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भारत सरकार
भारतीय भूवैज्ञानिक सर्वेक्षण
GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA

कर्नाटक राज्य के कोडागु, मैसूर, शिमोगा और चिक्मगलुर जिलो में भूआकृति संख्या 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01 और 49M/13 के कुछ हिस्सों में वृहद पैमाने पर (1: 50,000) भूस्खलन संवेदनशीलता मानचित्रण

(कार्य सत्र कोड संख्या: एम4एलएसएसएम/एनसी/एसआर/एसयू-केजी/2019/25179-32984)

(कार्य सत्र: 2019 - 2021)

MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NOS. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01 AND 49M/13 CHIKMAGALUR, KODAGU, MYSORE AND SHIVAMOGA DISTRICTS, KARNATAKA

(FSP CODE NO: M4LSSM/NC/SR/SU-KG/2019/25179-32984)

FIELD SEASONS: 2019-20, 2020-21

By

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STATE UNIT: KARNATAKA & GOA/ राज्य इकाई: कर्नाटक एवं गोवा

2021

भारत सरकार
भारतीय भूवैज्ञानिक सर्वेक्षण
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Field Seasons: 2019-20, 2020-21

By

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सारांश

पर्याप्त सुदूर संवेदन एवं क्षेत्र आयातों का उपयोग करते हुए 1:50, 000 पैमाने पर जीआईएस पर आधारित सीवनहीन भूस्खलन सुग्राहिता मानचित्र तथा त्रिविम भूस्खलन आधारभूत तैयार करने के लिए टोपोशीट सं. 48ओ/09, 48ओ/10, 48ओ/14, 57डी/03, 57डी/04, 58ए/01, 49एम/13 के भागों में कर्नाटक के चिक्कमंगलूरु, कोड़ग, मैसूर एवं शिवमोगा जिलों में भूस्खलन सुग्राहिता मानाचित्रण किया गया। अध्ययन क्षेत्र दो भागों में, यानि दक्षिणी भाग एवं उत्तरी भाग में विभाजित है। अध्ययन क्षेत्र के दक्षिणी भाग में कोड़ग एवं मैसूर जिलों के भाग आते हैं एवं कुल 548 वर्ग किलोमीटर क्षेत्र को कवर करते है, जो क्षेत्र टोपोशीट सं. 57डी/03, 57डी/04, 58ए/01, 49एम/13 में आते हैं। जबकि अध्ययन क्षेत्र के उत्तरी भाग में चिक्कमंगलूरु एवं शिवमोगा जिलों के भाग आते हैं व कुल 847 वर्ग किलोमीटर क्षेत्र को कवर करते है तथा टोपोशीट सं. 48ओ/09, 48ओ/10, 48ओ/14 में आते है।

आईआरएस, एलआईएसएस-III आँकड़े, कार्टोड़ेम तथा बहु-कालिक गूगल चित्रों की चाक्षुक व्याख्या के द्वारा आर्कजीआईएस में पूर्व-क्षेत्र मानचित्रों के लिए भूमि उपयोग/भूमि आच्छादन (भूउ/भूआ), भूआकृतिविज्ञान, ढाल गठन सामग्री (ढागसा), रिगोलिथ की स्थूलता (रिस्थू), अपवाह-तंत्र, ढाल आकारमिति (ढाल, अभिमुखता एवं वक्रता) तैयार किए गए। भूस्खलन सुग्राहिता मानचित्रण में विभिन्न विषयक मानचित्रों की तैयारी, उन पूर्व-क्षेत्र एवं एल-एस मॉड़लिंग के मान्यकरण के कार्य सम्मिलित है। क्षेत्र अध्ययन के दौरान 13 नए भूस्खलन की आकस्मिक घटनाएँ घटित हुईं एवं सभी निर्धारित प्रपत्र में रिकाड़ की गईं।

अधिकांश भूस्खलन विकृत ढालों यानि परिवर्द्धित ढाल सहित विस्तृत कर्तन ढाल (विकढा) मार्ग सेक्शन के किनारे अभिनिर्धारित किए गए हैं। ये ढाल राज्य राजमार्ग व राष्ट्रीय राजमार्ग तथा स्थानीय मार्गों के विस्तारित करने एवं दीर्घीकरण के लिए परिवर्द्धित किए गए हैं। इन भूस्खलन आपतनों के प्रेरणार्थक कारक मुख्यतया मानवजनित है, यानि पाद भाग को निकालने के द्वारा ढालों के अस्थायीकरण, पाद भाग एवं ढालों में उचित अपवाह-तंत्र की कमी, जिससे संधियों एवं विभंगों जैसे क्षीण सतहों में जल के रिसने का कारण बन जाता है। अध्ययन क्षेत्र में भूस्खलन के मुख्य ट्रिगरिंग कारक भारी वर्षा है, जिसने अपक्षयित चट्टान पिंड़ पर छिद्र दाब को बढ़ाने में मुख्य भूमिका निभाई है, जो अपरूपण की शक्ति में कमी में परिणमित होती है, जिससे परिवर्ती फेलियर हो जाते है।

वर्तमान अध्ययन के दौरान कुल 13 नए भूस्खलन अभिनिर्धारित किए गए है, जिनमें से 11 भूस्खलन मलबे ढाल हैं तथा 02 चट्टान ढाल हैं। ईसीएस के प्रमुख स्ट्रेचस कल्लट्टिपुर गाँव के दक्षिण पश्चिम में कॉफी एस्टेट की ओर अभिनिर्धारित किए गए है, जो भविष्य में ढाल फेलियर के लिए सुभेद्य है। एक ईसीएस सन्टावेरी के दक्षिण की ओर, लगभग 1.5

किलोमीटर की दूरी पर स्थित है। इस ईसीएस के साथ 02 मलबे ढाल भी अभिनिर्धारित किए गए हैं। केम्मन्नुगुंड़ी से एब्बे जलप्रपात के मार्ग सेक्शन पर ईसीएस रिकार्ड़ किए गए है, जो मार्ग के विस्तारण तथा मार्ग के दीर्घीकरण के कारण है। ईसीएस पर धारक भित्ति तथा रेखित अपवाह-तंत्र प्रबंध किए जाने पर भी ढाल भविष्य फेलियर के लिए सुभेद्य है। कैमारा के पश्चिम में, दूपाकान कॉफी एस्टेट की ओर ईसीएस अभिनर्धारित किए गए है एवं 01 मलबे ढाल भी रिकार्ड़ किए गए है। मार्ग के इस स्ट्रेच पर भूस्खलन की घटना पुन: प्रतीक्षित है। मानचित्रण के वर्तमान स्केल के अनुसार अध्ययन क्षेत्र के दक्षिणी भाग सापेक्षिक रूप से किसी भी मुख्य भूस्खलन से रहित है, इर्पू जल प्रपात पर रिकार्ड़ किए गए 01 भूस्खलन ही इस भाग में रिकार्ड़ किए गए एकमात्र भूस्खलन है। अध्ययन क्षेत्र के दक्षिणी भाग में, कुट्टा-विराजपेट-मकुटा मार्ग सेक्शन पर मार्ग सेक्शन के विस्तारण का कार्य चल रहा है, जो निकट भविष्य में भूस्खलन आपतन के कारण बन सकता है, चूँकि मार्ग के निर्माण प्राधिकारियों के द्वारा भू-वैज्ञानिक कारकों को अधिक महत्व नहीं दिया जा रहा है।

क्षेत्र में घटित हो रहे अधिकांश स्खलन ढाल पर उपरिशायित के रूप में स्व-स्थाने मृदा/लैटराइटी/अपक्षयित चट्टान पर हो रहे है। चूँकि क्षेत्र में पर्याप्त संख्या में भूस्खलन/ढाल फेलियर हैं, क्षेत्र के सुग्राहिता रेटिंग विश्लेषणात्मक पदानुक्रम प्रक्रिया (विपप्र) पद्धति के द्वारा किए गए, जिसमें प्रत्येक कारक के लिए विशेषज्ञ या ज्ञान चालित तकनीकों का प्रयोग करते हुए रेटिंग तथा-अंतर प्रेड़िक्टर वज़न दिए जाने है। इन ज्ञान-चालित रेटिंग/वज़न को मात्रात्मक मेट्रिसस में गणितीय रूप से एएचपी की सहायता से आसान तरीके से निर्धारित किए जा सकते है, यह अंतर-प्रेड़िक्टर वज़नों के लिए विभिन्न भू कारक वर्गो तथा विभिन्न भू कारकों के लिए गुणात्मक युगलवार महत्वपूर्ण मैट्रिक्स को तैयार किए जाने/निर्णीत किए जाने के बाद निर्धारित किए जा सकते है, जो क्षेत्र में स्थानीय विशेषज्ञों तथा भूस्खलन संबंधी अध्ययन करने वाले वैज्ञानिकों से की गई चर्चा से एवं प्राप्त टिप्पणियों के आधार पर तैयार किए गए है।

अंतिम सुग्राहिता मानचित्र 92.79% क्षेत्र को निम्न भूस्खलन सुग्राहिता संस्तर में विभाजित करता है, 06.26% क्षेत्र को सामान्य सुग्राहिता संस्तर में तथा 00.94% क्षेत्र को उच्च भूस्खलन सुग्राहिता संस्तर में विभाजित करता है। टोपोशीट सं. 48ओ/14 के दक्षिण-पूर्वी सिरे एवं टोपोशीट सं. 48ओ/10 के दक्षिण-पूर्वी सिरे पर स्थित क्षेत्र ढालों के परिवर्द्धन के कारण भूस्खलन के लिए अधिक सुभेद्य है। केम्मन्नुगुंडी के दक्षिण पश्चिम में एवं हेब्बे जलप्रपात के उत्तर-पूर्व में 06 भूस्खलन अभिनिर्धारित किए गए है जो उच्च सुग्राहिता संस्तरों में आते हैं, यह इस तथ्य को पुष्टीकृत करता है कि अनियंत्रित ढाल परिवर्द्धन तथा मानवजनित कार्य भूस्खलन घटनाओं के लिए अनुकूल हैं। अधिकांश उच्च सुग्राहिता संस्तर 25°-35° के बीच के ढाल प्रवणता के अनुरूप है। भूउभूआ के अनुसार परिवर्द्धित ढालों एवं बहुतायत कर्तन ढालों में स्थित बस्तियों वाले क्षेत्र भूस्खलन के लिए अधिक सुग्राहिता युक्त क्षेत्र है। भूआकृतिविज्ञान के अनुसार अधिकतर ढाल निम्न विच्छेदित ढालों में होते देखे गए हैं, जहाँ बड़े पैमाने पर ढाल परिवर्द्धन देखे गए हैं। देखे गए स्खलन उथले संक्रामी मलबे स्खलन हैं; अधिकांश स्खलन चौड़े होने एवं विस्तारित प्रकृति के हैं।

MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NOS. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01 AND 49M/13 CHIKMAGALUR, KODAGU, MYSORE AND SHIVAMOGA DISTRICTS, KARNATAKA

(FSP CODE NO: M4LSSM/NC/SR/SU-KG/2019/25179-32984)

Field Season: 2019-2020, 2020-21

By

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ABSTRACT

Landslide Susceptibility Mapping in parts of Toposheets Nos. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01, 49M/13 Chikmagalur, Kodagu, Mysore and Shivamoga Districts, Karnataka was carried out to prepare a seamless landslide susceptibility map and spatial (GIS-based) landslide database on 1: 50,000 scale using adequate remote sensing and field inputs. The study area is divided into two parts, viz, Southern Part and Northern Part. The southern portion of the study area covers the parts of Kodagu and Mysore districts and covers a total of 548 Sq.Km. area which falls under the Toposheet nos. 57D/03, 57D/04, 58A/01, 49M/13. Whereas, Northern part of the study area covers the parts of Chikmagalur and Shivamoga districts and covers a total of 847 Sq.Km. area and falls under the parts of Toposheet nos. 48O/09, 48O/10, 48O/14.

The Pre-field maps for Landuse/Landcover (LU/LC), Geomorphology, Slope Forming Material (SFM), Regolith Thickness (RT), Drainage, Slope Morphometry (Slope, Aspect and Curvature) were prepared in ArcGIS platform through visual interpretation of IRS, LISS-III data, CartoDEM and multi-temporal Google Imageries. The landslide susceptible mapping involves preparation of different thematic maps, validating of these pre-field and finally Landslide Susceptibility modelling.

Most of the landslides have been identified on the disturbed slopes *viz*, Extensive Cut Slopes (ECS) along with the modified slopes of road sections. These slopes have been modified for the widening and lengthening of State Highways (SH's), National Highways (NH's) and local village/town roads. The causative factors for these landslide incidences are mainly anthropogenic *i.e.*, de-stabilisation of slopes by removal of toe, lack of proper drainage at toe part and on the slopes causing seepage of water into the weaker plane like joints and fractures. The triggering factor for landslides in the study area is mainly due to the

heavy rainfall which has contributed an ample role to increase in the pore pressure of the weathered rock mass resulting in reduction of shear strength leading to the subsequent failure.

During the current study a total of 13-new landslides have been identified, out of which 11-landslides are debris slide and 02 are rock slide. Prominent stretches of ECS have been identified along the Southwest of Kallattipur village towards the Coffee Estate, which is vulnerable for future slope failures. One ECS has been located towards the South of Santaveri, about 1.5Km south. Along this ECS, 02-debris slides have been also recorded. At the road section from Kemmannugundi to Hebbe falls, ESC has been recorded which is due to road widening and load lengthening. Considering the slope condition and the type of material present, the slope is vulnerable for future failure even though retaining wall and lined drainage has been provided at the ECS. West of Kaimara, towards Dupakan Coffee Estate, ECS has been identified and 01-debris slide has also been recorded. On this road section re-occurrence of landslide is expected due to material present on the slope and its behavioral pattern. The southern part of the study area is relatively devoid of any major landslide as per the present scale of mapping except the 01-landslide that has been recorded, i.e., debris slide at Irppu Water falls. In the southern part of study area, widening of road section is going on near Kutta-Virajpet-Makuta road section which may lead to the landslide incidence in near future as geo-scientific factors are not given due weightage by the road constructing authorities.

Most of the slides of the area are occurring in in-situ soil/lateritic/weathered rock as overburden on slope. As the area is lacking the adequate incidences of landslides/slope failures, the susceptibility rating of the area has been done using Analytical Hierarchy Process (AHP) method wherein ratings and inter-predictor weights are given to individual factors using expert or knowledge driven techniques. This knowledge-driven ratings/weights in quantitative matrices can easily be determined mathematically using AHP, after preparing/deciding on the qualitative pairwise importance matrix for different geo-factor classes and amongst different geo factors for inter-predictor weights, obtained through discussion and comments received from local experts and landslide scientists engaged in landslide studies in the area.

The final susceptibility map divides about 92.79% area that falls under low landslide susceptibility zone, 06.26% area are in moderate susceptibility zone and 00.94% area falls under high landslide susceptibility zone. The area on the south-western fringe of Toposheet no. 48O/14 and south-eastern fringe of Toposheet no. 48O/10 is more vulnerable towards the landslide due to modification of slopes. Southwest of Kemmannugundi and north-east of Hebbe falls 06-landslides have been identified which falls under high susceptibility zones, this substantiates the fact that uncontrolled slope modification and other anthropogenic activities favors landslide occurrence. Most of the high susceptibility zones correspond to slope gradient class between 25°- 35°. In terms of LULC the area having settlement on modified slopes and Extensive cut slopes has the maximum susceptibility to landslides. In terms of geomorphology most of the slides have been observed to occur in lowly dissected slopes where large scale slope modification was observed. The slides observed are shallow translational debris slide; majority of slides are old reactivated slides of widening and enlarging in nature.

MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NOS. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01, 49M/13 CHIKMAGALUR, KODAGU, MYSORE AND SHIVAMOGA DISTRICTS, KARNATAKA

(FSP CODE NO: M4LSSM/NC/SR/SU-KG/2019/25179-32984)

Field Season: 2019-2020, 2020-21

By

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1. INTRODUCTION

1.1 Background Information

Natural hazards are an integral component of life on Earth system. With the ever increasing population and large scale encroachment of hilly and forested areas, landslides have become a topic of serious concern in our society. The pressure for infrastructural 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. Kedarnath tragedy in Uttarakhand in 2013, Malin landslide, Maharashtra in 2014, Kodagu landslide in 2018 and Kerala landslide in 2018 are prime examples of the devastation that landslides can cause. The landslides are one of the normal landscape building processes in undulating terrain and are common in Himalayas, Nilgiries and the Western Ghat regions in our country. Nearly 15% (0.49 million Sq.Km.) area, spread over 1112 Survey of India topographic map sheets, are landslide-prone in India. Thus, a systematic approach is required to map these areas to spell out 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 (GSI), being the nodal agency of the country for landslide studies launched nation-wide programme of National Landslide Susceptibility Mapping (NLSM) project with an aim to generate the seamless landslide susceptibility mapping database across 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 and geo-factor database and GIS based landslide-dependent empirical techniques as well as knowledge based techniques (AHP) for the data integration and landslide susceptibility modelling. The prime objective of this national programme is to prepare a seamless nation-wide landslide inventory and susceptibility database for easy retrieval, use and updation in future whenever new events and large-scale changes in geo-environmental parameters are encountered.

Under the current study, the area covering Chikmagalur, Kodagu, Mysore and Shivamoga districts in Karnataka, has been carried out. The study area is located on the Western Ghats with high hills and undulating topography. Chikmagalur and Shivamoga district are located at the mid-northern part of the Western Ghats whereas, Kodagu and Mysore districts are located at south-eastern part of the Western Ghats. These districts with their distinct geomorphological, geological, hydrological and meteorological 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 LULC pattern causes landslides or slope failures affecting the population. Thus, these districts along with their scenic beauty and pleasant climatic conditions is also becoming known for natural hazards. Infrastructural development in the form of laying new roads and widening of the existing roads that involve the modification of slopes disturb the equilibrium attained by the nature. Majority of slopes along the highways pose significant risk mainly from rainfall-induced slope failures. Heavy rain during monsoon leads to slope saturation by water that decreases the effective cohesion and generates hydrostatic pressures in the soil profile ultimately resulting in slope failures. Infrastructure development in terms of widening of existing road and construction must progress taking into account the scientific methods of slope treatment to restore and minimise the risk to slope instability.

Under the NLSM programme of GSI, the following objectives have been prioritised -

(i) To prepare landslide inventory database using high resolution remote sensing data and field inputs,

(ii) To prepare Toposheet-wise (1: 50,000 scale) spatial database for geo-factors of landslides using as input maps, and

(iii) To prepare landslide susceptibility map using multi-class index overlay method in a GIS platform.

The landslide susceptibility mapping on scale 1: 50,000 covering 1395 Sq.Km. area in parts of Kodagu, Mysore, Shivamoga and Chikmagalur districts in Karnataka state was carried out under the Annual Programme of GSI, Southern Region, vide FSP Code No: M4LSSM/NC/SR/SU-KG/2019/25179-32984 during the field season: 2019-2020, 2020-21.

1.2 Study Area

The study area falls under the SOI Toposheet Nos. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01 and 49M/13 Chikmagalur, Kodagu, Mysore and Shivamoga Districts, Karnataka and is bounded between latitudes as given in the below table (***Table-1***) according to their toposheet nos. and (***PLATE-1***) respectively.

Table 1, Latitude and Longitude of the Toposheets of the study area

Sl. No.	Toposheet Nos.	Latitude	Longitude
1.	48O/09	13°45' - 14°0'	75°30' - 75°45'
2.	48O/10	13°30' - 13°45'	75°30' - 75°45'
3.	48O/14	13°30' - 13°45'	75°45' - 76°0'
4.	49M/13	11°45' - 12°0'	75°45' - 76°0'
5.	57D/03	12°15' - 12°30'	76°0' - 76°15'
6.	57D/04	12°0' - 12°15'	76°0' - 76°15'
7.	58A/01	11°45' - 12°0'	76°0' - 76°15'

Chikmagalur, Shivamoga and Kodagu districts fall under the high precipitation zone and receive high amount of rain during the monsoon season whereas, Mysore district receives quite less rain fall in comparison with the other districts of Western Ghats. Hassan and Dakshin Kannada districts are lying towards the south and southwest directions respectively from Chikmagalur district. Chikmagalur district is bordered by Hassan district in the southeast, Tumkuru and Chitradurga district in the east and northeast direction respectively. Udupi district in the west and Shivamoga district in the north and northwest direction. Whereas Shivamoga district is lying on a regional trend of NW-SE direction and are adjacent to each other and also these two districts are located towards northwest from Chikmagalur district. Western boundary of Shivamoga district is bounded by Uttar Kannada which is on the shore of the Arabian Sea, and Goa state is towards northwest, Belgavi and Dharwar from north and north-west respectively. Shivamoga district is bounded by Belgavi and Davangere districts from northeast and east side respectively.

The study area is well connected by national highways (NH’s), state highways (SH’s) and other road networks of Karnataka state. Shivamoga is connected by Bangalore-Chitradurga-Haveri-Hubbali National Highway (NH-48), and this NH-48 is connected by SH-28 from Hubbali-Yellapur-Sirsi-Sagara-Shivamoga, Yellapur-Sirsi-Siddapur-Sagara-Shivamoga, and Sirsi-Siddapur-Shivamoga-Chikmagalur. This SH-28 is further connected by SH-15 and SH-26 which connects the study area falling under Shivamoga and Chikmagalur district. Fairly good network of roads exists, connecting taluk headquarters with district headquarters. Shivamoga town is well connected with all the important places of Karnataka state which is located at about 325 Km from Bangalore city (State Capital). The nearest railway station in the northern part of the study area is Shivamoga which is the district headquarter also and in the southern part nearest railway station is Mysore and is about 125 Km north from the study area.

Towards the southeast from the district headquarter, Lakkavalli is the locality wherefrom fieldwork area starts and covers the Lakkavalli Wildlife sanctuary and Bhadra National Tiger

Sanctuary. This National Tiger Reserve Sanctuary is divided in to several wildlife range and covers *viz*, Kemmannugundi, Hebbe, Muthodi, Tarikere, Tanigebylu Wildlife Range which comes under the study area and are located towards the south and southeast from the Shivamoga district headquarter. On the other hand, Chikmagalur district is located at 145 Km. towards south from Shivamoga district headquarters. The study area is located towards the north at about 55 Km. from Chikmagalur district headquarters. Chikmagalur, Kodagu, Mysore and Shivamoga districts are western part of the Karnataka province and falls in Western Ghats. Entire area comes under the administrative jurisdiction of partially under four (04) districts *viz*, Chikmagalur, Kodagu, Mysore and Shivamoga districts of Karnataka.

The area in parts of all assigned Toposheets for the FSP: 2019-2020 falls under highly undulating, moderately dissected hilly terrain comprising hills and valleys, covered with dense forest. The area has a network of well-connected roads. Mangalore-Chikmagalur and Tarikere-Chikmagalur main road is the major road that passes through the area. A number of landslide have been reported from Toposheet no. 48O/10 and 48O/14 and along Kemmannugundi road (2 landslides) from Toposheet no. 48O/15. Maruthi, K.V and Chandran K.V, (2010) have carried landslide inventory in parts of 48O/09, 48O/10, 48O/14 and 48O/15 in Uttar Kannada and Chikmagalur districts, Karnataka and opined that human interference in the form of slope cutting for construction of road coupled with high rainfall with ineffective drainage are the main factors causing landslides. Whereas, in recent past (2-3 years) a number of landslide incidences have been happened in and around Kodagu district which falls under the southern part of the study area. Mysore-Kodagu-Virajpet-Makuta, Kodagu-Virajpet-Shrimangala-Kutta and Mysore-Kodagu-Sullia-Mangalore main road is the major road that passes through the area. In order to study the landslides and to prepare a landslide susceptibility map an area of 1395 Sq.Km. is proposed for the current FS 2019-20 in 48O/09, 48O/10, 48O/14, 57 D/03, 57D/04, 58A/01 and 49M/13 in parts of Chikmagalur, Kodagu, Mysore and Shivamoga districts.

The southern part of the study area falls under the part of Kodagu and Mysore districts of Karnataka. Kodagu was earlier known as Coorg. The study area falls in the high precipitation zone with picturesque topography occupying the eastern and western slopes of the Western Ghats. It is bounded by, Hassan district on the north, Dakshin Kannada district on the west and Kasargod district of Kerala state on the south. The study area is well connected by highways and other main roads. The Bangalore-Mysore-Mangalore Highway (SH-88) and Mysore-Cannanore Highway (SH-88A) passes through the area. Fairly good network of roads connecting o taluk headquarters with district headquarters. Madikeri town is well connected with all the important places of the state. It is about 270Km. from Bangalore (State Capital), 125Km. from Mysore and

130Km. from Mangalore. The nearest Railway stations are Hassan and Mysore. Nearest Airport is located at a distance of about 125Km. at Mysore.

1.3 Action Plan

The method of landslide susceptibility modelling to be followed is knowledge driven indirect method (AHP). 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.

a) Individual ratings for geo-factor classes and weights of geofactors 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 has been 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 and used in such work may also be used after due discussion with the local experts.

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

1.4 Present Work

The present work includes preparation of various thematic layers on 1: 50,000 scale using ArcGIS software and Google Earth imageries. Open Series Maps of the study area were also taken into account while preparing Landuse/Landcover, Road and Location maps. Landslide inventory prepared at headquarters was validated and updated in the field during fieldwork. The pre-field maps were validated in field and have been updated on ArcGIS platform 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: 2019-20, 2020-21 and the achievements are given in ***Table 2***.

Landslide susceptibility mapping on the scale 1: 50,000, covering 1395 Sq.Km. area in parts of Chikmagalur, Kodagu, Mysore and Shivamoga districts, of Karnataka state has been taken up under the annual programme of Geological Survey of India, Southern Region, vide item code no: M4LSSM/NC/SR/SU-KG/2019/25179-32984 Toposheet Nos. 48O/09, 48O/10, 48O/14, 57 D/03, 57D/04, 58A/01 and 49M/13 for the field season 2019-2020 and covers total seven (07) toposheets of Survey of India.

Table 2: Nature, quantum of work and achievements

Nature of Work	Target F.S 2019-20, 2020-21 (Sq.Km.)	Achievements in Sq.Km.
1. Pre field map preparation		
a) Slope forming material map	1395	1395
b) Geomorphology and lineament map	1395	1395
c) Slope morphometry (slope, aspect & curvature) map	1395	1395
d) Landuse/Landcover map	1395	1395
e) Drainage map	1395	1395
f) Regolith depth map	1395	1395
ii) Preparation of landslide inventory map	1395	1395
2. Field based studies		
i) Field checking of all thematic maps. Field validation of landslide inventory and collection of recent and historic landslides	1395	1395
ii) collection of landslide inventory and damage data as per 41 point geo – parametric sheet	1395	1395
3. Post Field studies		
i) Updation of thematic and inventory maps in GIS	1395	1395
ii) Preparation of Landslide susceptibility map in GIS	1395	1395
4. Collection of rainfall data	(Collected rainfall data for 10 years)	

1.5 Physiography and Drainage

The study area is located in and around Western Ghats and represent an orogenic mountain range with steep escarpments to the west, parallel to the west coast of India. The topography of the area ranges from gently sloping plains in the eastern part to rugged hilly terrain having elevations ranging from about 600m to 1872m (Kalahati Giti- A peak lying on the Bababudan Hill Ranges) above MSL in the northern part of the study area. Whereas, in the southern part of the study area it varies from 470m to 1548m (Kari Mala/Nari Mala/ Katti Betta hill ranges). 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 central, northeastern and eastern parts are showing undulating terrain with isolated hillocks. Major drainage flows towards west and the area shows dendritic to parallel drainage pattern.

The Tunga and Bhadra are two main drainage channels/systems in the study area which flows from NE to SW and drains in to the Jog Falls in southern part. These streams are perennial cum seasonal by nature. Jog falls is 110 Km. southwest from Shivamoga district headquarter.

Several third order streams drain the rest of the area. The study area is covered by some of tributaries of river Cauvery. The average annual rainfall of Chikmagalur and Shivamoga district is about 4000 mm and the area enjoys tropical climate. Whereas, in the study area under Chikmagalur district rain fall is as similar as in Shivamoga district. The climate is dominated by SW monsoon, starting in June, ending in October providing a larger portion of annual precipitation. Rainfall data has been collected from available rain gauge stations for the past ten years.

In the southern part of the study area (Toposheet Nos. 57 D/03, 57D/04, 58A/01, 49M/13) which covers parts of Kodagu and Mysore districts, falls under the Western Ghats and represent an orogenic mountain range with steep escarpments to the west, parallel to the west coast of India. 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 central, northeastern and eastern parts are showing undulating terrain with isolated hillocks. Major drainage flows towards west and the area shows dendritic to parallel drainage pattern. Cauvery River flows towards southeast and drains the southern part. Several third order streams drain the rest of the area. The average annual rainfall of Kodagu district is about 4000 mm and the area enjoys tropical climate. The climate is dominated by SW monsoon, starting in June and ending in October providing a larger portion of annual precipitation. Rainfall data has been collected for seven rain gauge stations for the past ten years.

1.6 General Geology

The area exposes rocks of the Peninsular Gneissic Complex (PGC), Sargur Group, Bababudan Group, Chitradurga Group, mafic-ultramafic complex of Archaean age, basic intrusives of Paleoproterozoic age, acidic intrusives and laterites of Cenozoic age. Sargur Group of rocks are represented by ultramafics which are exposed as narrow bands and occurs as enclaves within PGC. Peninsular Gneissic Complex is represented by grey granite, granitic gneiss and older granitoid. Bababudan Group of rocks is represented by Kudremukh Formation consists of metabasalt and actinolite-chlorite schists. Chitradurga Group of rocks represented by Jhandimatti Formation, Joldhal Formation (locally referred as Bisgod Formation) and Ranibennur Formation in the area. Basic intrusives like dolerite dykes of Paleo-Proterozoic age are intruded into all these rock types in the area. Acid intrusives are represented by quartz veins traversing PGC. Laterite cappings of Cenozoic age are noticed on the greywacke-argillite.

In the study area, largest Archaean schist belt of the Dharwar Craton is the Dharwar-Shivamoga schist belt, lying in western part of the craton extending from north of Chikmagalur to a few Km. south of Belgaum. It is surrounded by Peninsular Gneissic Complex (PGC), generally presumed to be older and have been intruded by several granitic bodies. The oldest supracrustal rocks of the Dharwar Craton have been interpreted to be those of Sargur Group, which occurs within Peninsular Gneiss, generally as narrow belts and scattered isolated enclaves. They have been partially migmatised, assimilated and granitised by younger granitoid intrusions of the PGC. Rocks of Bababudan Group overlie those of Sargur Group and Peninsular Gneisses with a marked angular unconformity. The Chitradurga Group of rocks unconformably overlies the Bababudan Group or rests directly on the PGC basement. A polymictic conglomerate characterized by granite clasts mark the unconformity in both the Chitradurga and Shivamoga belts, but locally grades into oligomictic conglomerate and phyllite, greywacke and arkose.

