slide (where slide material stopped) by appropriate concrete measures (Retaining wall with weep holes) before going for back filling of slope. Strengthened concrete measures right from firm hard rock surface to provide lateral support to the road. Surface water is to be diverted from unstable slopes by ditches and pipes. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		Road leading to Nittur is in grave danger, as the slide is retrograding and can lead to road subsidence. Therefore it requires an immediate attention.

39	Photos. Sketch of Plan & section of the slide	:	 **Debris slide leading to road subsidence**
40	Summary/Abstract	:	A debris slide is observed on the downside of road bench in weathered gneissic rock. Extensive slope cut for constructing road left an unsupported cut down the road bench. The slope was also disturbed for increasing agriculture area activities. A first order stream is modified and presently converted into plantation area. Similarly second order stream is also converted into cultivation land. This stream is connected with the back water of Linganamakki reservoir. During heavy rain ground-water levels rose as a result of filling of reservoir, or the rise in level of streams, this caused erosion at the base of slopes.Cumulatively, shear strength reduced that lead to mass failure down the road. Poor drainage network on upside of the road also contributed to seepage of water down the road. Slight subsidence of the road towards cut slope face is observed. The crown is saturated and retrograde that may lead to fail or subsidence of the road during heavy rain. Therefore an urgent attention requires safeguarding the road leading to Nittur.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/89
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Sidlukuni

7	Latitude	:	13.9186
8	Longitude	:	74.9231
9	Length *(m)*	:	~55
10	Width *(m)*	:	~64
11	Height *(m)*	:	~25
12	Area *(m2)*	:	
13	Depth *(m)*	:	~2
14	Volume *(m3)*	:	~7,040
15	Run out distance *(m)*	:	~50
16	Type of Material	:	Debris
17	Type of movement	:	Flow
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Deep rotational failure
23	History	:	
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation & bushes on upslope. Acacia and Nilgiri plantation on mid slope. Plantation on valley downslope
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Around 0.25 acres agriculture land Timma D/o Padmi,Vill. Sidlukuni has been affected by the debris.
32	Livestock Loss	:	Nil
33	Communication	:	Stream used for irrigation is blocked with debris derived from the failed surface.
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land consumed under debris flow.Areca nut and banana plantation damaged during the event of sliding.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by stream undercut the slope making it steeper &increased the slope instability. Granite gneiss altered into laterite/saprolite corresponding to soil thickness more than 5m that saturated and added the weight. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.

37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. The debris accumulated at the body of slide should be grown up with deep rooted plants. Crown cracks to be sealed with some impervious material & covered with tarpaulin to avoid any water infiltration. Blocked drainage at the foot slope should be clear for free flow of water. Surface water is diverted from unstable slopes by ditches and pipes. Forest trenches on vulnerable slope are to be sealed immediately to avoid water infiltration.
38	Remarks, if any		A note is submitted on 28th Feb, 2020 to the Deputy Commissioner, Shimoga for requiring an urgent attention and precautionary measures. The excavated slope if left untreated is sure to pose threat during heavy rainfall.
39	Photos. Sketch of Plan & section of the slide	:	 **Google imagery of the landslide occurred on 09th August,2019**  **View from toe of the debris flow**

			 **Debris flow initiated as rotational failure; crown subsidence distinct**  **Transverse crack observed above the crown on hill slope**
40	Summary/Abstract	:	Massive debris flow initiated on the upper slope of the ridge as rotational failure & is further came downas debris flow collecting materialfrom upper catchment area. The slide occurred on north-westerly slope during rain event of August 2019. Debris slide on 09th August 2019 occurreddue to slope cut and diversion of stream for increasing agriculture area and for better irrigation. The north-east flowing stream accelerated the toe erosion during heavy incessant rainfall. This caused steepening of slope due to undercutting and thus faileddue to overloading and reduced shear strength.The ridge part of the hill is having sparse vegetation with thin slope wash, whereas in the mid slope & downslope the thickness of the regolith increases and attains a thickness >5m.Highly saturated lateritic soil with thickness correspondingto 5 to 10 m added an extra weight.Percolation of water resulting in building up of pore water pressure on ground water saturation and reducing the cohesive strength.Rapidly running water and gravity driven movement induced by lubricating action of ground water thus derived the debris down slope at fast pace consumed much of the forest area and destroyed plants of Areca nut,

			Acacia and Banana. Huge debris blocked the stream flow, resulting in diversion of water into the agriculture land. Huge debris mass is accumulated in the zone of accumulation. This could surely impose another threat during heavy rain. According to a local resident Shri K.K Shivanand, the forest department has modified the forest after growing Accacia and Nilgiri plants. These practices of removing natural soil layer degrade the soil competency. Forest trench is also observed on the slope which is transverse to it. These trenches will provide easy way of water seepage and enhance sub surface erosion. Transverse cracks observed above the crown of the slide shows that the slide is still active and retrograding. Crack is approx 30m in length, 5-6 inch wide and 5-6 feet in depth. The crack is in arc shape that reveals initiation of another mass failure. Numerous small stream and underground streams are observed on the debris in the zone of accumulation. The slope is highly vulnerable to failiure during high rain. People living around these slopes should remain vigilant, particularly during themonsoon period and any physical change in the slope or widening of the landslide crack should immediately bring into the notice of authorities.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/90
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Sidlukuni
7	Latitude	:	13.9182
8	Longitude	:	74.9220
9	Length *(m)*	:	~14
10	Width *(m)*	:	~15
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~210
15	Run out distance *(m)*	:	~10
16	Type of Material	:	Debris

17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation & bushes on upslope. Acacia and Nilgiri plantation on mid slope. Plantation on valley downslope
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Around 0.2 acres agriculture land(Survey No. 29/1A/A11) of K.S Saraswati ,Vill. Sidlukuni has been affected by the debris.
32	Livestock Loss	:	Nil
33	Communication	:	Stream used for irrigation is blocked with debris and rock derived from the failed surface.
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest landdestroyed under debris flow.Areca nut, Pepper and banana plantation of the land owner damaged during the event of sliding.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by stream undercut the slope making it steeper &increased the slope instability. Oversaturation of first order stream increased hydrostatic pressure leading to outburst of stream and result in mass failure. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Blocked drainage at the foot slope should be clear for free flow of water. Surface water is diverted from unstable slopes by ditches and pipes
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Google Earth imagery of landslide (Imagery data:26/11/2019)**  **View from toe of the debris slide**
40	Summary/Abstract	:	Debris slide on 09th August 2019 occurredon northerly moderate slope. The first order stream flowing northerly meets the higher order stream at foot slope. During the heavy incessant rainfall spell of August 2019, the east flowing higher order stream blocked at upstream due to the earlier landslide (landslide no.89) debris. The voluminous water of first order stream does not get enough space to discharge its water on higher order stream at downstream. Also blockage at upstream results in acceleration of toe erosion and diversion of higher order stream. The ground water level on the slope increased as a result of filling of higher order stream. This increased hydrostatic pressure led to outburst of stream in jointed and fractured rock along with debris.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/91
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Mani
7	Latitude	:	13.9221
8	Longitude	:	74.9237
9	Length *(m)*	:	Land subsidence and ground cracks observed
10	Width *(m)*	:	
11	Height *(m)*	:	
12	Area *(m2)*	:	
13	Depth *(m)*	:	
14	Volume *(m3)*	:	
15	Run out distance *(m)*	:	
16	Type of Material	:	Debris
17	Type of movement	:	Subsidence
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Advancing
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Cut-slope for making settlement
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil

34	Infrastructure	:	Cracked walls & floors in Ramachandra's house.
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Unscientific way of cutting slope for making settlement thus removing toe support &increasingslope instability. The subsidence and fissures has occurred during heavy rainfall that occurred due to infiltration of water resulting in increase of hydrostatic pressure and reduction of the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Retaining wall with weep holes behind the house can also be done for better protection. Subsurface drains to be installed to relieve hydrostatic pressure by draining the excess water. Surface water is diverted from unstable slope by ditches and pipes.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of an extensive slope-cut at the back of house**  **Cracks on wall and floor partly damaged the house**
40	Summary/Abstract	:	A small subsidence and NW-SE running ground crack is observed on slope and at toe of the slope affecting a house. The ground crack occurred on 08th August 2019 during spell of incessant rain. Crack is observed along the flank of cut-

			slope. Upslope covers with sparse vegetation and plantation, while a foot track is also present above the cut-slope made for settlement. These are creating an extra stress on the slope. Slow movement of debris material down the slope is also observed backside of the house. The crack so formed is in Ramachandra house is due to hydro-compaction of collapsible soil. During heavy rain the soil near the surface becomes saturated and water table rose. When the water table rose beneath a foundation, it created hydrostatic pressure that forced water through any small fissures or imperfections in the foundation created ground cracks. The opening on the slope is still active and can rejuvenate during rain with percolation of water. Therefore an immediate measure should be taken before next rain.People living around this slope should remain vigilant, particularly during themonsoon period and any physical change in the slope or extension of the cracks should immediately bring into the notice of authorities.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/92
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Mani-Bennette road
7	Latitude	:	13.9321
8	Longitude	:	74.9238
9	Length *(m)*	:	~12
10	Width *(m)*	:	~30
11	Height *(m)*	:	~10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~180
15	Run out distance *(m)*	:	~05
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive and Widening

21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Gneissosity trends NNW-SSE dipping 50^{o} ENE.
27	Land use/ Land cover	:	Moderate vegetation and extensive slope cut for road construction and widening.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Removal of toe support for road widening/construction, high slope gradient are the primary causes while heavy antecedent rainfall triggered the mass to fail.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength. The percolating water through soil wet the clay layer adding to the weight that reduces the slope strength.
37	Recommendations	:	Slope gradient should be ease by constructing benches. Proper drainage with concrete lining should be made at the foot of the slope. Blocked drainage should be made clear from debris.
38	Remarks, if any		Electric pole on other side of the road is bend and temporarily supported with a wooden plank. This should be immediately maintained by the concerned authority.

39	Photos. Sketch of Plan & section of the slide	:	 **Debris slide initiated due to widening of road (at the road bend)**
40	Summary/Abstract	:	The debris slide is initiated as a planar failure. The slope forming material got saturated by percolation of water during heavy spell of rain which increased its mass. Top of the hill sparse vegetation is observed reflecting presence of rock and/or thin soil cover. However, oversaturated weathered rock& soil is observed on the slope corresponding to soil thickness 3 to 5m.The area is already witnessed an extensive slope cut for constructing road has played a vital role in making the slope unstable. Intense and sustained rainfall leads to the saturation of slopes and increased groundwater levels within the mass. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/93
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Lingadakai road
7	Latitude	:	13.9267
8	Longitude	:	74.9055
9	Length *(m)*	:	~15
10	Width *(m)*	:	~20
11	Height *(m)*	:	~12

12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~300
15	Run out distance *(m)*	:	~5
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Granite gneiss
26	Structure	:	Foliation:NW, dipping 30°NE
27	Land use/ Land cover	:	Cut-slope for making settlement and sparse vegetation on upslope.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Unscientific way of cutting slope for making settlement thus removing toe support &increasingslope instability. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Surface & sub-surface water is to be diverted from unstable slope by ditches and pipes
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Cut-slope failure occurred for constructing settlement**
40	Summary/Abstract	:	The slide initiated as a planar failure. The slide initiated after disturbance of the slope for making settlement. No support has been provided by the house owner.Top of the hill sparse vegetation is observed reflecting presence of rock and thin soil cover.Weathered and saturated debris with soil thickness approx 1 m observed on slope. The soil acts as a conditioning factor for landslides and the hard rock acts as the slip plane as observedat the crown part of the land-slide. Sparse vegetation and bushes on upslope were unable to hold the soil erosion during rainfall. The slide is still active and need immediate lateral support.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/94
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Changolli
7	Latitude	:	13.9300
8	Longitude	:	74.8662
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 25
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	

13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~300
15	Run out distance *(m)*	:	~ 5
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct, highly weathered rock
27	Land use/ Land cover	:	Sparse vegetation on upslope, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. Quartz-chlorite-schist altered to laterite/Saprolite with thickness 3-5 m adding the weight on saturation. Infiltration of water made their way inside the slope resulting in building up of pore water pressure and reducing the cohesive strength.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining.Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		Electric pole is tilted and requires an immediate attention to maintain by the concerned authority.

39	Photos. Sketch of Plan & section of the slide	:	 **View of an Earth slide near the road bend**
40	Summary/Abstract	:	The landslide is an active earth slide having translational movement along rupture plane with approx. 5m run-out distance. Earth slide occurred due to slope cut for road construction that left unsupported. Highly saturated lateritic soil with thickness corresponding to 3 to 5 m added an extra weight and percolation of water resulting in building up of pore water pressure and reducing the cohesive strength. Crown of the slide is saturated & retrograssive in nature. The soil along with uprooted shrubs & trees terminated at the base of the slope. Down the slope, below the road bench a stream is running southerly. The valley part with higher order stream is now completely converted into cultivation land. The large valley area of the stream is now modified into smaller area parallel to the road bench. During high incessant rain, voluminous water doesn't accommodate in the stream channel resulting in flooding in cultivation area, also results in ground water raise.Groundwater saturation may increase pore pressures within the weathering profile associated with these zones and thus reduce strength.Encroachment of valley for plantations and agriculture are aggravatinglandslide proneness.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/95
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Changolli

7	Latitude	:	13.9296
8	Longitude	:	74.836
9	Length *(m)*	:	~15
10	Width *(m)*	:	~20
11	Height *(m)*	:	~13
12	Area *(m2)*	:	
13	Depth *(m)*	:	~2
14	Volume *(m3)*	:	~600
15	Run out distance *(m)*	:	~12
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-chlorite-schist
26	Structure	:	Not distinct; highly weathered rock
27	Land use/ Land cover	:	Extensive cut-slope for making settlement, Cashew plantation and bushes on Upslope
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant Rainfall
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support for constructing settlement without giving any lateral support and thick saturated soil cover of 3 to 5m are the primary causes that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength. Slope is to be made stable by growing more plants and trees to reinforce soil.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the

			hazard considerably. Surface water is to be diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of Debris slide due to extensive cut slope**
40	Summary/Abstract	:	The slide initiated after south-westerly slope has been extensively cut for making settlement. No lateral support has been provided by the land owner Shri M.N Krishna.The cut slope failure occurred on 08th August 2019 during the rainfall event. Highly weathered and saturated debris with soil thickness 3-5 m increased the pore pressure and thus reduced shear strength of the soil. Presence of cracks in the crown part reveals that the slide is still active and retrograding. Sparse vegetation on upslope not withstanding surface erosion during rainfall and increased stress towards failure. Downslope stream is modified from larger basin area into a smaller one. The larger channel area is converted into cultivation land. Huge debris is accumulated on the slope. The slope should be planted with deep root trees which will withhold the soil, reduces soil moisture content and maintain slope stability. Encroachment of valley for plantations and agriculture are aggravatinglandslide proneness.The excavated slope if left untreated is sure to pose threat during heavy rainfall.
41	Date of Reporting	:	
42	Landslide Category	:	I

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/96
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	

6	NH/SH/Locality	:	Nittur-Bailgi road
7	Latitude	:	13.9402
8	Longitude	:	74.8801
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 22
11	Height *(m)*	:	~ 11
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~154
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation :NW, dipping 50°NE
27	Land use/ Land cover	:	Thick vegetation on upslope, cut slope for construction of road, Backwater of Linganamakki reservoir at downslope below the road bench
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and

			weathered rock mass.The establishment of reservoirs has led to change in the flow regime of thestream.
37	Recommendations	:	Easing of slope and proper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	Multiple (03no's) old suspended slides are observed to have occurred on the steep slope. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) observed on the slope corresponding to soil thickness of 5m to 7m got saturated by percolation of water during rains which increased its mass. During intense rainfall, ground water level rose as a result of filling reservoir or the rise of backwater stream which caused erosion at the base of slope making the slope prone to failure.Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is covered with vegetation & is saturated.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/97
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Bailgi road

7	Latitude	:	13.9413
8	Longitude	:	74.8799
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 11
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~168
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation :NW, dipping 50°NE
27	Land use/ Land cover	:	Thick vegetation on upslope, cut slope for construction of road, Backwater of Linganamakki reservoir at downslope below the road bench.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, and toe erosion by first order stream are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass.The establishment of reservoirs has led to change in the flow regime of thestream.

37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide partly covered with vegetation; crown visible**
40	Summary/Abstract	:	An old suspended slide hasoccurred at the road bend. Initially, slope has been cut for road construction making it unstable. A first order stream running south-easterly observed to meet back water of Linganamakki reservoir. During intense rainfall, ground water level rose as a result of filling reservoir or the rise of backwater stream. This increase of water levels ultimately aggravated the toe erosion by Ist order stream inducing the slope to fail.Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is partly covered with vegetation.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/98
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nittur-Bailgi road
7	Latitude	:	13.9417
8	Longitude	:	74.8799
9	Length *(m)*	:	~ 14

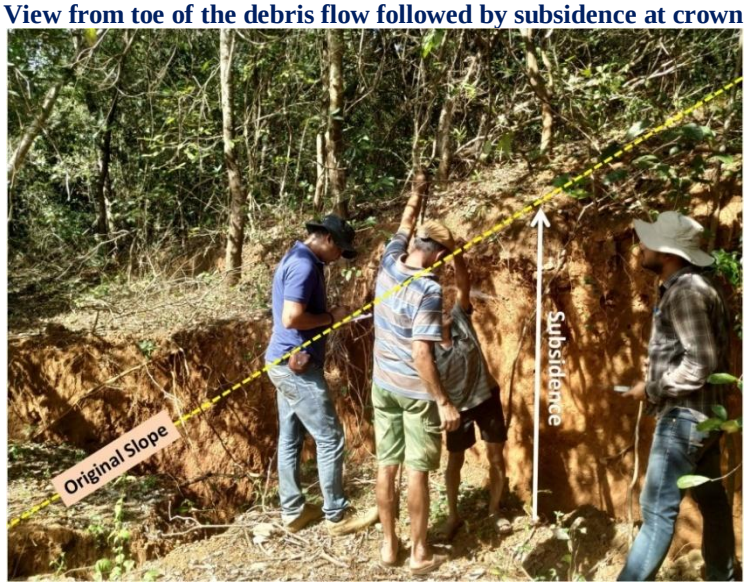
10	Width *(m)*	:	~ 10
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~140
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation :NW, dipping 50°NE
27	Land use/ Land cover	:	Thick vegetation on upslope, cut slope for construction of road, Backwater of Linganamakki reservoir at downslope below the road bench
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. Regolith /Soil thickness varies from 5m to 7m corresponding to considerable depth of soil and weathered rock mass.The establishment of reservoir has led to change in the flow regime of thestream.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with bushes; crown visible**
40	Summary/Abstract	:	An old suspended slide has occurred at the road bend near the culvert draining the first order stream to back water. Initially, slope has been cut for road construction making it unstable. Highly weathered soil got saturated by percolation of water during rains which increased pore water pressure and reduced the cohesive strength. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity. The zone of accumulation of the slide is covered with vegetation & is saturated.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/99
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Kesaremane; Bailgi-Hebbige road
7	Latitude	:	13.9522
8	Longitude	:	74.8916
9	Length *(m)*	:	~60
10	Width *(m)*	:	~200
11	Height *(m)*	:	~20
12	Area *(m2)*	:	
13	Depth *(m)*	:	~3

14	Volume *(m3)*	:	~36000
15	Run out distance *(m)*	:	~500
16	Type of Material	:	Debris
17	Type of movement	:	Flowand subsidence
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Deep rotational failure
23	History	:	
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-chlorite-schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation with bushes on upslope. Acacia Plantation, Areca nut and pepper plantation on downslope.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Agriculture land of K.T Vasudeva & K.R Nirmala with Survey no. 128/2, 128/1 resp. has been affected by the debris.
32	Livestock Loss	:	Nil
33	Communication	:	Stream used for irrigation is blocked with debris derived from the failed surface.
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest landdestroyed under debris flow.Areca nut and peeper plantation of above mentioned land owners also damaged during the event of sliding.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by stream undercut the slope making it steeper & increasing the slope instability. Encroachment of valley for plantations and agriculture are aggravating landslide proneness. Soil thickness is more than 7m adding the weight on saturation. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. The debris accumulated at the body of slide should be planted with deep rooted plants. Crown cracks to be sealed with some impervious material & temporarily covered with tarpaulin to avoid any water infiltration. Blocked drainage at the foot slope should be cleared for free flow of water. Surface water is to be diverted from unstable slopes by ditches and pipes.

38	Remarks, if any		A note is submitted on 28th Feb, 2020 to the Deputy Commissioner, Shimoga for giving an urgent attention and take precautionary measures. The excavated slope if left untreated is sure to pose threat during heavy rainfall.
39	Photos. Sketch of Plan & section of the slide	:	 **View from toe of the debris flow followed by subsidence at crown**  **Subsidence of the ground at crown (*Sparse vegetation on upslope*)**  **Subsidence followed by cracks with depth varies from 1 to 8 ft**

			 **Stream blocked due to debris diverted in plantation area**
40	Summary/Abstract	:	Massive debris slide initiated from the forest region as rotational failure & is further moved down as debris flow collecting material from upper catchment area. The slide occurred on southerly slope during rain event of August 2019. The slope is modified by cutting the hillside slope and diversion of stream for increasing agriculture area and for better irrigation. Debris slide on 08th August 2019 occurred due to toe erosion by first order SSE flowing stream during heavy rainfall. This stream discharges its water to back water of Linganamakki reservoir. During intense rainfall, ground water level rose as a result of filling reservoir. Groundwater saturation increased pore pressures within the weathering profile associated with these zones and thus reduced the strength. The increase in water level ultimately aggravated the toe erosion by Ist order stream causing steepening of slope due to undercutting making the slope vulnerable to fail. The ridge part of the hill is covered withsparse vegetation with thin slope wash, whereas in the mid slope & downslope the thickness of the regolith increases and attains a thickness >5m.Rapidly running water and gravity driven movement induced by lubricating action of ground water thus derived the debris down slope at fast pace destroyed much of the forest area and plants of Areca nut, Acacia and Black pepper. Huge debris blocked the stream flow, resulting in diversion of water into the agriculture land. Subsidence and crown cracks observed on the upper part of the slide shows that the slide is still active and retrograding.Transverse cracks (at N13°57'10.1"and E74°53'29.8”) observed on top of the hill above the crown part of the slide. The cracks are 0.3 m to 2m’ wide and are 5’ to 8’ in depth and are capable of accommodating more water that can trigger another mass failure.Longitudinal cracks also present above the crown part of the slide. Multiple land subsidence is observed at the top of the hill that can initiate another slide.The opening in the form of large size cracks/ fissures can trigger a slide with percolation of water.Huge debris mass is accumulated in the

			zone of accumulation. This could surely impose another threat during heavy rain.People living around these slopes should remain vigilant, particularly during themonsoon period and any physical change in the slope or widening of the landslide crack should immediately bring into the notice of authorities.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/100
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Hebbige
7	Latitude	:	13.9534
8	Longitude	:	74.8954
9	Length *(m)*	:	~25
10	Width *(m)*	:	~60
11	Height *(m)*	:	~20
12	Area *(m2)*	:	
13	Depth *(m)*	:	~2
14	Volume *(m3)*	:	~6000
15	Run out distance *(m)*	:	~20
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Deep rotational failure
23	History	:	
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Laterite
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation with bushes on upslope. Acacia Plantation, Areca nut and pepper plantation on downslope.
28	Hydrological condition	:	Wet