Shivamoga Schist Belt is one of the largest Archean Schist Belts in the Dharwar Craton and is known for its manganese and gold mineralization. Most of the manganese quarries and its old workings are located in Shivamoga and Davangere districts. The Shivamoga schist belt is a NW-SE trending schist belt which covers an area of 25,000 Sq.Km.. area and extends from Tarikere valley to Goa and goes beyond Ratnagiri in Maharashtra.

On the basis of compiled geological mapping on 1: 50,000 scale (***PLATE-12***), rocks of Sargur Group, Peninsular Gneissic Complex (PGC), Chitradurga (Shivamoga) Group of Dharwar Supergroup, Mafic-Ultramafic complex of Archean age are exposed and basic intrusive like dolerite dykes of Paleo-Proterozoic age are intruded into all rock types.

Older metamorphics of Sargur Group of Rocks represented by ultramafics are exposed as narrow bands and occurs as enclaves. Peninsular Gneiss represented by grey granite and older granitoids are widely exposed in the eastern part of the area. The granitoids locally called as Karwar Granite is intruded into in the Dharwar Supergroup of rocks. A segment of North Kanara Belt comprising Bababudan Group of rocks represented by Kudremukh Formations consisting of Metabasalt and actinolite-chlorite schist. Chitradurga Group of rocks represented by Joldhal Formation (locally referred as Bisgod Formation) and Ranibennur Formation are exposed in the area. The Joldhal Formation consists of orthoquartzite, limestone, dolomite, phyllite, Mn phyllite and BMQ. The Ranibennur Formation of Chitradurga Group consists of greywacke-argillite suite of rocks. All the rock types in the area has been traversed by the basic intrusive like dolerite dykes.

Primary Structures like bedding is noticed in Quartzites, banded magnetite quartzite and limestone. In general, the trend of the bedding is NNE-SSW to NNW-SSE with dips ranging from 30° to 80° both in easterly and westerly. Foliation in gneiss and other schistose rocks in the area are parallel to bedding.

The regional stratigraphic succession of the area established by the earlier workers as described in ***Table 3***.

Table 3: Regional Stratigraphy of the area

Supergroup	Group	Formation	Lithology	Age
	Younger Intrusives	Basic Intrusives	Dolerite	Palaeoproterozoic
	Layered Ultramafic Complex	Motimakki Ultramafites	Gabbro	Archaean
			Vanadiferous Titano-Magnetite	
			Talc-Tremolite Schist	
			Peridotite	
			Pyroxenite	
Dharwar	Chitradurga (Shivamoga)	Ranibennur	Argillite	
		Joldal	Banded Iron Formation (BIF)	
			Magniferous Phyllite	
			Phyllite	
			Limestone	
	Bababudan (Western Ghat)	Kudremukh	Quartzite	
			Hornblende-actinolite – chlorite schist	
			Actinolite-chlorite schist	
			Pillowed Metabasalt	
Peninsular Gneissic Complex	Peninsular Gneiss-I	Grey Granites (older)	Grey Granite	
		Granitoids	Granitoid (Karwar)	
	Sargur		Ultramafite	

Southern part of the study area is mainly represented by of rocks of Sargur Group, Peninsular Gneissic Complex (PGC) and Charnockite Group of Archaean age. Younger intrusives like granites and pegmatite veins of Archaean-Proterozoic age were later intruded into PGC. Sargur Group of rocks comprise garnet-sillimanite schist, kyanite-mica gneiss±sillimanite, amphibolite and garnetiferous granitite schist. In the south and southwestern part of the study area (south-east of Madikeri), about 3Km. wide, NW-SE trending band of kyanite-mica gneiss±sillimanite is exposed for a strike length of about 25 Km. The rock is medium grained, bluish grey consisting of quartz, plagioclase, feldspar, kyanite, sillimanite, muscovite-mica±graphite. Small lenses and an elongated band of garnet-sillimanite schist occur near 7Km south and 2.5Km. north of Madikeri in the western part.

The rock is dark grey in colour and mainly consists of biotite, quartz, sillimanite, muscovite and garnet. Amphibolite is occurring as small patches and thin bands. The rock is medium to coarse grained and dark grey to greenish grey in colour consisting of hornblende and plagioclase feldspars with accessory garnet and quartz, which are exposed in the southwestern part of the area. Small lenses of garnetiferous granitite schist of Sargur Group of rock is exposed within gneisses in the southwestern part. Biotite hornblende gneiss of PG-I of PGC, is the major rock type in the area with well-developed banding. They are generally coarse grained and light coloured striking NW-SE with a dip of 50°-60°.

Charnockite group of rocks comprise charnockite and pyroxenite granulite. Charnockite, generally light to dark grey in colour is well exposed in the south of Kushalnagar over a large area as lenticular body found interfoliated with biotite gneisses and shows clear gradations towards the latter. Generally they are of intermediate variety made essentially of quartz, intermediate plagioclase, hypersthene and hornblende with accessory minerals as biotite, apatite, zircon and iron ore. Pyroxene granulite trending NNW – SSE in northern part is well exposed as narrow linear bands within the PGC. The bands are 5 to 100 m wide and the strike length ranges from 1 to 3Km. The rock is dark coloured, medium to coarse grained and consists of hypersthene, diopside, plagioclase feldspar and biotite. A body of younger granite intrusive into the biotite gneisses is observed around Murnad in southwestern part. The rock is found as massive boulders and generally consists of quartz, feldspar and biotite. Few pegmatite veins of very smaller dimension trending NW -SE are seen intruding into the gneisses in the southwestern part. Thin capping of laterite measuring 5 to 8m in thickness, occurs over the gneisses in the southwestern part. They are dark brown in colour and contain hematite, limonite, goethite and numerous quartz grains (Srivastava and Sunder, 2016).

The gneisses show well developed foliations. The strike of the foliation is varying from N65°W-S65°E to E-W with steep northerly dips of 60°-70°. The gneisses show lineations trending N-S with plunge of 30°-40° towards south. Minor antiforms plunging 20°-40° towards SW, recorded within the PGC in northcentral part of the area. In T.S. No. 48P/16, Peninsular Gneiss-I of PGC represented by granitic gneiss occupies 75% of the area in the central and eastern part. It consists mainly of quartz, feldspar and biotite and at places appears as augen gneiss. The Charnockite Group forms a major rock unit in the SW part and comprises hornblende diopside granulite, calc granulite and charnockite and pyroxene granulite. Hornblende diopside granulite is light green consisting mainly hornblende plagioclase and diopside. It occurs as a wide body bordering with PG-I in the western and southwestern part and is exposed 2 km south and southwest of Virajpet, 1Km. west of 1195 hill. Calc granulite is coarse grained, mesocratic consisting tremolite, calc plagioclase and quartz. It occurs as thin lenses and is exposed in the northern bank of Barapole, *i.e.,* 2Km. north and NE of 778 hill, Ayyankunnu male and 2Km. SW of Hudikere. Charnockite occurs over a wide area interlayered with garnet, garnetiferous sillimanite gneiss in SW corner and western part. Charnockite is coarse grained, gneissic to granulitic, mesocratic to melanocratic, consisting of feldspar, pyroxene and minor biotite. At places, it is garnet bearing, quartz is noticed in the northwest of Karokattakari. At places they range in composition from acidic to intermediate and basic types. Quartz veins trending E-W occurring within PG-I are exposed north and SE of Ponnampet, NW and SE of Gonikoppa and in the central part of the area. Small body of dolerite dyke trending NW-SE is seen exposed 1Km. south of Podakeri. The foliation in charnockites and gneissosity in gneisses are the major penetrative structures which generally trend NE-SW with local variations with steep dips towards NW. In SW corner the attitude of the foliations in charnockites and garnetiferous sillimanite gneiss appears that the rocks along with amphibolite have been folded into an antiform with a SW closure.

1.7 Methodology

The methodology to be followed is primarily landslide dependent following a raster-based ArcGIS 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.

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 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: -

1.7.I. Pre-Field Studies

During pre-field period, the landslide inventory and different thematic maps have been prepared using different source data. The pre-field maps are as follows:

- **Landslide Inventory Map**: Landslide inventory map is prepared using data from old reports, multi temporal Google Imagery and LISS III/LISS IV data as source data in ArcGIS software.

- **Slope Morphometry (Slope, Curvature and Aspect) Map:** Slope Morphometry (Slope, Curvature and Aspect) pre-field maps are prepared using CartoDEM data (freely available on BHUVAN portal www.portal.bhuvan.nrsc.gov.in) having 30m*30m resolution as source data in ArcGIS software.
- **Drainage Map:** Drainage pre-field map is prepared using CartoDEM data (freely available on BHUVAN portal www.portal.bhuvan.nrsc.gov.in) having 30m*30m resolution as source data in ArcGIS software.
- **Landuse/Landcover Map (LULC):** Pre-field LULC map has been prepared using multi temporal google imagery and ArcGIS base map as source data in ArcGIS software.
- **Geomorphology Map:** Geomorphology pre-field map is prepared using multi temporal google imagery, ArcGIS base map and 1: 50,000 scale NGLM legacy map as source data in ArcGIS software.
- **Slope Forming Material Map (SFM):** Slope Forming Material (SFM) pre-field map is prepared using multi temporal google imagery, ArcGIS base map, 1:50,000 scale geological legacy map and proxies from LULC and geomorphology maps as source data in ArcGIS software.
- **Regolith Thickness Map:** Regolith Thickness pre-field map is prepared using multi temporal google imagery, proxies from geomorphology map and slope map as source data in ArcGIS software.

1.7. II. Field Based Studies

During the field validation period, all the pre-field maps are validated in the field by visiting all the assessable locations and noting the modifications. The landslide points from pre-field landslide inventory are also checked and if any new slides are encountered in the field, 42-point proforma are noted for all landslides, the existing landslide inventory is updated based on field data.