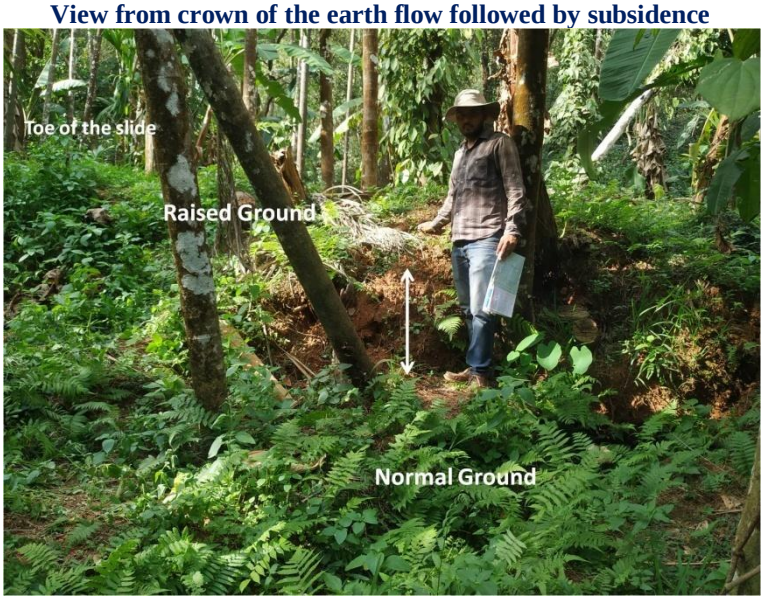
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Agriculture land of H.D Vasudeva has been affected by the landslide soil and stream diversion.
32	Livestock Loss	:	Nil
33	Communication	:	Stream used for irrigation is blocked with soil derived from the failed surface.
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest landdestroyed under earth flow.Areca nut and peeper plantation of the land owner also damaged during the event of sliding.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by stream has undercut the slope making it steeper &increasedthe slope instability. Encroachment of valley for plantations and agriculture are aggravating landslide proneness. Laterite/Saprolite cover thickness is more than 10m adding the weight on saturation. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. The debris accumulated at the body of slide should be grown up with deep rooted plants. Crown cracks to be sealed with some impervious material & covered with tarpaulin to avoid any water infiltration. Disrupted drainage pathways should be restored. Surface water is diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		The excavated slope if left untreated is sure to pose threat during heavy rainfall.
39	Photos. Sketch of Plan & section of the slide	:	 **View from toe of the slide**
40	Summary/Abstract	:	Massive earth slide initiated on mid-slope as rotational failure & is further graded down as earth flow. The slide occurred on westerly slope during rain event of August 2019. The slope is modified by cutting the hillside slopeand

			diversion of stream for increasing agriculture area and for better irrigation. Earth slide on 08th August 2019 occurred due to toe erosion by south-east flowing stream during heavy rainfall. This caused steepening of slope due to undercutting and thus failed due to overloading and reduced shear strength.The ridge part of the hill is covered with sparse vegetationand thin slope wash, whereas in the mid slope & downslope the thickness of the soil increases and attains a thickness >10m.Groundwater saturation increased the pore pressures within the weathered profile associated and thus reduced strength.Rapidly running water and gravity driven movement induced by lubricating action of ground water moved the soilmass down slope at faster pace destroyed much of the forest area and plants of Areca nut, Acacia and Black pepper. Huge debris blocked the stream flow, resulting in diversion of water into the agriculture land. As per H.D Vasudeva (Land owner), crown cracks are present on the upper part of the slide which reveals that the slide is still active and retrograding. An old slide is observed adjacent to this slide on upstream side. The old slide is covered with vegetation and is highly saturated. Therefore, as observed the slide is widened with retrograde. As an immediate measure stream channel should be made free from any disruption (blockage).
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/101
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Hebbige
7	Latitude	:	13.9530
8	Longitude	:	74.8979
9	Length *(m)*	:	~60
10	Width *(m)*	:	~100
11	Height *(m)*	:	~25
12	Area *(m2)*	:	
13	Depth *(m)*	:	~2
14	Volume *(m3)*	:	~12000

15	Run out distance *(m)*	:	~50
16	Type of Material	:	Earth
17	Type of movement	:	Flow
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Deep rotational failure
23	History	:	
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Laterite
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation with bushes on upslope. Acacia Plantation, Areca nut and pepper plantation on downslope.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Agriculture land of K.R Prasanna has been affected by the soil.
32	Livestock Loss	:	Nil
33	Communication	:	Natural course of stream is modified and used for irrigation is blocked with soil derived from the failed surface.
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest landdestroyed under earth flow.Plantation comprises Areca nut and peeper.Toe side of the slide bulged up to 4ft from normal ground level. Water pipes on plantation area compressed due to slow movement of ground along the slope direction.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by stream which has undercut the slope making it steeper &increased the slope instability. Encroachment of valley for plantations and agriculture are aggravating landslide proneness. Soil thickness is more than 7m adding the weight on saturation. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Huge debris accumulated at the body of slide should be planted with deep rooted plants. Crown cracks to be sealed with some impervious material & temporarily covered with tarpaulin to avoid any water infiltration. Blocked drainage at the foot slope should be made clear for free flow of water. Surface water is diverted from unstable slopes by ditches and pipes.
38	Remarks, if any		The excavated slope if left untreated is sure to pose threat

			during heavy rainfall.
39	Photos. Sketch of Plan & section of the slide	:	 **View from crown of the earth flow followed by subsidence**  **Bulging of the ground at the toe of the slide**
40	Summary/Abstract	:	Massive earth slide initiated from the forest region as rotational failure & is further moved down as earth flow collecting material from upper catchment area. The slide occurred on southerly slope during rain event of August 2019. The slope is modified by cutting the hillside slope and diversion of stream for increasing agriculture area and for better irrigation. Earth slide on 08th August 2019 occurred due to toe erosion by first order easterly flowing stream during heavy rainfall. The stream discharging its water to Linganamakki reservoir. During intense rainfall, ground water level rose as a result of filling reservoir. Groundwater saturation may increase pore pressures within the weathering profile associated with these zones and thus reduce strength. It is observed that at a stretch of approx. 120 m along the stream, small to large scale earth slides are occurring due to varying degree of toe erosion. The increase in water level ultimately aggravated the toe erosion by stream causing steepening of slope due to undercutting making the slope vulnerable to fail. The ridge part of the hill is covered with sparse vegetationand thin slope wash,

			whereas in the mid slope & downslope the thickness of the soil increases and attains a thickness >7m.Rapidly running water and gravity driven movement induced by lubricating action of ground water thus derived the debris down slope at faster pace destroyed much of the forest area and plants of Acacia and Areca nut. Soil from the slide has blocked the stream flow, resulting in diversion of water into the agriculture land. Subsidence and crown cracks are observed on the upper part of the slide shows that the slide is still active and retrograding.Transverse cracks (at N13°57'11.6"and E74°53'52.3") and land subsidence observed on top of the hill that recurred to form another slide.Huge soil is accumulated in the zone of accumulation. This could surely impose another threat during heavy rain.People living around these slopes should remain vigilant, particularly during themonsoon period and any physical change in the slope or widening of the landslide crack should immediately bring into the notice of authorities. The plantation land at the foot of the slope has bulged up to 4ft.This may be the toe of the displaced material along the slip circle. It can also be due to addition of water to the soil mass (over-consolidated soil) that increased groundwater level resulted in increased hydrostatic pressure and bulged ground.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/102
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Kirkodi
7	Latitude	:	13.9771
8	Longitude	:	74.8876
9	Length *(m)*	:	~45
10	Width *(m)*	:	~35
11	Height *(m)*	:	~25
12	Area *(m2)*	:	
13	Depth *(m)*	:	~2
14	Volume *(m3)*	:	~3150

15	Run out distance *(m)*	:	Debris terminated and flown with the reservoir
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Deep translational failure
23	History	:	
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Laterite
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation with bushes on upslope. Hill is bounded by Linganamakki reservoir.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest landdestroyed under earth flow.Forest trees uprooted due to slide.
36	Geo-scientific Causes	:	The hill is bounded by reservoir therefore the flow regime is changed in the area. Heavy rainfall is a critical factor in triggering landslide because it generates rapid increases in pore pressure and groundwater flow in the saturated area. Toe erosion accelerated during rain, undercut the slope making it steeper & increasing the slope instability. Laterite thickness of more than 10m adding the weight on saturation.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Google imagery of the slide induced due to reservoir flooding** ***(Imagery date: 26/11/2019)***  **Field Photo of the slide taken from a distance**
40	Summary/Abstract	:	Massive earth slide initiated as translational failure on westerly slope. The slide initiated after reservoir flooding during incessant and high rain event of August, 2019.The area is inaccessible, and therefore the study has been carried out remotely. Laterite soil thickness of more than 10m at the exposed failure slope and sparse vegetation on upslope is observed. With the filling of reservoir, the surrounding ground water level rose. Groundwater saturation increased the pore pressures within the weatheredlateritic profile associated and thus reducedcohesion and shear strength and increased its weight and bulk density. Moreover, the resulting flood undercut the slopes to produce landslide.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/103
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Kirgodi; Kapdur-Malur road
7	Latitude	:	13.9469
8	Longitude	:	74.8608
9	Length *(m)*	:	~14
10	Width *(m)*	:	~30
11	Height *(m)*	:	~11
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~210
15	Run out distance *(m)*	:	~05
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Hb-actinolite- chlorite schist intruded by Dolerite and Quartzite
26	Structure	:	Not observed
27	Land use/ Land cover	:	Sparse vegetation. Slope cut for extending agriculture area.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land destroyed due to mass failure.
36	Geo-scientific Causes	:	Removal of toe support for increasing agriculture area and diversion of stream for irrigation. Toe erosion by diverted stream which has undercut the slope making it steeper and thus unstablised the slope. Soil cover thickness is more than 5 to 7m adding the weight on saturation. Reduction of shear strength of soil on super- saturation due to heavy rain.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Blocked drainage at the foot slope should be made clear for free flow of water. Drainage should be provided with concrete lining.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of earth slide initiated due to toe erosion by stream**
40	Summary/Abstract	:	The landslide is an active earth slide having translational movement along rupture plane. Earth slide occurrence is due to anthropogenic activities i.e. Slope cut and diversion of stream for increase of agriculture area or for better irrigation. Diversion of stream towards foot of the slope accelerates the toe erosion during rainfall. This causes steepening of slope due to undercutting and thus fails due to overloading and reduced shear strength.Also, the contact zone between dolerite/quartzite (intrusive) and Hb-actinolite- chlorite schist (Weathered rock) act as zone of groundwater migration. Groundwater saturation may increase pore pressures within the weathered profile associated with the zone and thus reduces strength.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/104
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Malur
7	Latitude	:	13.9528
8	Longitude	:	74.8515
9	Length *(m)*	:	~ 16
10	Width *(m)*	:	~ 40
11	Height *(m)*	:	~ 12
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~640
15	Run out distance *(m)*	:	~ 10
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Very Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Slide occurred in the year 2018 has been rejuvenate in the year 2019
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Hornblende-actinolite-chlorite schist and Quartzite
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation and bushes on upslope, slope-cut for increasing Areca-nut plantation area at downslope.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil

33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Areca nut Plantation of Halappa, Malur Grama is partly damaged due to stream blockage and diversion.
36	Geo-scientific Causes	:	Lithology contacts of Quartzite (competent) and Hb-actinolite-chlorite schist (highly weathered) facilitating percolation of water that increased hydrostatic pressure and reduced shear strength. While Removal of toe support due to IInd order stream erosion are the primary causes that tend to reduce the shearing strength. Since the area has already witnessed an old slide earlier, the old cracks so formed may have played a key role for rainfall infiltration.
37	Recommendations	:	Easing of slope with proper grading with plantation of deep rooted trees will increase the slope stability. Drainage system should be supported by concrete work. Blocked stream should be made clear of landslide debris.
38	Remarks, if any		Slide reactivated in the month of August,2019 as conveyed by Halappa (local resident)
39	Photos. Sketch of Plan & section of the slide	:	 **Reactivated slide exposes rock/weathered rock at the rupture plane**
40	Summary/Abstract	:	A reactivated slide is observed due to toe erosion by southerly flowing stream during heavy incessant rainfall. This causes steepening of slope due to undercutting and thus failed due to overloading and reduced shear strength. The pre-existing plane of interface between soil and weathered rock has led to separation and the consequential movement aided by water action. The old slip zone with lower permeability was an important factor to cause the infiltrated water to accumulate and form a high pore water pressure zone above slip zone. The high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide deposit again. Consequently the saturated debris moved down the slope along a weak plane under the influence of gravity exposing rock/weathered rock at the body of slide. The slide is

			adjacent an old slide, which is covered with bushes.
41	Date of Reporting	:	
42	Landslide Category	:	II

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/105
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Mallur
7	Latitude	:	13.9534
8	Longitude	:	74.8591
9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 30
11	Height *(m)*	:	~ 15
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~270
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivated
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation on upslope and Cultivation downslope
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil

31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Areca nut plantation of Yogaraj is partly damaged due to flooding.
36	Geo-scientific Causes	:	Removing soil from hillsides for increasing cultivation area results in a significant reduction in lateral support. Diversion of main stream channel towards hill side accelerated toe erosion. Reduction of shear strength of soil on super-saturation due to heavy rain. The exposed vertical cut section is highly weathered lead to accelerate the mass failure.
37	Recommendations	:	Natural drainage should be left unaltered. Plantation/Cultivation on the nala/stream should be avoided for the free flow of water. Benching on the slope is advisable for easing the slope. The drainage should be lined with concrete to avoid any infiltration from the stream.
38	Remarks, if any		Main course of stream is converted into cultivation land.
39	Photos. Sketch of Plan & section of the slide	:	 **Distant view of reactivated slide adjacent to an old suspended slide**