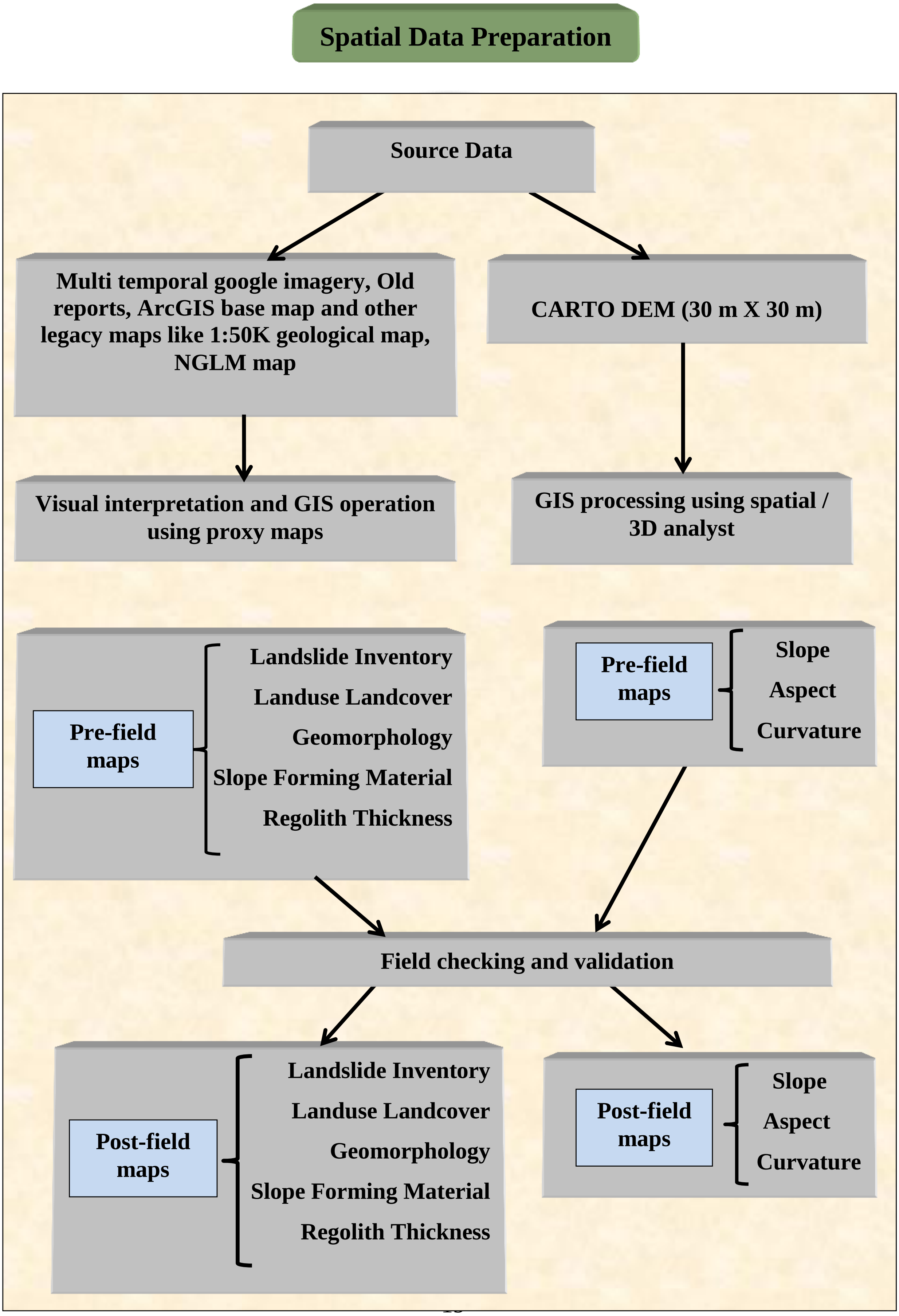
1.7.III. Post-Field Studies

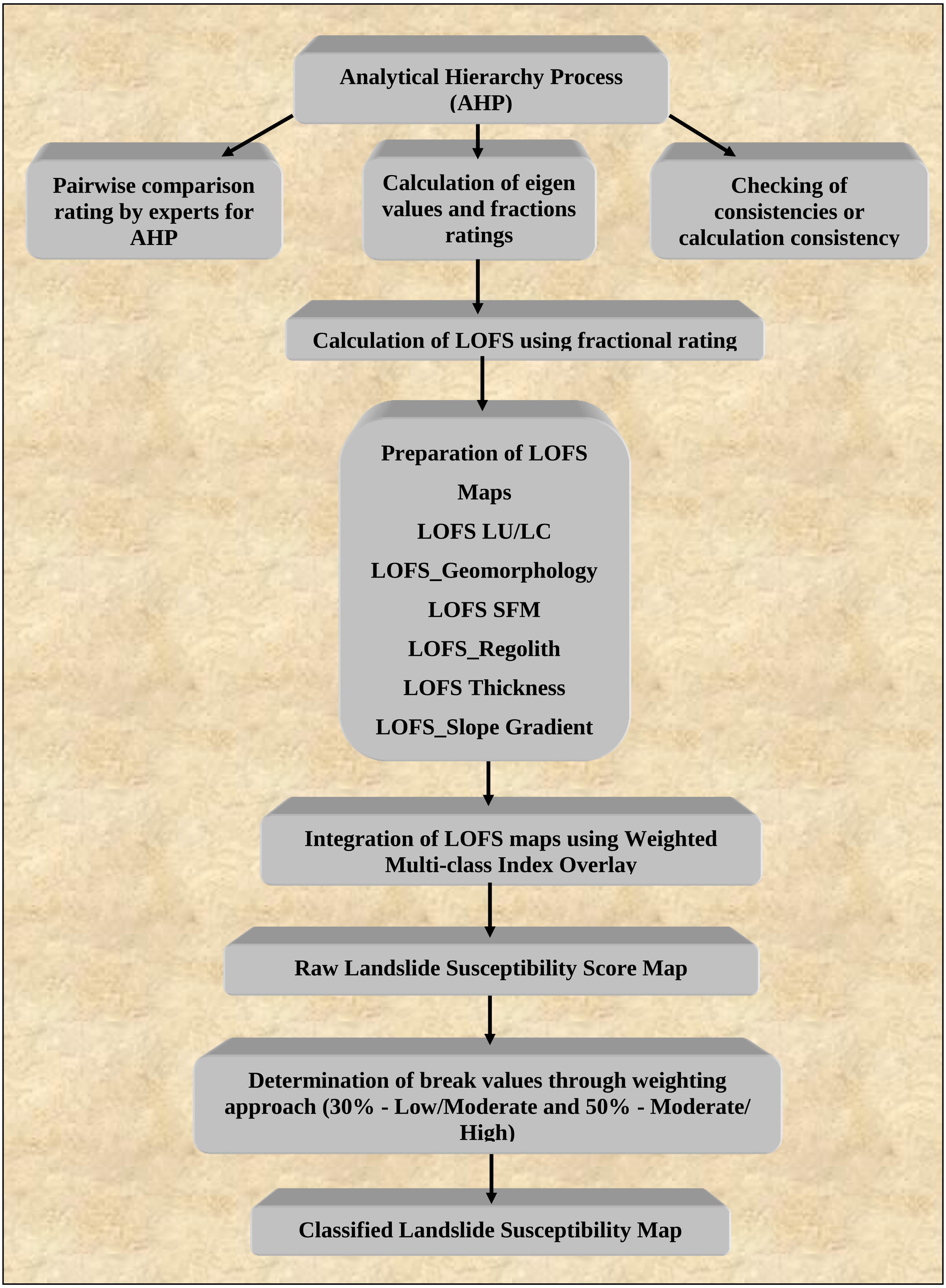
After the field validations are complete, all the thematic maps are updated as per field inputs and finalised. The landslide inventory is also updated as per field inputs. Once all the thematic maps are finalised and landslide inventory is updated, heuristic (knowledge driven) techniques are adopted for modelling (Brunsden, 1973) and generation of final landslide susceptibility map of the area. For modelling using heuristic (knowledge driven) techniques, individual ratings for geo-factor classes and weights of geofactors 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.

- Heuristic (knowledge driven) technique modelling requires fixation of individual ratings for geo-factor classes and weights of geo-factors for the entire area. So, these initial ratings are fixed with the knowledge of terrain and with discussion with local experts for Analytical Hierarchy Process (AHP).
- A total of eight factor maps, viz., Slope, Aspect, Curvature and Drainage (derived from 30 m resolution CARTO DEM). Geomorphology and Landuse/Landcover (prepared using multi-temporal Google Earth imageries and SPOT images as base maps in ESRI ArcGIS), Slope Forming Material and Regolith Thickness (through field-based studies and GSI Geological map) were prepared for susceptibility analysis. Besides these maps, Landslide Inventory map was also prepared using old inventory data from reports/ notes/ archives of GSI and new landslides recorded during the fieldwork.
- All the above eight maps were used for assessment of factor class ratings. However, only six thematic maps (except aspect and drainage) were considered for validation of Landslide Susceptibility Map (LSM) of the study area, due to the absence of identified factor classes in a particular map.
- Once all the ratings for geo-factor classes and weights of geo-factors are fixed, Landslide Occurrence Favourability Score (LOFS) is calculated using pair wise comparison matrix and fraction rating in Microsoft excel software.
- After calculation of LOFS for all the geo-factor classes LOFS maps of the geo-factors are prepared using ArcGIS software.
- Once all the LOFS maps are prepared, raw landslide susceptibility score map is prepared using weighted multi class index overlay method in ArcGIS software.
- After raw landslide susceptibility score map is prepared classified landslide susceptibility map is prepared and determination of break values are done through weighing approach (30% is the boundary between low to moderate susceptibility and 50% is the boundary between moderate to high susceptibility).

The proposed work has been done in a GIS-based platform and through development and use of site-specific/terrain-specific weights/ratings. As the known incidences of landslides in the proposed study area are only limited, the susceptibility model is based on Analytical Hierarchy Process (AHP) developed on the basis of the judgment formed on observations made in the neighboring areas that expose similar geological and geomorphic environment. The proposed work has derived to culminate in the generation of landslide susceptibility map separating areas with varying degrees of susceptibilities to landslide initiation and a huge thematic and landslide database. The map and the database will be useful geo-information tool to the stake holders and administrators for land use planning, regulations and development of disaster management plans.

Figure- 1: Flow diagram showing process of Landslide Susceptibility Mapping




Analytical Hierarchy Process (AHP)
Pairwise comparison rating by experts for AHP
Calculation of eigen values and fractions ratings
Checking of consistencies or calculation consistency
Calculation of LOFS using fractional rating
Preparation of LOFS Maps
LOFS LU/LC
LOFS_Geomorphology
LOFS SFM
LOFS_Regolith
LOFS Thickness
LOFS_Slope Gradient
Integration of LOFS maps using Weighted Multi-class Index Overlay
Raw Landslide Susceptibility Score Map
Determination of break values through weighting approach (30% - Low/Moderate and 50% - Moderate/ High)
Classified Landslide Susceptibility Map

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2. PREVIOUS WORK ON LANDSLIDE STUDIES

Previous works on landslides in the study area include: Micro-scale landslide studies were carried out in and around road corridors for the landslide inventory mapping by K.V. Maruthi and K.V. Chandran, 2010 and 2013.

Landslide is the major causative factor of natural damage in and around the study area. To investigate these areas (especially the site specific areas) which are prone to landslides are under very much focused in this study. To search for the new sites as well as the previous slides are main concern of this assignment. In this connection numbers of landslides have been reported by the previous workers from the study area. These details Toposheet wise are given as follows: total 6 landslide incidences have been recorded by previous workers in earlier past. Toposheet wise details are given as below in **Table-4** and **Table-5**.

2.1 Landslide Details Falling Under Toposheet No. 48O/09

Under this Toposheet none of the landslide have been reported in the study area as per by the earlier work accrued out by the GSI and other government agencies.

2.2 Landslide Details Falling Under Toposheet No. 48O/10

Table 4: Landslide inventory details of T.S. no. 48O/10

Sl. Nos.	Year	TS. Nos.	Longitude	Latitude	Dimension of slides (m)		
					Length	Width	Height
1.	2010-12	48O/14	75 44 49.9	13 32 14.8	11.20	14.30	0.50
2.	2010-12	48O/14	75 44 58	13 33 37	15.80	23.00	1.00

Under this Toposheet total only 02-landslides has been reported by the previous workers.

2.3 Landslide Details Falling Under Toposheet No. 48O/14

Table 5: Landslide inventory details of T.S. no. 48O/14

Sl. Nos.	Year	TS. Nos.	Longitude	Latitude	Dimension of slides (m)		
					Length	Width	Height
1.	2010-12	48O/14	75 45 5.6	13 31 51.1	36.80	40.20	1.50
2.	2010-12	48O/14	75 45 4.0	13 31 25.6	38.20	40.80	1.50
3.	2010-12	48O/14	75 45 19.7	13 33 17.9	15.80	22.30	1.0
4.	2010-12	48O/14	75 45 37.9	13 33 13.3	14.00	18.10	1.0

Under this Toposheet total 4-landslides have been reported (Mishra and Pradhan, 2009) by the previous workers.

Under the Toposheet Nos. 57 D/03 57D/04 and 58A/01 and 49M/13 landslide inventory is not available.

3. LANDSLIDE INVENTORY

Landslide inventory envisages prepare a document or channelize or enlist the possible past and present record of any kind of earth mass movement. Landslide inventories form an essential basis for landslide susceptibility, hazard and risk analysis. Landslide inventories that span for 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. Landslide inventories contain basic information about landslides such as location, classification, morphology, volume, run-out distance, activity and date of occurrence/activity etc., and can be prepared through various methods such as detailed geomorphologic study, mapping from remote sensing data and topographic maps, historical archive studies and interviews. Each data source used to construct the new landslide inventory (David et. al., 2000) 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 and 1984). These signatures are mostly visible as morphological changes such as changes in slope type, breaks in slopes, hummocky surfaces, etc. These morphological signs are interpreted here to determine important landslide information such as type of failure (Brunsden, 1973), 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 map 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 ArcGIS (up to the resolution of 30m) and high resolution Google Earth data of different time periods (from 2002 to 2018) were used as the main data product for generating the multi-temporal landslide inventory for this area. For landslide inventory mapping in Google Earth platform, it used to have different temporal and spatial inputs remotely with the ground control referring to the fieldwork studies covering on the route and off the route of any road corridor of any possible accessible area.

3.2 Inventory Mapping

The following steps were used for digitizing a landslide polygon in ArcGIS 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 ArcGIS using "conversion" function. In ArcGIS 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-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 SPOT data and Toposheet in ArcGIS.
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. After identifying the landslides in the field, the morphological parameters (landslide scar length, width and depth) were noted carefully after measuring them in the field using a meter tape. Additional data such as landslide type, run-out distance, present land use/Landcover class, regolith thickness, 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 and entered in a geo-database of ArcGIS. Though in the present study area, slides reported earlier and marked on ArcGIS using their locational attributes could not be identified due to thick vegetation cover. No slope failure could be identified using satellite imageries and Google Earth due to their small dimension and thick vegetation cover.

All the slope failures observed in the field are located in the Western and central part of the study area. One 2-year old landslide was observed near Irppu Water Fall. This landslide is in

PGC lithounit. At the place of this landslide, a retaining walls of 0.5-1m height have been constructed at the base but there are many multiple smaller slope failures observed within the old slide scar that need to be looked into and proper mitigation measures are adopted. Due to the proper remedial measure at this slide, it is stabilized as of now.

A total of 13-new landslides have identified (*details of all 13-landslides are attached as in Annexure-2*), out of which 11-landslides are debris slide and 02-landslides are rockslide. 1st rockslide has been recorded near Sampigekan Coffee Estate under the toposheet no. 48O/10. This rockslide is due to the road widening for the coffee estate work. Whereas, 2nd rockslide has been recorded near Rajbhawan which is near Kemmengundi Forest Check-post and falls under the toposheet no. 48O/10. Southwest of Kallattipur village towards the Coffee Estate, Extensive Cut Slope (ECS) have been identified and which is vulnerable for future slope failures. About 1.5km south of Santveri, on the road section ECS has been recorded. Along this ECS 02-debris slides has also been recorded. Southwest of Kallattipur village towards the Dupadakan Coffee Estate, ECS dimension is about 800m and this road stretch is vulnerable for future slope failures. Along this ECS section, 02-debris slides have also been recorded. At the road section from Kemmengundi to Abbey falls, ESC has been also recorded and it's length is up to 8.3 Km. Which is vulnerable due to road widening and load lengthening.

The ECS section near South of Santveri, connecting Shivamoga-Chikmagalur SH is about 1800m which falls under the toposheet no. 48O/14 is vulnerable for the landslide. Considering the slope condition and the type of overburden material present, the slope is vulnerable for future failure even though retaining wall and lined drainage has been provided at the ECS. West of Kaimara, towards Dupadakan Coffee Estate, ECS has been identified for about 3.8 Km. and 01-debrisslide has also been recorded. At this road stretch re-occurrence of landslide is expected. All the pre field thematic maps has been validated during the fieldwork were the following observations has been recorded. At the road section from Kemmengundi to Abbey falls, ESC has been recorded which is due to road widening and load lengthening. Considering the slope condition and the type of material present, the slope is vulnerable for future failure even though retaining wall and lined drainage has been provided at the ECS. West of Kaimara, towards Dupadakan Coffee Estate, ECS has been identified and 01-debris slide has also been recorded. At this road stretch re-occurrence of landslide is expected.

The southern part of the study area is relatively devoid of any major landslide incidences as per the present scale of mapping except the 01-landslide that has been recorded, i.e., Debris slide at Irppu Water falls under the toposheet no. 49M/13. In the southern part of study area, widening of road section is going on near Kutta-Virajpet-Makuta which may lead to the landslide incidence in near future as geo-scientific factors are not given due weightage by the road constructing authorities. This is further emphasize that heavy rainfall and deforestation may lead to loosening of the overburden which may slide. Here in the study area deforestation is on modified slope for the coffee plantation.

4. LANDSLIDE SUSCEPTIBILTY ANALYSIS

This chapter comprises of the materials and methods used in landslide susceptibility analysis using 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 local terrain conditions. Landslide susceptibility (Cees et. al, 2008**)** 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 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 and Vargas, 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 priori 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. (in 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 et al, 2010).

For susceptibility analysis six factor maps were prepared that are considered to be the main spatial causative 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, overloading, 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 ArcGIS. 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 another cause for landslides. Slope angle is formed between any part of the surface of the earth and the horizontal datum. It is a means 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 and Hodder, 1993; Derruau, 1983).

Slope morphometry is defined by slope aspect, curvature and gradient ***(PLATE-05, 06, 07)***. 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 ArcGIS software using spatial analyst tool. A positive curvature represents upwardly convex surface, while a negative curvature indicates that the surface is upwardly concave at a given pixel. 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.

Table 6: LOFS map and area coverage in pixels for Slope gradient of the study area

CLASS	Rank	LOFS	Area coverage (Pixels.)	Area covered (%)
<15	2	0.1631	1271737	89.57793
15-25	4	0.4597	114017	8.031069
25-35	8	1.0000	24579	1.731282
35-45	6	0.2817	6680	0.470522
>45	2	0.1631	2686	0.189195

For the slope gradient map as a derivative of DEM, the area was classified in to five classes ranging from <15° up to >45°. A large part of the area (89.57%) falls in low slope range i.e., <15° class. 15°-25° slope gradient class occupies 08.031% of the study area. About 01.73% of the area is occupied by 25° to 35° class, which is having maximum weightage according to the ratings given in AHP. The area coverage in pixels along with LOFS and rank is given in ***Table-6***.

Table 7, LOFS map and area coverage in pixels for slope curvature map of the study area

CLASS	Rank	LOFS	Area coverage (Pixels)	Area covered (%)
Concave	4	0.4113	369143	26.0015
Flat	2	0.1676	116167	8.182509
Convex	6	1.0000	934389	65.81599

Curvature map is classified into three classes i.e. convex, flat and concave slopes. Slope Curvature in the area ranges from -0.9.5 to +0.9.1. About 08.18% of the area falls in flat slope. The Convex slope (>0.1) class which is given the maximum weightage in the area covers about 65.815% of the study area while 26.0015% of the area falls under Concave slope (<0.1). The area coverage in pixels along with LOFS and Rank is given in ***Table-6.*** More weightage and ranking is given to convex slope class (>0.1) and slope gradient (25°-35°). The convex slope is more fragile to loss of mass and 25°-35° slope are mostly influenced by anthropogenic activities and habitat in the study area. Four landslides recorded in the area fall in concave class while remaining two falls in convex slope class.

4.3.2 Geomorphology

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-09)*** of the study area was prepared in ArcGIS software through visual interpretation of multi-temporal Google Imageries of the area. NGLM data acquired from SRO, Hyderabad was also taken into account while preparing the geomorphology map of the study area. The obtained pre field map was checked and validated in field. The post-field changes in Geomorphology map have been done and final map has been compiled (***PLATE-09***). In terms of geomorphology the area was grouped into the following classes namely ridge top, highly dissected slopes, moderately dissected slopes, low dissected slopes, mounds, hill top, valley fill, pediment-pediplain complex, rolling plains and river. The dissected slopes (high, moderate or low) were mapped based on visual interpretation with the help of Google Imagery by taking topographic ruggedness and presence of drainage as criteria. Most of the area (about 33.62%) falls in Low dissected slopes followed by Rolling Plain (31.46), Pediment-Pediplain Complex (19.13%), and highly dissected slope (5.37%). Highly dissected slope is given maximum weightage (rating 6) using AHP method followed by lowly dissected slopes (rating 4). The area coverage for each class in pixels, LOFS and rank is given in Table-8. Highly dissected slope is ranked less than the moderately dissected slope based on the ground scenario. It is observed in the study area that the anthropogenic activities like toe cutting, road cut section and extensive cut are predominantly causative factors apart from natural causes.

The details of geomorphic features are given as follows:

Ridge: This is the topmost part of the hills/mountains which is formed by the intersection of two escarpments from the opposite directions (NGLM Manual, 2010). It also acts as the water divide.

Dissected Structural Hills: These 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).

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: The 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: It is complex landform where both pediplain and pediments occur and it is difficult to separate them. These are observed towards northeast, east and southeast of Siddapur.

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).

Mounds: These are the isolated hills having low relief and lowly dissected slopes and almost flattish, rounded tops.

Table 8: LOFS, rank and area coverage in pixels for Geomorphology of the study area

Class	Rank	LOFS	Area coverage (Sq.Km.)	Area covered (%)
Lowly Dissected Slope	4	0.1947	469	33.62007168
Moderately Dissected Slope	6	0.4020	0	00.00
Highly Dissected Slope	8	0.727	75	5.376344086
Mound	4	0	0	00.00
Ridge Top	4	0	27	1.935483871
Water body	0	0	94	6.738351254
Rolling Plain	0	0	439	31.46953405
Valley Fill	0	0	24	1.720430108
Pediment Pediplain Complex	0	0	267	19.13978495

4.3.3 Land Use and Land Cover

Landuse/Landcover changes, whether of natural origin or man-made, can influence the susceptibility of slopes to landslides (Diaz et al, 2006). 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, P. M. and Massari, R.). The land-use/land-cover of an area directly reflects the human interaction with nature. At places this interaction has exceeded the boundaries and led to man's conflict with nature resulting in the balance of nature being disturbed. This has resulted in many natural calamities – landslides being the foremost result of this over exploitation. Despite the Western Ghats being a UNESCO world heritage site and one of the eight hottest biodiversity hotspots in the world, it is still being exploited thoroughly, damaging natural slopes, flora and fauna. There have been drastic changes in the landuse/landcover patterns and scarcity of water, low rainfall in recent years in this area, may be a direct result of these anthropogenic activities. Remote sensing in forest management has led to many studies that concluded that forest clearing dramatically accelerates rates of landslides over rates in undisturbed forest (Siddle et al., 1985: Montgomery et al., 2000).

The study area (northern part as well as southern part) consists of lush green forests, low height and high height plantations consisting of coffee, black pepper, teak etc. The commercial plantations form a major part of landuse in this area, causing large scale exploitation and disturbances in slope stability. Besides these, paddy cultivation is the major landuse pattern in low lying area/valley fill. Settlements are observed in almost all parts of the study area, a classic example of man encroaching into the nature's territory. This often results in slope cut failures, mostly along road cuts. This is augmented by heavy rainfall during monsoon. The major part of the area is occupied by plantations, which is the main source of income for the people in the study area, followed by forests and cultivated land. Human habitation has seen an increase in the past decade, since the area is a popular tourist destination; creation of holiday homes and resorts in the interior parts of the forests has also led to deforestation. These home stays are very much attractive looking in to the scenic beauty of the surroundings. National Wildlife Sanctuary and Tiger Reserve Sanctuary at both parts (northern part as well as southern part) of the study area is prime attraction for the tourists.

Construction of roads and railways (in northern part of the study area) has opened channels for exploitation and caused rapid changes in LULC of the area. The LULC map ***(PLATE-08)*** 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 ArcGIS through kml to feature conversion. In ArcGIS 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 landuse/landcover map was checked in the field at all accessible locations. The area in terms of LULC can be classified in to the following classes for both the part of study area: Barren, cultivation (Photo-1 and 2), settlement, settlement on modified slope, sparse vegetated areas

(Photo-13 and 14), moderate vegetated areas (Photo-15 and 16), thick vegetated areas, river, low height plantation, high height plantation, extensive cut slope (Photo-20, 21, 22, 23 and 24), quarry, and fallow land. The areas along river banks is covered with alluvial material and along low lying valleys is covered with overburden material and are being used for cultivation. Major part of the area about 65.054% is covered with thick vegetation lying in all part of the study area. The next class of highest % is occupied by moderate vegetation covering 06.27% of the area. The south western part of the study area is occupied by moderate and thick vegetation and South eastern part is mostly covered by cultivation. Rest of the area is primarily covered by LHP 3.88% of the study area consists of barren land. Settlements in the area are widely distributed and are a vital cause in disturbing the natural equilibrium of slopes. Slope modification for settlement and commercial plantation is quite rampant in the area. The maximum weightage is given to extensive slope cut followed by sparse vegetation 1.88% of the area respectively. The area coverage of each factor class in pixels, LOFS and rank is given in ***Table-9***.

Thick Vegetation: In the study area (both northern and southern part) predominates in thick vegetation (Photo-5, 6 and 12) which has been fragmented at many places by human activities. Most of the forests are exploited for timber and for cooking purposes. There are several varieties of spices available in these forests.

High Height Plantations: These include commercial plantations like rubber, coconut, areca nut, teak, silver oak etc. They mostly cover the northern and north-western part of the area (in both the part of the study area). Areca nut plantations and Rubber plantation (Photo-8 and Photo-17) are found all over the study area.

Low Height Plantations: Kodagu, Chikmagalur and Shivamoga districts are famous for coconut, cashew, cocoa, banana, coffee, and spices. These constitute the low height plantations (Photo-3, 7 and 18) of the area and occupy central, southern and north eastern part of study 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. Labourers from other states are also being brought in to work in plantations and live there. The study area is also a well-known tourist spot, hence to cater to the needs of the tourists, several holiday homes resorts and hotels have come up, thus increasing the urbanization index of the area.

Settlements on Modified Slope: Many slopes in and around Thithimathi, Ponampasate, Theralu, Mepali, T.Shettigeri, NR Pura, Kemmannugundi, Kaimara, Hebbe, Santhaveri and other important localities such as Lingadahalli, and Lingapura etc. have been modified for human use thus increasing the landslide susceptibility index of the area.

Extensive Slope Cut: Roads and railways are required for improving connectivity and communication in any area. The study area also has good road connectivity though at the cost of extensive damage to slopes (Photo-20). 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.

Table 9, LOFS, rank and area coverage in pixels for Landuse/Landcover of the study area

Class	Rank	LOFS	Area coverage (Sq.Km..)	Area covered (%)
Barren	1	0.0626	65.21	4.639546
Cultivation	2	0.0937	165.70	11.78913
Fallow Land	1	0.0626	0.02	0.001383
Plantation (HHP)	4	0.1988	0.92	0.065548
Plantation (LHP)	3	0.1366	110.53	7.864195
Quarry	5	0.2912	0.01	0.000639
Settlement	1	0.0683	21.76	1.548051
Moderate Vegetation	5	0.5631	6.27	0.446125
Thick Vegetation	4	0.1988	904.34	65.0543
Sparse Vegetation	7	0.5631	26.48	1.884286
Water body	0	0.0000	94.26	6.706803

4.3.4 Slope Forming Material (SFM)

The area under study is observed to have shallow debris slides. These slides occur in the overburden part of slopes where the upper shallow layer slides over the more competent material either bedrock or denser overburden material. These slides are often triggered by high rainfall and anthropogenic activities. Thus careful study of slope forming material is a must for this study area. Slope Forming Material (SFM) (***PLATE-10***) map was prepared in ArcGIS 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 SFM is classified in to the following classes: Rock, transported soil, alluvium and in-situ soil. Though the area comprises of high hill ranges and valleys, transported soil could not be identified due to thick vegetation cover.

On slopes as well as ridge tops, barren rock is present at places where the slope gradient in general is more than 35°, most of the study area (about 88.12%) is covered by in-situ soil. 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 in-situ soil and amphibolites are assigned maximum weightage because minerals present in amphibolites are highly susceptible to weathering and the loose in-situ soil has poor shear strength due to water saturation in Western Ghats climatic conditions. The area covered in pixels, LOFS and rank is given in ***Table-10***.

Table 10: LOFS, rank and area coverage in pixels for Slope forming material of the study area

CLASS	Rank	LOFS	Area Coverage (Sq.Km.)	Area Coverage (%)
In-situ soil	4	0.240	1228	88.12233
Water body	0	0.068	93	6.614509
Granite gneiss	4	0.068	3	0.213371
Meta-basalt	1	0.068	8	0.56899
Ferruginous phyllite	0	0.068	3	0.213371
Banded magnetite quartzite	1	0.068	3	0.213371
Dolerite	0	0.068	0	00.00
Carbonaceous phyllite	1	0.068	6	0.426743
Gabbro	0	0.240	0	00.00
Transported Soil	0	0.150	51	3.627312
Charnockite	0	0.000	0	00.00

4.3.5 Regolith Thickness

One of the most sensitive parameters is soil thickness (Van Westen et. al, 2008 and Page et al., 1994) 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 soils, pore water pressure may be due to: (i) hydrostatic head, (ii) pressure exerted by water flowing through a soil mass whose volume remains constant, and (iii) pressures associate with stress changes in the soil, which initiates changes in volume of the soil mass (consolidation or swelling) (Parcher, JV and Means, RE, 1968).

Thickness of overburden (Photo-11) is directly controlled by SFM, geomorphology, LULC and slope gradient. Overloading of slopes with sediments, debris, quarry dump may result in slope failures often triggered by heavy rainfall. During the fieldwork, regolith/overburden thickness is estimated by observing road cuts, forest trenches and nala sections wherever available. An attempt has been made to record the approximate overburden depth and it is observed that in low dissected hill slope with low slope gradient, the overburden depth is relatively more (approx. 2 to 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 10m and more than 10m (***PLATE-11***). At the same time, it is remarkable point that along the road section we have best exposure or overburden and also to estimate its thickness too. 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. Regolith depth of <0.5m depth is observed on rocky, steep slopes and is included into rock class. In the study area we have rock as slope forming material only at very few places. Regolith thickness for which is taken as less than 0.5m. Major part of the study area (about 61.86%) has a regolith depth of .5m to 5m. Some places (about 1.577%) have regolith depths of more than <0.5 m like Kemmannugundi, Kaimara, Lingapura, Kurchi, Mepali, Theralu, and Irppu area is occupied by regolith depths of 5-10m and about 29.89 area falls under this zone (1, 2, 6) are in south of Thithimathi and Ponampasate and near by the Lingadahalli area. The factor class 0.5m to 5m is given the maximum weightage for landslide occurrence using AHP. The area covered by each factor class in terms of pixels, LOFS and rank is given in ***Table-11***.

Table 11: LOFS, rank and area coverage in pixels for Regolith Thickness of the study area

CLASS	Rank	LOFS	Area coverage (Sq.Km.)	Area covered (%)
< 0.5 m	0	0	22	1.577061
0.5 - 5 m	7	1	863	61.86
5 - 10 m	4	0.322	417	29.89
River	0	0	00.00	00.00
Water body	0	0	93	6.666667

4.4 Landslide Susceptibility Analysis (AHP)

Landslides or rather slope failures in the study area are concentrated mainly along roads and other transportation corridors. Recording these slope failures which are a result of anthropogenic activities and considering them for susceptibility zonation of the study area would be highly biased. Since very few, almost negligible of slide is observed elsewhere in the area, the normal method of modeling cannot be used here.

In 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 geofactors 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 pairwise importance matrix for different geo-factor classes and amongst different geofactors 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 demonstrated through some illustration 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 landsliding 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 ratings 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:

$$CI = \text{maks eigen value} - n/n-1 \qquad \text{Eq-1}$$

$$\textit{maks.eigenvalue} = \sum\nolimits_{\iota} wi.\mathrm{ci} \qquad \text{Eq-2}$$

The consistency ratio is then calculated as,

$$CR = CI/RI \qquad \text{Eq-3}$$

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

If CR $\geq$ 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 pairwise 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 (SPS) used is given in ***Table-12***.

Table 12: 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 SPS 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 pairwise ratings; estimated eigenvectors of pairwise rating matrix; and estimation of consistency vector (CV), consistency index (CI) and consistency ratio (CR) for judgment of consistency of pairwise ratings of factors, respectively for all maps was calculated. Example of LULC for calculation of LOFS is given in ***Table-13.***

Table 13: 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 14: 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

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. Here ***Table-15*** is showing calculation of consistency index (CI) and consistency ratio (CR) and table 16 is showing mutual comparison of individual factor maps and weights.

Table 15: 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	0.01395	0.01158	0.0113	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	0.01395	0.01158	0.0113	0.01292	0.02041	0.02052	0.01158	0.02052	0.21283	0.01774	0.0626
MV	0.10204	0.1039	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	0.0678	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	0.0339	0.02153	0.06122	0.02873	0.02317	0.02873	0.46439	0.0387	0.1366
QR	0.10204	0.1039	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	0.01395	0.01158	0.0113	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	0.0678	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 16: 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	0.08868	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
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

Factor Classes	
Factor	**Rank**
Barren (B)	1
Cultivation (CL)	2
Extensive Slope Cut (ESC)	9
Fallow Land (FL)	1
Moderate Vegetation (MV)	5
Plantation (HHP)	4
Plantation (LHP)	3
Quarry (QR)	5
Settlement (S)	1
Thick Vegetation (TV)	4
Sparse Vegetation (SV)	7
Water Body (WB)	0

Factor	**Slope**	**Curvat**	**SFM**	**LUL**	**Geo**	**RT**
Slope	1.00	8.00	4.00	2.00	4.00	6.00
Curvat	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

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

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 geo-factor 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 geo-factor is prepared with the help of “Lookup” command in ArcGIS, using raster map of the geo-factor as “input raster” and “geofactor_LOFS$LOFS” as lookup field.

For determination of Predictor Weight for the geofactor, one comparison matrix is calculated in microsoft excel software for the pair wise qualitative comparison of all the geofactors. In the comparison matrix, fraction weight is calculated for all the geofactors. 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 geofactors. 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 geofactor, 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 done using 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 Factor$_n$*50)*weight of Fcator$_n$] / 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 Factor$_n$*30)*weight of Fcator$_n$] / 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

The landslide susceptibility map is the key tool for the landuse planning, management and risk mitigation. Landslide susceptibility mapping aims to differentiate the earth surface into homogeneous areas according to their probability towards the 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 the purposeful decisions, and an appropriate methodology for analysis and modelling leading to the utilization of landuse pattern for the civil development and or civilization.