			 **Main course of stream converted into cultivation land with diversion of stream towards hill side**
40	Summary/Abstract	:	Debris slide in the month of August, 2019 reactivated and occurred due to anthropogenic activities i.e. extensive slope cut and diversion of stream for increase of agriculture area or for better irrigation. Diversion of large stream towards foot of the slope into smaller area accelerates the toe erosion during rainfall. This causes steepening of slope due to undercutting and thus fails due to overloading and reduced shear strength. The slide is seen occurring all along the stream where the vertical cut exceeding 5m.The slide is associated with an old suspended slide. The small man-made stream unable to accommodate the large volume of water during rain and therefore the water rushed to the cultivation land (earlier main course of stream) destroyed paddy crops. The slope is covered with bushes and scattered trees. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/106
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Kattinkal
7	Latitude	:	13.9925
8	Longitude	:	74.8079

9	Length *(m)*	:	~20
10	Width *(m)*	:	~62
11	Height *(m)*	:	~16
12	Area *(m2)*	:	
13	Depth *(m)*	:	~3
14	Volume *(m3)*	:	~3720
15	Run out distance *(m)*	:	~20
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Deep planar failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Laterite
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation with bushes on upslope. Extensive Slope cut for extending plantation area downslope.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land destroyed due to mass fail.
36	Geo-scientific Causes	:	Removal of toe support for increasing plantation area and diversion of stream for irrigation. Toe erosion by diverted stream undercut the slope making it steeper and thus madethe slope unstable. Laterite cover thickness is more than 10m adding the weight on saturation. Reduction of shear strength of soil on super- saturation due to heavy rain;
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Deep rooted plants should be grown on the slope. Blocked drainage at the foot slope should be made clear for free flow of water. Drainage should be provided with concrete lining.

38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of multiple earth slides occurred along the stream**  **Crown View of the earth slide showing retrogression**  **Crown View of the earth slide showing thick lateritic soil**
40	Summary/Abstract	:	Multiple earth slidesin the month of August, 2019 occurreddue to removal of soil from hillsides for increasing cultivation area leaving behind a vertical cut section and diversion of main stream channel towards hill side. The southerly running IIndorder stream during heavy rain

			charged with large volume of water and was lacking in place. This resulted in acceleration of toe erosion of the slope. The highly weathered vertical cut section has been undercut making the slope unstable. Saturated lateritic soil corresponds to thickness more than 10m adding an extra stress on slope. The gentler slope with sparse vegetation and bushes has reduced soil strength thus produced an extra stress on slope. Thus, the slope failed due to overloading and reduced shear strength. Consequently the saturated soil moved down the slope along a weak plane under the influence of gravity. It is observed that several small to large mass failures on vertical cut sections occurred along the stream run off. Transverse cracks above the crown reveal that the slide is still active & retrogressive. Fractured crown as observed can trigger another mass failure in the event of rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/107
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi-Kasgod road
7	Latitude	:	13.9153
8	Longitude	:	74.8320
9	Length *(m)*	:	~ 11
10	Width *(m)*	:	~ 8
11	Height *(m)*	:	~ 9
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~56
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure

23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz-chlorite schist and Hornblende-actinolite-chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation on upslope, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth of soil and weathered rock mass. Removal of toe support after road cutting is the primary causethat tends to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail. The slide is occurring at the litho contact between Quartz-chlorite-schist and Hornblende-actinolite-chlorite schist. The contact act as a path for facilitating the water infiltration & thus giving rise to increase in hydrostatic pressure leading to failure subsequently.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Debris accumulated in the drainage line should be cleared. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of a road cut initiated debris slide**
40	Summary/Abstract	:	The debris slide is observed to have occurred on the south-westerly slope. Initially, slope has been extensively cut for road construction making it unstable. The slope forming material observed on the slope corresponding to soil thickness of 3m to 5m got saturated by percolation of water during rains which increased its mass. The slide is occurring at litho contact of Qtz-chlorite-schist and Hb-actinolite-chlorite schist. The lithology contact also played an important role in infiltration of water and increased ground water saturation. This may have increased the pore pressure within the weathered profile associated with this zone and thus reducedthe shear strength.Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. Top of the hill isbarren and sporadic sparse vegetation is observed reflecting presence of rock and thin soil cover. Downslope below the road bench, higher order stream is running easterly.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/108
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Nagodi- Kodanagar road
7	Latitude	:	13.9203
8	Longitude	:	74.8178

9	Length *(m)*	:	~ 18
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 15
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~360
15	Run out distance *(m)*	:	~ 5
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow translational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite-schist
26	Structure	:	Foliation:NE-SW
27	Land use/ Land cover	:	Sparse vegetation on upslope, Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.Schist is characterized by flaky minerals which weather quickly and promote instability.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.

38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **Earth slide along the Nagodi-Kodanagar road**
40	Summary/Abstract	:	Earth slide initiated as a planar failure and is occurredduring the rain event of August2019. Initially, slope has been cut for road construction making the slope unstable. The thick soil covers over the hard rock got saturated by percolation of water during rains that added the weight and increased pore water pressure thereby reduced the cohesive strength. Top of the hill is barren and sporadic sparse vegetation is observed reflecting presence of rock and thin soil cover.However highly weathered soil is observed on the slope corresponding to soil thickness of 3m to 5m. Consequently, the saturated debris material moved down the slope along a weak plane under the influence of gravity. Downslope below the road bench, higher order stream running easterly and flood plain is observed.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/109
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Magod; Milestone:Kollur-21Km
7	Latitude	:	13.9443
8	Longitude	:	74.8330
9	Length *(m)*	:	~ 14

10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~11
12	Area *(m2)*	:	
13	Depth *(m)*	:	~2
14	Volume *(m3)*	:	~336
15	Run out distance *(m)*	:	~ 5
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow translational failure
23	History	:	Not known
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite-schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation and bushes on upslope, Extensive cut slope for road
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength. The slide has occurred during heavy rainfall that caused infiltration of water resulting in building up of pore water pressure and reducing the cohesive strength.Schist is characterized by flaky minerals which weather quickly and promote instability.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage at the base of slope should be provided with concrete lining. Landslide debris accumulated at the drainage line should be removed before next rain.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Earth slide due to extensive slope cut**
40	Summary/Abstract	:	Earth slide initiated as a planar failure and is occurredduring the rain event of August2019. Initially, slope has been cut for road construction making the slope unstable. The thick soil cover over the hard rock got saturated by percolation of water during rains that added the weight and increased pore water pressure thereby reduced the cohesive strength. Top of the slope is covered with bushes and scattered trees reduces soil strength thus produced an extra stress on slope.However highly weathered soil is observed on the exposed failure surface corresponding to soil thickness of 3m to 5m. Consequently the saturated debris material moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/110
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sulvalli- Herbettu road
7	Latitude	:	13.9470
8	Longitude	:	74.7785
9	Length *(m)*	:	~ 22
10	Width *(m)*	:	~ 50
11	Height *(m)*	:	~ 20

12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~1100
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Moderately dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist and Quartzite
26	Structure	:	Foliation trending NNW, dipping 40°ENE
27	Land use/ Land cover	:	Barren slope covered partly with bushes and occasionally small trees , Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Soil thickness varies from 1m to 2m corresponding to soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall triggered the mass to fail.The slide is occurring at the litho contact between Hb-actinolite-chlorite schist and quartzite. The contact act as a path for facilitating the water infiltration & thus giving rise to increase in hydrostatic pressure leading to failure subsequently.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Debris accumulated in the drainage line should be cleared. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **View of a slope cut initiated debris slide**
40	Summary/Abstract	:	Multiple debris slidesare observed to have occurred on the northerly slope. Initially, slope has been extensively cut for road construction making it unstable. The quartzite is intruded into schist and along these contact, the schist is showing a high degree of alteration and development of reddish-brown, coarse-grained sandy matrix. The litho contact played an important role in infiltration of water and increased ground water saturation. This may haveincreased thepore pressure within the weathered profile (schist) associated with this zone and thus reducedshear strength. The percolating water through soil adding an extra weight that reduced the slope strength. Increased water easily percolates and reduced the friction along zone of weakness causing material above that particular plane to slide along the lubricated surface. The failure surface is highly wet and covered with bushes reflecting the shallow ground water level.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/111
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Sulvalli-Herbettu road
7	Latitude	:	13.9449
8	Longitude	:	74.7760

9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 32
11	Height *(m)*	:	~ 17
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~640
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Reactivate
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Not known
24	Geomorphology	:	Moderately dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist and Quartzite
26	Structure	:	Foliation trending NNW, dipping 40°ENE
27	Land use/ Land cover	:	Barren slope covered partly with bushes and occasionally small trees , Extensive cut slope for road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Soil thickness varies from 3m to 5m corresponding to soil and weathered rock mass. Removal of toe support after road cutting, high slope gradient are the primary causes that tend to reduce the shearing strength while heavy antecedent rainfall trigger the mass to fail.The slide is occurring at the litho contact between Hb-actinolite-chlorite schist and quartzite. The contact act as a path for facilitating the water infiltration & thus giving rise to increase in hydrostatic pressure leading to failure subsequently.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Debris accumulated in the drainage line

			should be cleared. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of reactivated debris slide partly covered with bushes**
40	Summary/Abstract	:	Debris slide is observed to have reactivated and occurred on the northerly slope. Initially, slope has been extensively cut for road construction making it unstable. The quartzite is intruded into schist and along these contact, the schist is showing a high degree of alteration and development of reddish-brown, coarse-grained sandy matrix. The litho contact played an important role in infiltration of water and increased ground water saturation. This mayhave increased pore pressure within the weathered profile (schist) associated with this zone and thus reducedshear strength.Since the area already witnessed an old slide earlier, the old cracks so formed may also played a key role for rainfall infiltration. The old slip zone with lower permeability was another important factor to cause the infiltrated water to accumulate and form a high pore water pressure zone above slip zone. The high pore water pressure zone decreased the shear strength of slip zone and triggered the reactivation of an old landslide again.The crown part is visible, while the accumulation zone is wet and partly covered with bushes. The runoff material has been dumped on the other side of the road.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/112
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13

5	Name of the slide	:	
6	NH/SH/Locality	:	Ikkibilu- Kirgodgi road
7	Latitude	:	13.9384
8	Longitude	:	74.8485
9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 14
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~98
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Hb-actinolite-chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Sparse vegetation on upslope, Slope cut for construction of road
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removal of toe support after road cutting is the primary cause that tend to reduce the shearing strength while heavy antecedent rainfall triggeredthe mass to fail. There is no lateral support along the road. Regolith /Soil thickness varies from 3m to 5m corresponding to considerable depth

			of soil and weathered rock mass.
37	Recommendations	:	Easing of slope with proper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work and any obstructions in the drainage should be cleaned.
38	Remarks, if any		
39	Photos. Sketch of Plan & section of the slide	:	 **View of an old Suspended slide**
40	Summary/Abstract	:	An old suspended slide is observed in easterly slope. Initially, slope has been cut for road construction making it unstable. The slope forming material (SFM) laying over the hard rock got saturated by percolation of water during rains which increased its mass, decreased the shear strength. Consequently, the saturated material moved down the slope along a weak plane under the influence of gravity. Shallow rooted plants and bushes are observed on upslope are unable to withhold the soil and easy to erode during rain.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/113
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Ikkibilu- Kirgodgi road
7	Latitude	:	13.9322
8	Longitude	:	74.8454
9	Length *(m)*	:	~20

10	Width *(m)*	:	~60
11	Height *(m)*	:	~16
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~320
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Multiple
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old Slide
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation trending NW-SE
27	Land use/ Land cover	:	Thick vegetation. Slope cut for extending agriculture area.
28	Hydrological condition	:	Damp
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes. Aggravated toe erosion by IInd order stream.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Removing soil from hillsides for increasing cultivation area results in a significant reduction in lateral support. Diversion of main stream channel towards hill side accelerates toe erosion. Infiltration of water made their way inside the slope making a seepage path thereby making a potential slide surface.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Natural flow of drainage should be unaltered. Plantation/Cultivation on the flow path of stream should be avoided for the free flow of water.
38	Remarks, if any		Main course of stream is converted into agriculture land.

39	Photos. Sketch of Plan & section of the slide	:	 **Distant view of an old slide** ***Natural course of stream converted into agriculture land***
40	Summary/Abstract	:	Multiple old debris slides occurreddue to removal of soil from hillsides for increasing cultivation area leaving behind a vertical cut section and diversion of main stream channel towards hill side. The north-easterly running IIndorder stream during heavy rain charged with large volume of water and was lacking in accommodation. This resulted in acceleration of toe erosion of the slope. The highly weathered vertical cut section has been undercut making the slope unstable. Saturated soil corresponding to thickness more than 5m adding an extra stress on slope. Thus, the slope failed due to overloading and reduced shear strength. Consequently the saturated soil moved down the slope along a weak plane under the influence of gravity.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	**Field**		**Description**
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/114
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	48K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Vill. Changvalli
7	Latitude	:	13.9300
8	Longitude	:	74.8700
9	Length *(m)*	:	~20
10	Width *(m)*	:	~25

11	Height *(m)*	:	~14
12	Area *(m2)*	:	
13	Depth *(m)*	:	~0.5
14	Volume *(m3)*	:	~250
15	Run out distance *(m)*	:	~20
16	Type of Material	:	Earth
17	Type of movement	:	Slide
18	Rate of movement	:	Extremely Rapid
19	Activity	:	Active
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow rotational failure
23	History	:	Not known
24	Geomorphology	:	Lowly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Not distinct
27	Land use/ Land cover	:	Moderate vegetation on upslope. Extensive Slope cut for extending plantation area downslope.
28	Hydrological condition	:	Wet
29	Triggering Factor	:	Intense and (or) sustained rainfall lead to the saturation of slopes.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Part of Forest land & trees destroyed due to mass fail. Areca nut plantation suffered from flooding resulted due to stream diversion.
36	Geo-scientific Causes	:	Removal of toe support for increasing plantation area and diversion of stream for irrigation. Toe erosion by diverted stream undercut the slope making the slope unstable. Soil thickness is more than 5m adding the weight on saturation. Reduction of shear strength of soil on super- saturation due to heavy rain and ground water change.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Deep rooted plants should be grown on the slope. Blocked drainage at the foot slope should be made clear for free flow of water.
38	Remarks, if any		Encroachment of valley for plantations is aggravating landslide proneness.