The landslide susceptibility score map is obtained after generating LOFS maps for all the geo-factor classes and using weighted multiclass index overlay method to generate raw susceptibility score map which is classified into low, moderate and high susceptible areas so that it can be understood easily by the common man. The susceptibility is expressed in terms of the relative likelihood of an area for initiation of landslide or slope failure in a pixel (the mapping unit) under the given geo-environmental conditions. According to the final susceptibility map obtained after AHP modelling. The final susceptibility map divides about 92.79 % area falls under low landslide susceptibility zone, 6.26 % area are in moderate susceptibility zone and 0.94 % area falls under high landslide susceptibility zone. The area on the south-western fringe of Santhaveri, west of Kemmannugundi, Kaimara and west of Irppu, South of Lingadahalli (Near Hebbe), these area falls under high susceptibility zones, this corroborates the fact that uncontrolled slope modification and other anthropogenic activities contribute in landslide occurrence. Most of the high susceptibility zones correspond to the slope gradient class between 25°-35°. It has been observed that most of the slides occur in this slope gradient class 15°-25° (06-slides) and 25°-35° (07-slides). In terms of landuse/landcover the area having settlement on modified slopes and extensive cut slopes (ECS) has the maximum susceptibility to landslides. In terms of geomorphology, most of the slides are observed to occur in lowly dissected slopes (13-lansdslides). It has to be noted here that most of the slides occurring in low dissected slopes are located along cut slopes where modification slope and slope disturbances are maximum.

Most of the area in toposheet no. 48O/10 and 48O/14 falls under moderate to high susceptibility which can be attributed to two facts (i) most parts in this sheet have steep slope gradients as compared to northern part of the area, and (ii) natural slopes have been excavated and modified for construction of highways, settlements and commercial plantations rendering the slopes unstable and prone to failures. Several incidences of road cut failure varying from 15m to 75m in size have been recorded along the Kemmannugundi to Hebbe road section. On the other hand, along Irppu to Mepali road section occurrences of slope cut failures and road subsidence are present which are almost stabilized due to the vegetation growth and lined drainage maintenance by PWD and other stake holders. Uncontrolled slope modification, removal of vegetation and overloading of slopes are few measures for slope failure in this area.

All the places where extensive slope cuts are demarcated are falling in high susceptibility zone. These places are vulnerable to slope failures due to removal of toe material and construction work being carried out without any remedial measures make these slopes unstable.

In the western part of the study area there are moderately dissected slopes having slope gradient of 25° to 45° which has been given the maximum weightage for landslide susceptibility. Deforestation and slope disturbance have been observed in this part of study due to human interference as the place is a significant tourist destination. Due to these factors the western part of the area having steep hills, thick forest and plantations has been classified in to moderate to high susceptible zone.

Most of the northern, central and eastern part of study area is categorised into low to moderate susceptibility zone in all three toposheet of the study area. This may be attributed to presence of low lying planes which are abounding in cultivation and low height plantations. In addition to this most of the area has slope gradients less than 15° which renders the area stable. Since the area has thick vegetation on the slope forming material, the site is penetrated by roots of these plants. This also provides stability to area as far as slope failure is concerned.

6. CONCLUSIONS AND RECOMMENDATIONS

The hazards that landslides pose to society tend to be less appreciated as compared to other hazards. This is because landslides seldom occur at the same places. As compared to other hazards (viz. floods) where some sort of early warning systems has been developed, landslide warning in terms of time and location of occurrence can rarely be predicted with accuracy. Nevertheless, until some reliable system is developed for prediction of landslide occurrence, mitigation of damage caused by slope failures and creating better awareness among common man are the only tools against this natural hazard. The area under study is affected with slides of small dimension. Small landslides make up the vast majority of landslide incidents that affect communities and individuals globally. These costs are mostly associated with human habitation and transport linkages. The decision whether to actively manage small landslides either by slope stabilisation methods or mitigation of their impacts is function of the cost-benefit analysis that are undertaken explicitly or implicitly (Elisabeth et al., 2015). About 0.94 % of area is grouped under high susceptibility zone covering all 07 Toposheets. Most of this area lies around transportation corridors and extensive slope cut areas. Besides, hills with steep slopes are also grouped under moderate to high susceptible zones.

The susceptibility map thus obtained using Analytical hierarchy process (AHP) gives a qualitative indication in the study area about particular mapping units (pixel in this case having 50m*50m resolution) being susceptible to landslide occurrence under the cumulative effect of geo factors under consideration. This does not have any time connotation and it is assumed that the same geo-environmental conditions will prevail in the future that augmented the present slope failures. These conditions may change with time and so will the susceptibility index of the area. The areas categorised under high and moderate zones are enlisted below in brief:

Some areas southwest of Santaveri near to Kemmannugundi and Hebbe, have extensive slope cuts. This part of the slope falls under moderate to high susceptible zone. Though the surrounding areas are covered under low susceptibility zones but still due to anthropogenic activities this hill has a possibility of slope failure occurrence in future under the influence of factors like rainfall, weathering etc. There have been previous instances of slope failures near road section causing damage to road transportation. Since, the area is densely populated slope failures may cause great damage to life and property. This has to be conveyed to the concerned local authorities and preventive measures like slope terracing, retaining walls etc. should be taken up. Moreover, the local authorities should also consider shifting of residential areas to other stable areas to minimise damage in the current calamities.

A total of 13-new landslides have identified, out of which 11-landslides are debris slide and 02-landslides are rockslide. 1st rockslide has been recorded near Sampigekan Coffee Estate under the toposheet no. 48O/10. This rockslide is due to the road widening for the coffee estate work. Whereas, 2nd rockslide has been recorded near Rajbhawan which is near Kemmengundi Forest Check-post and falls under the toposheet no. 48O/10. Southwest of Kallattipur village towards the Coffee Estate, Extensive Cut Slope (ECS) have been identified and which is vulnerable for future slope failures. About 1.5km south of Santveri, on the road section ECS has been recorded. Along this ECS 02-debris slides has also been recorded. Southwest of Kallattipur village towards the Dupadakan Coffee Estate, ECS dimension is about 800m and this road stretch is vulnerable for future slope failures. Along this ECS section, 02-debris slides have also been recorded. At the road section from Kemmengundi to Abbey falls, ESC has been also recorded and it's length is up to 8.3 Km. Which is vulnerable due to road widening and load lengthening.

The ECS section near South of Santveri, connecting Shivamoga-Chikmagalur SH is about 1800m which falls under the toposheet no. 48O/14, is vulnerable for the landslide. Considering the slope condition and the type of overburden material present, the slope is vulnerable for future failure even though retaining wall and lined drainage have been provided at the ECS. West of Kaimara, towards Dupadakan Coffee Estate, ECS has been identified for about 3.8 Km. and 01-debris slide has also been recorded. At this road stretch recurrence of landslide is expected. All the pre field thematic maps has been validated during the fieldwork were the following observations has been recorded. At the road section from Kemmengundi to Abbey falls, ESC has been recorded which is due to road widening and load lengthening. Considering the slope condition and the type of material present, the slope is vulnerable for future failure even though retaining wall and lined drainage has been provided at the ECS. West of Kaimara, towards Dupadakan Coffee Estate, ECS has been identified and 01-debris slide has also been recorded. At this road stretch re-occurrence of landslide is expected.

The southern part of the study area is relatively devoid of any major landslide incidences as per the present scale of mapping except the 01-landslide that has been recorded, i.e., Debris slide at Irppu Water falls under the toposheet no. 49M/13. In the southern part of study area, widening of road section is going on near Kutta-Virajpet-Makuta which may lead to the landslide incidence in near future as geo-scientific factors are not given due weightage by the road constructing authorities. This is further emphasize that heavy rainfall and deforestation may lead to loosening of the overburden which may slide. Here in the study area deforestation is on modified slope for coffee plantation.

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 hillslopes. 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 preparatory 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, based on other factors.

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.

Spatio-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 and the elements at risk.

Recommendations:

Based on the evaluation of the geofactors 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 suggested:

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 on a larger scale 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 and also suggested to investigate thoroughly through geotechnical investigation with engineering geologists.

Landslide susceptibility mapping is useful 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 consult the report and landslide protection work should be undertaken in consultation with civil engineers.

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.

7. References

Ankur Kumar Srivastava and Harsha Sunder E., **2016**. Macro-Scale (1:50,000) Landslide Susceptibility Mapping in Parts of Toposheet No. 48P/15 & 16, Coorg District, Karnataka, GSI Report, FSP: 2015-2016.

Atkinson, P. M. and Massari, R., May 1998. Generalized Linear Modelling of Susceptibility to Landsliding in the Central Apennines, Italy, Computers & Geosciences. Volume 24, Issue 4, 15 Pages 373-385.

Brunsden, D., The application systems theory to the study of mass movement. Geologica Applicatae Idrogeologia., Univ. of Barlin., 8, 1, 185-207, 1973.

Cees J. Van Westen, Enrique Castellanos and Sekhar L. Kuriakose, December 2008. Spatial data for landslide susceptibility, hazard, and vulnerability assessment: An overview, Engineering Geology, Volume 102, Issues 3–4, 1, Pages 112-131.

Derruau, Max 1983. GEOMORFOLOGÍA (Max Derruau) Ariel Geografía. Librería: Libros Fugitivos (Valencia, España).

David R., Montgomery Kevin M., Schmidt Harvey M., Greenberg William and E. Dietrich, 2000. Forest clearing and Regional Landsliding, Geology, 28 (4): 311-314.

Diaz, F.E. Gonzáles, R.L. Hermanns, A. Folguera, and L. Fauque, 2006. Landslide dams in the Central Andes of Argentina- showing the need of revising the established landslide dam classification, Italian Journal of Engineering Geology and Environment, Special Issue 1.

Ghosh, S., Carranza, E.J.M., Van Westen, C.J., Jetten, V.G. and Bhattacharya, D.N., 2010. Selecting and weighting spatial predictors for empirical modeling of landslide susceptibility in the Darjeeling Himalayas (India). Geomorphology, 131 (1–2): 35-56.

Guzzetti, F., Reichenbach, P., Cardinali, M., Galli, M. and Ardizzone, F., 1999. Probabilistic landslide hazard assessment at the basin scale. Geomorphology, 72 (1-4): 272-299.

Janardhana M. R., Vinutha D. N, Abdul-Aleam Ahamed D. AL-Qadhi, June 2016. Janardan Landslides in Coorg District of Karnataka State. International Journal of Innovative Research in Science, Engineering and Technology. Vol. 5, Issue 6.

Long and De Smedt, 2012. Application of an analytical hierarchical process approach for landslide susceptibility mapping in A Luoi district, Thua Thien Hue Province, Vietnam. Environmental Earth Sciences. v66 i7. 1739-1752.

Maruthi K.V, Kumar V., 2013. A note on the preliminary post disaster investigation of landslides occurred around Madikeri, Coorg District, Karnataka. Unpub. GSI reports of FS 2012-13.

Maruthi, K.V and Chandran K.V, (2010) Landslide inventory along NH and SH of Ghat roads in Uttar Kannada and Chikmagalur districts, Karnataka, Progress report for FSP 2010-2012.

Maruthi, K. V., and Chandran, K. V., Landslide Inventory Along Natural Highway and State Highway of Ghat Road in North Goa and South Goa District, Goa, Unpublished Report, FSP: 2012 – 2013.

NGLM Manual NRSC, Hyderabad, 2010. Manual for National Geomorphological and Lineament Mapping on 1: 50,000 scale, First Edition, 2010.

Parcher, JV and Means, RE, 1968. Soil mechanics and foundations, Merrill (Charles E) Publishing Company 1300 Alum Creek Drive Columbus, OH United States, pp Xvi-573, FIGS, TABS, REFS.

Page, A. L., McGrath, S. P., A. C. Chang, and E. Witter, 1994. Land application of sewage sludge: scientific perspectives of heavy metal loading limits in Europe and the United States.

Saaty, T.L., 1977. A scaling method for priorities in hierarchical structures. Journal of the Mathematical Psychology, 15 (3): 234-281.

Saaty, T.L., 1980. The Analytic Hierarchy Process. New York: McGraw-Hill.

Saaty, T.L. and Vargas, L.G. (2001). Models, Methods, Concepts and Applications of the Analytic Hierarchy Process. Kluwer Academic Publishers, Norwell. http://dx.doi.org/10.1007/978-1-4615-1665-1.

Selby, M. J., A. P. W. Hodder, 1993. Hillslope Materials and Processes. Oxford University Press.

Siddle, H.J., 1985. Groundwater tracing in a South Wales landslide, Research Centre (Environment) Workshop.

Terlien, Mark T. J., August 1998. The determination of statistical and deterministic hydrological landslide-triggering thresholds, Environmental Geology, Volume 35, Issue 2–3, pp 124–130.

Van Westen, C.J., Castellanos Abella, E.A. and Sekhar, L.K., 2008. Spatial data for landslide susceptibility, hazards and vulnerability assessment: an overview. In: Engineering geology, V. 102, 3-4 pp. 112-131.

Varnes, D.J., 1978. Slope movement types and processes. In: Schuster, R.L., Krizek, R.L. (Eds.), Landslides: Analysis and Control. Special Report, V. 176. Transportation Research Board, National Academy of Sciences, Washington, DC, pp. 11–33.

Varnes, D.J., 1984. Landslide Hazard Zonation: A Review of Principles and Practice. UNESCO, Daramtiere, Paris, p. 61.