39	Photos. Sketch of Plan & section of the slide	:	 **View of an earth slide occurred along the convex part of stream**
40	Summary/Abstract	:	Earth slide in the month of August, 2019 occurreddue to removal of soil from hillsides for increasing plantation area leaving behind a vertical cut section and diversion of main stream channel towards hill side. During high incessant rain, voluminous water doesn't accommodate in the stream channel resulting in flooding in plantation area, also result in ground water raise. This resulted in acceleration of toe erosion of the slope. Groundwater saturation increased pore pressures within the weathered profile associated with this zone and thus reduce the strength. The gentler slope with sparse vegetation and bushes reduced soil strength and produced an extra stress on slope. Consequently, the saturated soil moved down the slope along a weak plane under the influence of gravity. Forest trees uprooted due to the sliding, while stream blocked with landslide materials got diverted into plantation land. These results in flooding and destroy of Areca nut trees.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/115
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kodachadri
7	Latitude	:	13.8670
8	Longitude	:	74.8986

9	Length *(m)*	:	~ 14
10	Width *(m)*	:	~ 12
11	Height *(m)*	:	~ 13
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~168
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist and Banded magnetite quartzite
26	Structure	:	Foliation: NW, dipping 40°NE
27	Land use/ Land cover	:	Thick vegetation, slope cut for jeepable road
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Jeepable road cutting on the steep slope and removal of soil from hillsides results in a significant reduction in lateral support, while heavy antecedent rainfall triggered the mass to fail. Improper and inadequate drainage arrangements along the road side.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the steep slope and at the bend of the road. The inclination of planar failure slope is observed to be around 50°. Initially, high angel slope has been cut for construction of road making the slope unstable. The slope forming material laying over the hard rock got saturated by percolation of water during rains which increased its mass. The saturated debris material moved down the slope along a weak plane under the influence of gravity. Removal of debris exposing the underlying rocks below the crown. Another reason that facilitates the slope-mass to failure is the litho contact between Quartz chlorite schist (weathered) and Banded magnetite quartzite that was disturbed by road cutting thus increased stress. The contact zone act as zone of groundwater migration.Groundwater saturation may have increasedthe pore pressures within the weathered profile associated with this zone and thus reduced strength. The failure surface of the slide is covered with bushes and small trees.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/116
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kodachadri
7	Latitude	:	13.8672

8	Longitude	:	74.8854
9	Length *(m)*	:	~ 12
10	Width *(m)*	:	~ 20
11	Height *(m)*	:	~ 10
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~240
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation: NW, dipping 40°NE
27	Land use/ Land cover	:	Barren with occasional bushes, slope cut for jeepable road
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Jeepable road cutting on the steep slope and removal of soil from hillsides results in a significant reduction in lateral support. Improper and inadequate drainage arrangements along the road side.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work. Blocked drainage should be made free for the water flow.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide along the road bend**
40	Summary/Abstract	:	An old suspended slide is observed to occur due to improper drainage network along the road side. The inclination of planar failure slope is observed to be around 50°. Initially, slope has been cut for construction of jeepable road making the slope unstable. The slope is further modified for drainage and left without giving any concrete measure. During heavy rain the drainage increased toe erosion towards the hill side at the road bend. This resulted in removal of lateral support with saturation of overlying material. The saturated debris material moved down the slope along a weak plane under the influence of gravity.The slope is barren with thin slope wash. The blocked drainage should be made clear to avoid any sub-surface flow or sub-surface erosion. This can lead to road subsidence or mass failure at downslope.
41	Date of Reporting	:	
42	Landslide Category	:	III

GEOPARAMETRIC DATA SHEET (42 POINTS)

No	Field		Description
1	Location/ Slide No.	:	KAR/SHIMOGA/48K13/2019/117
2	State	:	Karnataka
3	District		Shimoga
4	Toposheet No.	:	4K/13
5	Name of the slide	:	
6	NH/SH/Locality	:	Kodachadri
7	Latitude	:	13.8627
8	Longitude	:	74.8750
9	Length *(m)*	:	~ 20
10	Width *(m)*	:	~ 22

11	Height *(m)*	:	~ 16
12	Area *(m2)*	:	
13	Depth *(m)*	:	~1
14	Volume *(m3)*	:	~440
15	Run out distance *(m)*	:	Not observed
16	Type of Material	:	Debris
17	Type of movement	:	Slide
18	Rate of movement	:	Rapid
19	Activity	:	Suspended
20	Distribution	:	Retrogressive
21	Style	:	Single
22	Failure mechanism	:	Shallow planar failure
23	History	:	Old slide
24	Geomorphology	:	Highly dissected slope
25	Geology/Lithology	:	Quartz chlorite schist
26	Structure	:	Foliation: NW, dipping 40°NE
27	Land use/ Land cover	:	Thick vegetation, slope cut for jeepable road
28	Hydrological condition	:	Dry
29	Triggering Factor	:	Incessant rainfall is deduced to be the main triggering factor.
30	Death of persons	:	Nil
31	People affected	:	Nil
32	Livestock Loss	:	Nil
33	Communication	:	Nil
34	Infrastructure	:	Nil
35	Agriculture/forest/Barren	:	Nil
36	Geo-scientific Causes	:	Jeepable road cutting on the steep slope and removal of soil from hillsides results in a significant reduction in lateral support, while heavy antecedent rainfall triggers the mass to fail. Improper and inadequate drainage arrangements along the road side.
37	Recommendations	:	Easing of slope withproper grading, possibly reduce the hazard considerably. Drainage system along the road should be supported by concrete work.
38	Remarks, if any		

39	Photos. Sketch of Plan & section of the slide	:	 **Old Suspended slide covered with vegetation**
40	Summary/Abstract	:	An old suspended slide is observed to have occurred on the steep slope and at the bend of the road. The inclination of planar failure slope is observed to be around 50°. Initially, high angel slope has been cut for construction of jeepable road making the slope unstable. The slope forming material laying over the hard rock got saturated by percolation of water during rains which increased its mass. The saturated debris material moved down the slope along a weak plane under the influence of gravity. Removal of debris exposing the underlying rocks below the crown. The failure surface of the slide is covered with bushes and small trees.
41	Date of Reporting	:	
42	Landslide Category	:	III

Annexure-III

Average Annual Rainfall pattern in and aroundstudy area from 2010 to 2019.

Rain-gauge Stations	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sagara T.B	2159.6	2057.7	1445.8	2309.6	2224.9	1466.6	1212.5	1562.6	1912.9	2186.4
Anandapura	1989	1531.9	1291.4	1762.6	1909.8	1166.6	1138.6	1069.2	1583.89	2085.63
Avinahalli	2776.3	2658.6	1917.6	2873.2	2942	1335	1342.3	1771	2327.25	2784.66
Thyagarthi	1839.2	1513.7	1119.6	1846.4	1958.5	1065.3	866.3	1179.6	1578.5	1917.7
Guttanahalli	2045.3	1556.2	995.8	1628.4	1431.1	871.6	630.3	1178	1535	1319
Gowthampura	2045.3	1264.29	1264.29	1402.9	1759.4	1126.9	872.1	1067.2	1391.3	2445.9
Joga	4883.2	6022.9	4964.9	6694	6524.9	3752.1	3937.7	3796.4	5624	5154
Linganamakki Dam	3346.6	3989.5	2965.1	4425.4	4145.3	2916	2357.8	2407.6	3890	4425
Hosanagara Hobli	3149.3	3704	2489.7	4034.1	4414.1	3309.2	1633.8	3156.1	2812.9	3659.34
Shikaripur Hobli	1208.7	768.8	859.1	1184.3	1411.7	754	686	743.8	1040.17	1216.12
Shiralakoppa	1157.8	1029.4	809.6	1214.4	1444	675.4	553	597.2	702	909
Hosuru	1196.5	904.5	761.8	930.1	964.1	734.5	629.7	851.8	845.16	1101.84
Udugani	1350	1055.1	892.4	1296.3	1377.8	871.5	748.4	908.4	899.45	1283.18
Mani Dam	6014.1	7142.4	6779.4	7960	6610	5165	4009	4921	5165	7960
Sampekatte	3540	4138.3	3916	5559	4805.4	2698.2	2625.2	3315.4	2813	5519.3
Savehaklu	6553.8	8106.8	7709	7880	6722.3	4965	4648	4771	4709.5	5371.5
Nagara	4465.8	5503.8	5441.2	5755	5484.3	3549	3557	3917	5051	5713.5
Kundapur	4906	4370	4157	4800.2	3544.4	3628.5	3332.1	3669.8	4288.64	5389.18

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