Locality Index

Locality Index: Northern Part (Shivamoga and Chikmagalur District)

Sl. Nos.	Name	Latitude	Longitude
1.	Aramballi	13.66282259	75.51024578
2.	Bale	13.53568338	75.50736431
3.	Balekoppa	13.61497701	75.50728941
4.	Ballavara	13.56477826	75.80404802
5.	Bilalkoppa	13.56320086	75.56114468
6.	Dandubittahara	13.55783649	75.63832996
7.	Gangur	13.55426329	75.8207883
8.	Gonagikatte	13.57091936	75.80948128
9.	Guddadabeeranahalli	13.62847143	75.74027805
10.	Gurupura	13.64930502	75.72660977
11.	Haledanivasa	13.63294491	75.5467779
12.	Handur	13.57816884	75.5537682
13.	Hebbe	13.51783452	75.57730235
14.	Hiluvalli	13.59977652	75.5364771
15.	Hippala	13.52933911	75.63239243
16.	Hogarehalli	13.57549374	75.88903332
17.	Honnekudige	13.55555527	75.55386629
18.	Hulithimmapura	13.59066887	75.81267723
19.	K.Kanabur	13.73080148	75.51019359
20.	Kakanhosudi	13.74091042	75.53641761
21.	Kallahalu	13.57800323	75.83896156
22.	Kallathipura	13.5606298	75.7906057
23.	Karvani	13.53362177	75.66979379
24.	Kesavimane	13.53487885	75.72583063
25.	Kundurkaval	13.6388542	75.67322255
26.	Kusabur	13.69756691	75.5216358
27.	Lakkanahalli	13.50807923	75.88708938
28.	Lakkavalli Ma	13.59840114	75.65573993
29.	Lingadahalli	13.59701362	75.84642195
30.	Lingapur	13.73337306	75.52904236
31.	Lingapura	13.62785732	75.53637397
32.	Mallenhalli	13.61301882	75.81679571
33.	Maraganhalli	13.51201888	75.91645796
34.	Masalapur	13.52189538	75.8987974
35.	Mensur	13.59797385	75.5072624
36.	Nagalapura	13.57537857	75.50744046
37.	Nandigave	13.55666973	75.61478486
38.	Narasimharajapura (NR Pura)	13.60794944	75.50874887
39.	Pillebeeranhalli	13.53465051	75.82424023
40.	Ranganathapura	13.60206132	75.76938336
41.	Ravoor	13.59057899	75.54953338
42.	Salur	13.54511728	75.56542629
43.	Santaveri	13.51852547	75.80525385
44.	Sarya	13.51855404	75.54501531
45.	Satguli	13.70610687	75.51536145
46.	Shankaraghatta	13.59955338	75.81554133
47.	Shankarghatta	13.57680938	75.82726798

48.	Shiragalale	13.5768887	75.53058077
49.	Siddamaji Hosuru	13.75636208	75.51333647
50.	Soosalavani	13.63239782	75.51905476
51.	Thanigebylu	13.58760589	75.75356991
52.	Tyagadabagi	13.63375086	75.77796626
53.	Udeva	13.56029937	75.83402148
54.	Varkate	13.55153397	75.53348754
55.	Varthegundi	13.57464821	75.75921382
56.	Vittala	13.6446199	75.53623117
57.	Yemmedoddi	13.54630474	75.9114682
58.	Yeradahankalu	13.57333806	75.85634267

Locality Index: Southern Part (Kodagu and Mysore District)

Sl. Nos.	**Locality Name**	**Latitude**	**Longitude**
1.	Ajjamada	11.99158538	75.99394243
2.	Anechaukur	12.23289965	76.0326408
3.	Arekeri Forest	12.22901101	76.0305075
4.	Badaga	12.00304074	76.02763677
5.	Balekovu	11.99557975	76.08742916
6.	Balele	12.16447379	76.0218106
7.	Balele	12.13656464	76.05242365
8.	Bannamotte	12.02838747	76.00084026
9.	Beeruga	11.99285081	75.94042237
10.	Bekke Sodlur	12.10479396	76.00173195
11.	Bettattur	12.17768377	76.05218288
12.	Bilur	12.14150324	76.01004799
13.	Churikadu	12.01167781	76.05058887
14.	Devamachi Forest	12.26962226	76.0044183
15.	Devanur	12.14388179	76.05660088
16.	Dhanugala	12.17977796	76.00133169
17.	Gonigadde	12.03900216	76.06423328
18.	Hathugaattu Forest	12.10755075	76.10878503
19.	Hermadu	12.01185982	76.03034633
20.	Kaimane	11.97825975	76.01170237
21.	Kainatti	12.14716739	76.04914272
22.	Kakkur	11.99290266	76.01110532
23.	Kalhalla	12.06820112	76.10948177
24.	Kandur	12.03986041	76.00137543
25.	Kanoor	12.08753762	76.04500483
26.	Kanur	12.08681215	76.03327011
27.	Karmadu	12.10573334	76.06557333
28.	Kembkolli	11.9984265	76.05064425
29.	Kommenakeri	12.02137064	76.01144412
30.	Konanakatte	12.1743806	76.00958984
31.	Kothur	12.06394028	76.02185251
32.	Kottageri	12.11976592	76.02166906
33.	Kumtoor	11.99597446	75.99848961
34.	Kurchi	11.95511148	75.95803345
35.	Kutta	11.96759846	76.04794084
36.	Lakunj	12.05270551	76.02969202

37.	Manchalli	11.95130083	75.99841577
38.	Marur	12.22531038	76.01056796
39.	Masamane	11.96210628	76.03014825
40.	Mattigodu	12.22869093	76.02095333
41.	Mepalli	11.99643465	75.85133706
42.	Murkal	12.11504869	76.13565709
43.	Nagarhole	12.02078963	76.10377129
44.	Nalkeri	12.01815575	76.10862603
45.	Nallur	12.15123018	76.00338353
46.	Nanchi	11.99436556	76.07418755
47.	Nellur	11.99207481	76.03723323
48.	Nittur	12.11044439	76.05670925
49.	Pallen	12.02337637	76.04392796
50.	Perumal Devaru	11.997444	75.96468335
51.	Ponnappasante	12.15835259	76.01654847
52.	Poojekal	11.97368917	76.02782762
53.	Salugodu	12.16567394	76.04167288
54.	Sodlur	12.04356274	76.0403526
55.	T. Shettigeri	12.03332153	76.00461982
56.	Theralu	11.96793264	75.88255945
57.	Thithimathi	12.22205338	76.00144802

SYNOPSIS OF WORK DONE

1.	**Title of the report**	MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NOS. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01, 49M/13 CHIKMAGALUR, KODAGU, MYSORE AND SHIVAMOGA DISTRICTS, KARNATAKA
2.	**FSP Code No**	M4LSSM/NC/SR/SU-KG/2019/25179-32984
3.	**Field Season**	2019-20, 2020-21
4.	**Date of Commencement**	21st October 2019
5.	**Date of Completion**	15th January 2021
6.	**Officers associated with the investigation and no. of days spent in the field**	1. Jayesh Chourasia, Senior Geologist-83 Days 2. Rahul Kumar Chaurasia, Geologist-89 Days
7.	**Quantum of work done**	

1. Pre-field preparation	
(i) Slope Forming Material map	1395 Sq.Km.
(ii) Geomorphology & Lineament map	1395 Sq.Km.
(iii) Slope Morphometry (slope, aspect & curvature) map	1395 Sq.Km.
(iv) Landuse / Landcover map	1395 Sq.Km.
(v) Drainage map	1395 Sq.Km.
(vi) Regolith thickness map	1395 Sq.Km.
(vii) Preparation of Landslide Inventory Map	1395 Sq.Km.
2. Field-based studies	
(i) Field-checking of all thematic maps	1395 Sq.Km.
(ii) Field validation of landslide inventory and collection of recent and historic landslides (using archives, old reports, road register etc.)	1395 Sq.Km.
(iii) Collection of landslide inventory and damage data as per 42 point geo parametric data sheet	13 Nos.
(iv) Validation of landslide susceptibility map at important locations	1395 Sq.Km.
3. Post-field studies & modelling	
(i) Updation of thematic and inventory maps in GIS	1395 Sq.Km.
(ii) Preparation of Landslide Susceptibility Map in GIS	1395 Sq.Km.
4. Collection of rainfall data from available rain stations	1395 Sq.Km.

8. Expenditure

Expenditure Details	Amount (Rs.)
Wages	1,17,717.97/-
OC	1,01123.09/-
POL	101171.88/-
Total	320012.94/-

FIVE POINT PROFORMA

Title of the report: "Macro-scale (1:50,000) Landslide Susceptibility Mapping in Parts of Toposheets Nos. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01, 49M/13 Chikmagalur, Kodagu, Mysore and Shivamoga Districts, 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/2019/25179-32984 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/2019/25179-32984
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.	21st October 2019 Jayesh Chourasia, Senior Geologist-83 Days Rahul Kumar Chaurasia, Geologist-89 Days Total
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. R. Sajeev Director

GEOLOGICAL SURVEY OF INDIA

Certificate of Quality of the report

Project/ Division: NLSM/EG Division

FSP No.: FSP Code No: M4LSSM/NC/SR/SU-KG/2019/25179-32984

Mission: IV

Title of the report: Macro-scale (1:50,000) Landslide Susceptibility Mapping in Parts of Toposheets Nos. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01, 49M/13 Chikmagalur, Kodagu, Mysore and Shivamoga Districts, 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. Jayesh Chourasia, Senior Geologist	83 days	
2. Rahul Kumar Chaurasia, Geologist	89 days	

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 results to 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
Shri. K. V. Maruthi Director	01	03	

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

LIST OF PLATES

PLATE-01

Location Map of The Study Area

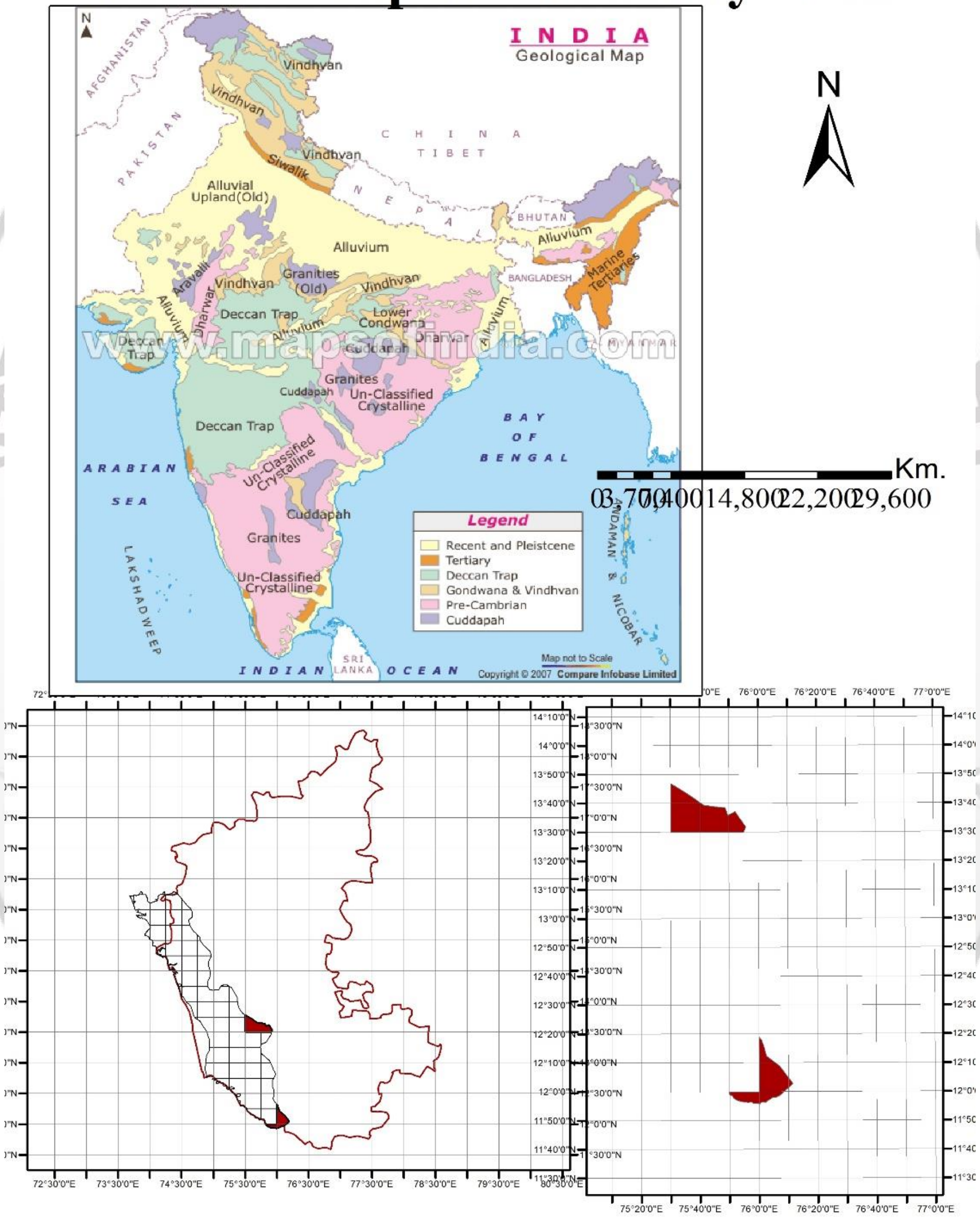
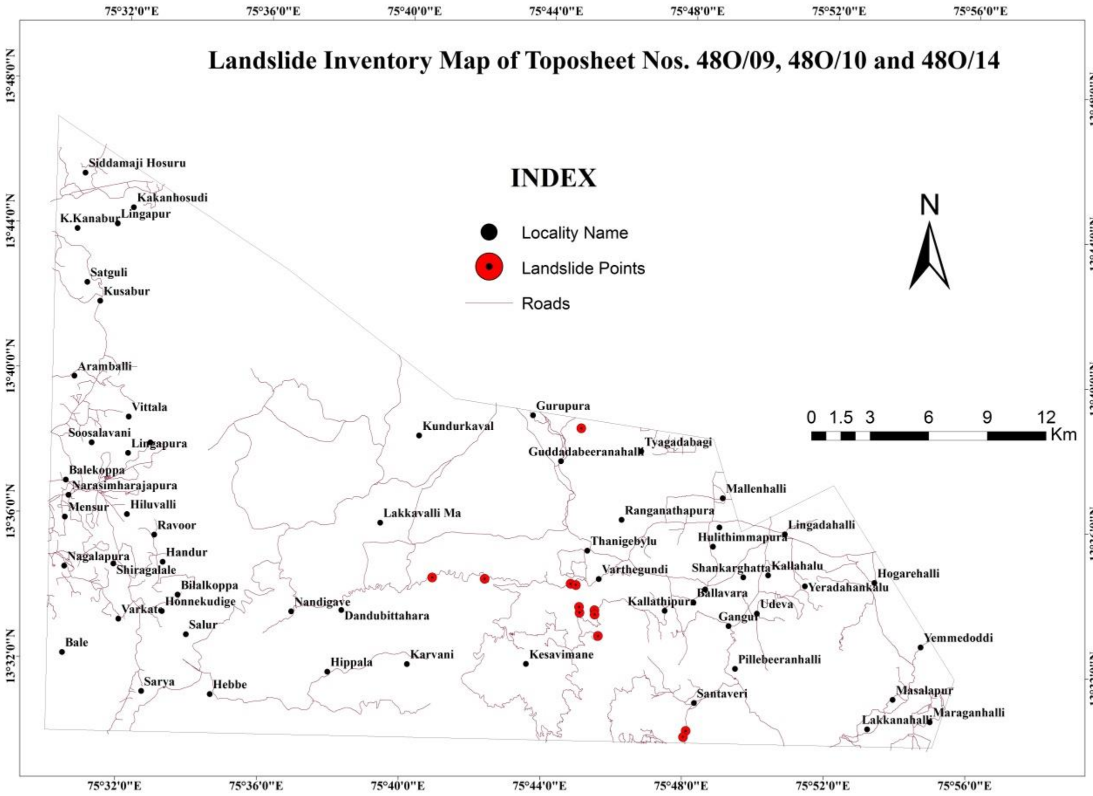


PLATE-02

Landslide Inventory Map of the study area



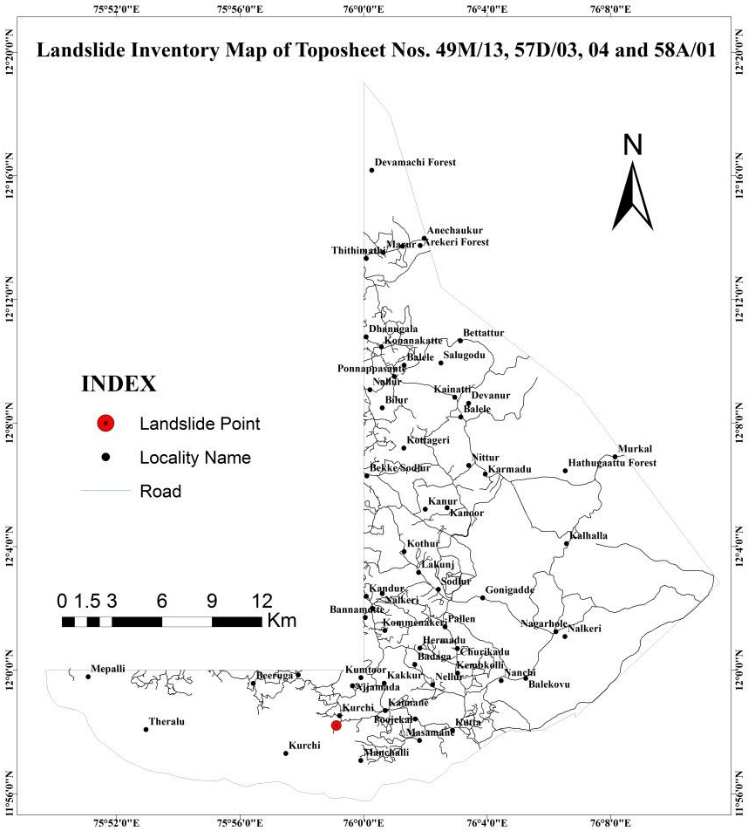
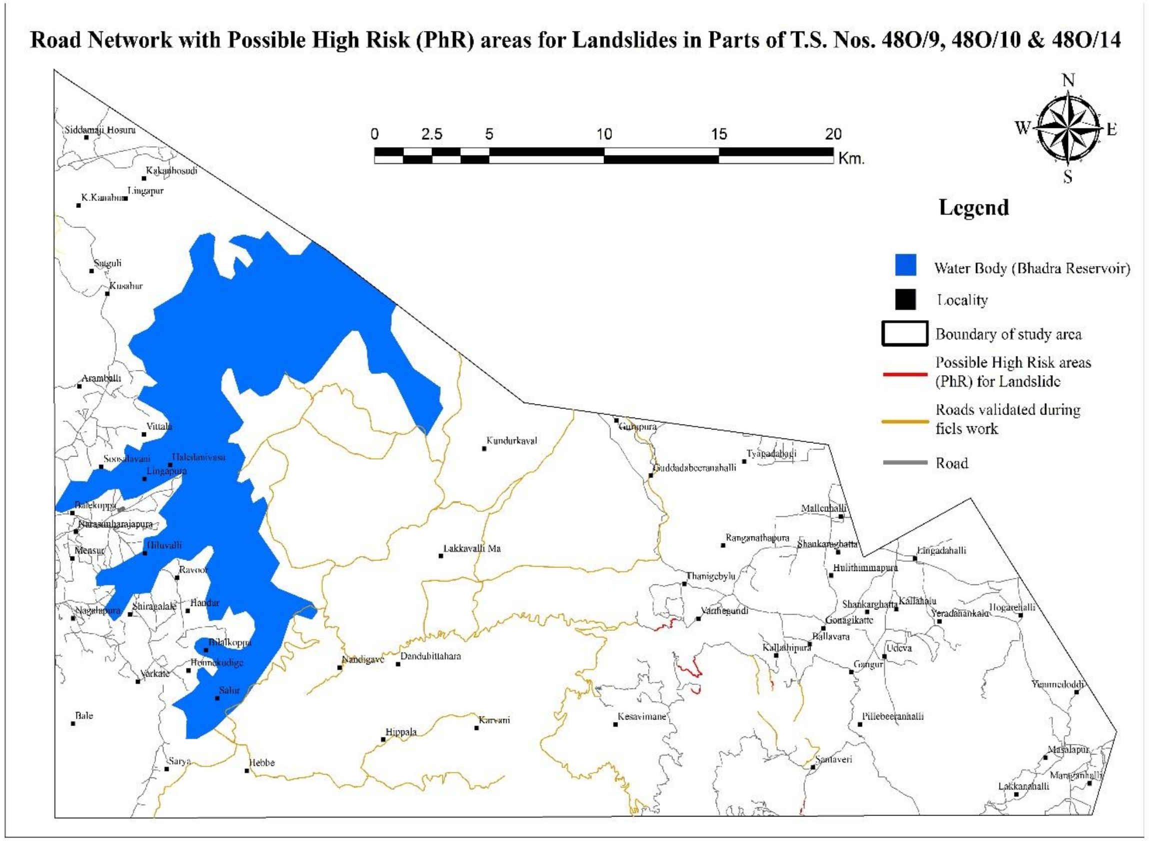


PLATE-03


Road Network with Possible High Risk (PhR) areas for Landslides in Parts of T.S. Nos. 48O/9, 48O/10 & 48O/14
0 2.5 5 10 15 20 Km.
N
S
W
E
Legend
Water Body (Bhadra Reservoir)
Locality
Boundary of study area
Possible High Risk areas (PhR) for Landslide
Roads validated during fiels work
Road

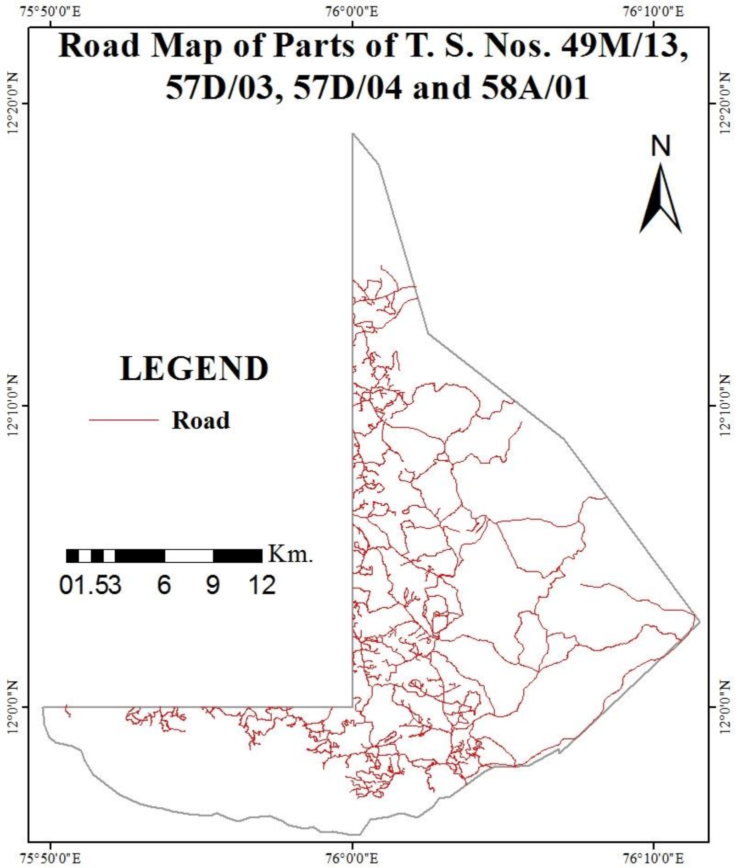
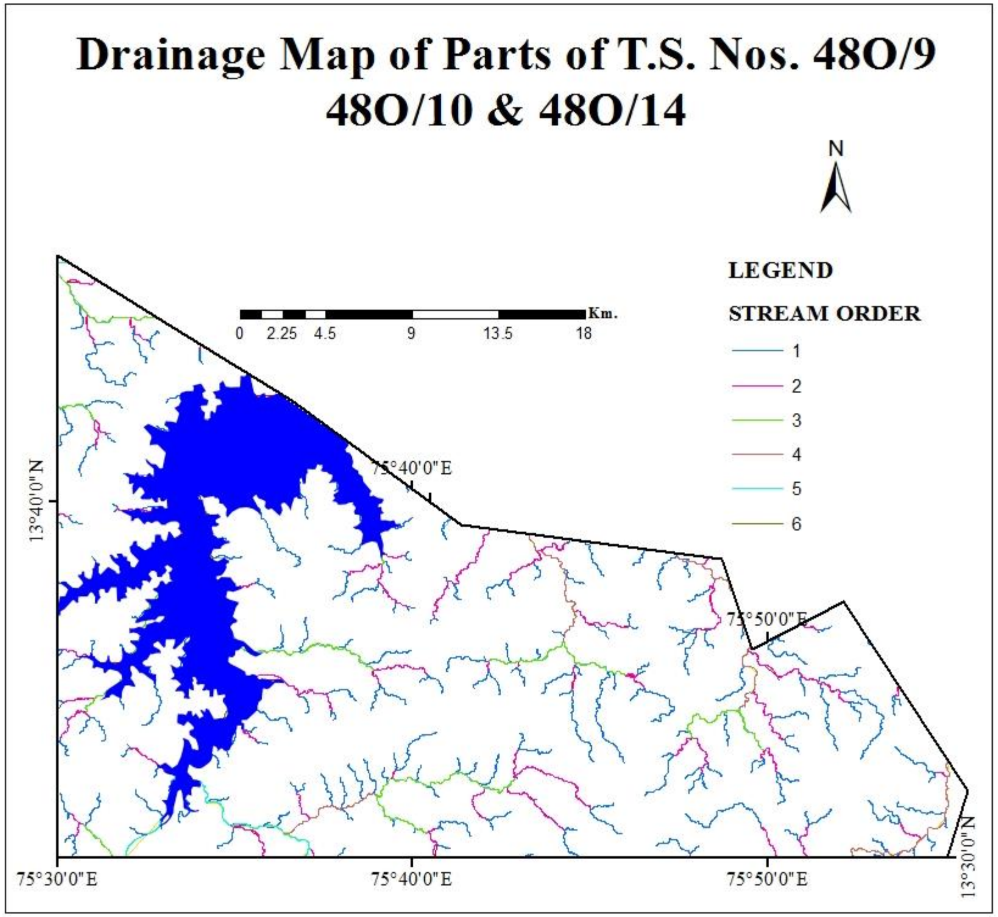
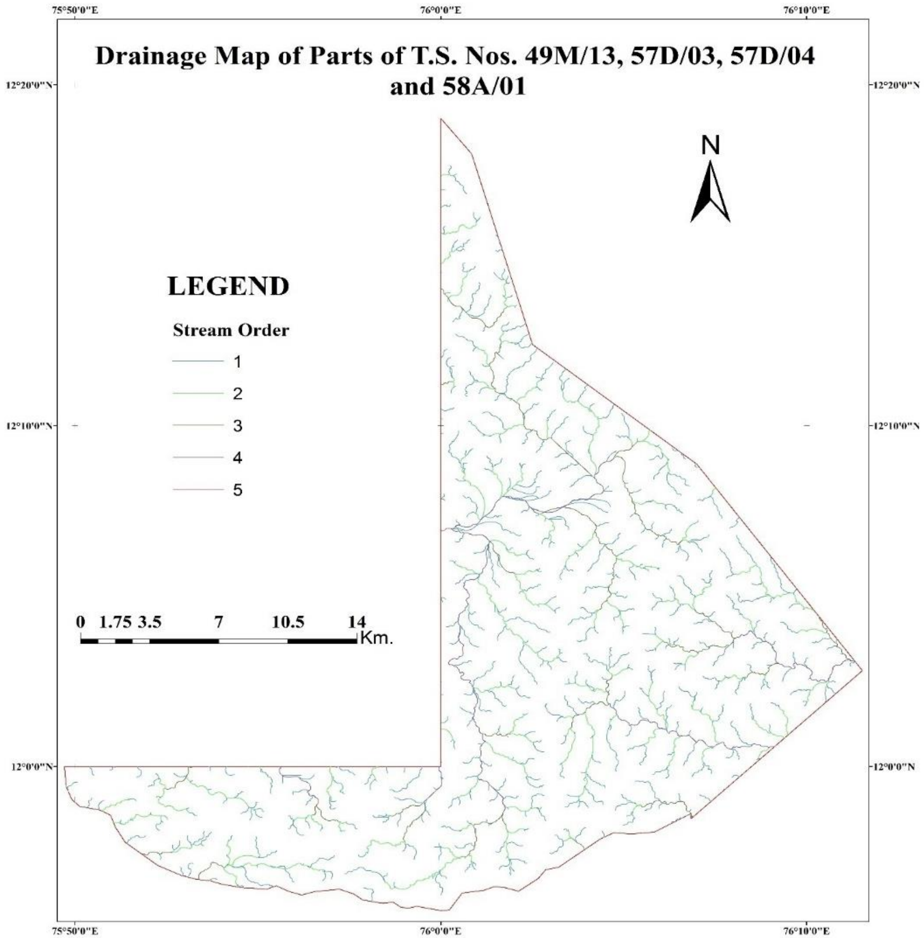

Road Map of Parts of T. S. Nos. 49M/13, 57D/03, 57D/04 and 58A/01
N
LEGEND
Road
01.53 6 9 12 Km.
75°50'0"E
76°0'0"E
76°10'0"E
12°20'0"N
12°10'0"N
12°0'0"N

PLATE-04

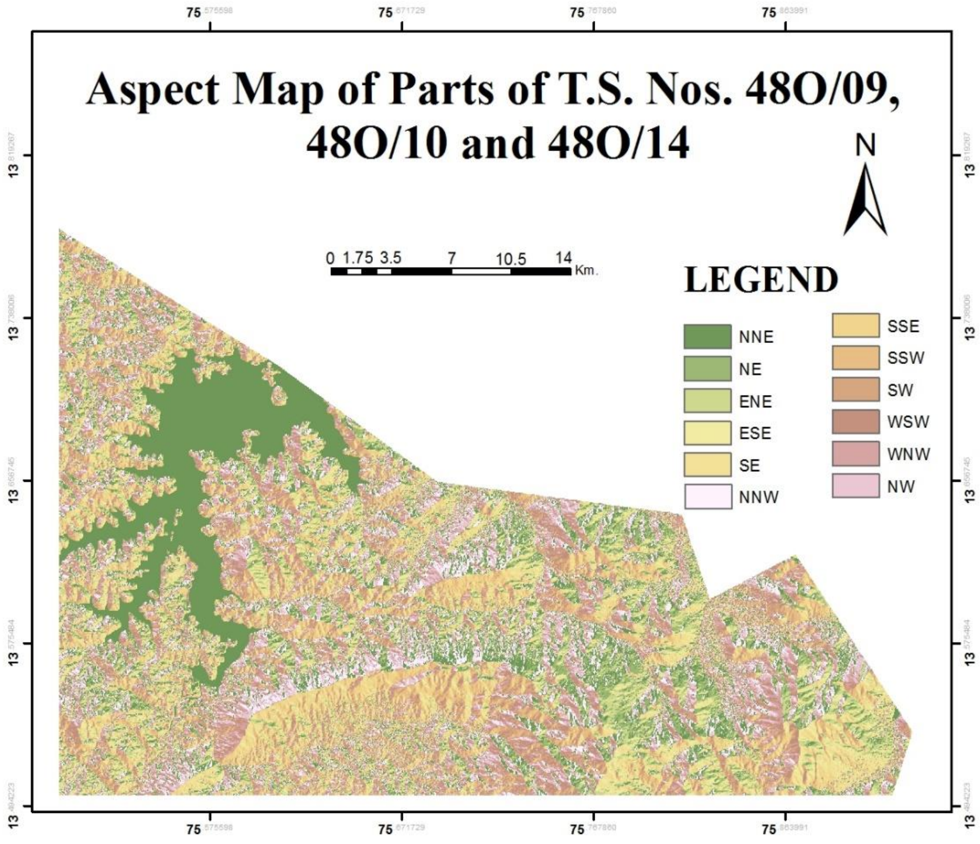


Drainage Map of Parts of T.S. Nos. 48O/9
48O/10 & 48O/14
N
LEGEND
STREAM ORDER
1
2
3
4
5
6
0 2.25 4.5 9 13.5 18
Km.
75°40'0"E
75°50'0"E
13°40'0"N
13°30'0"N
75°30'0"E
75°40'0"E
75°50'0"E

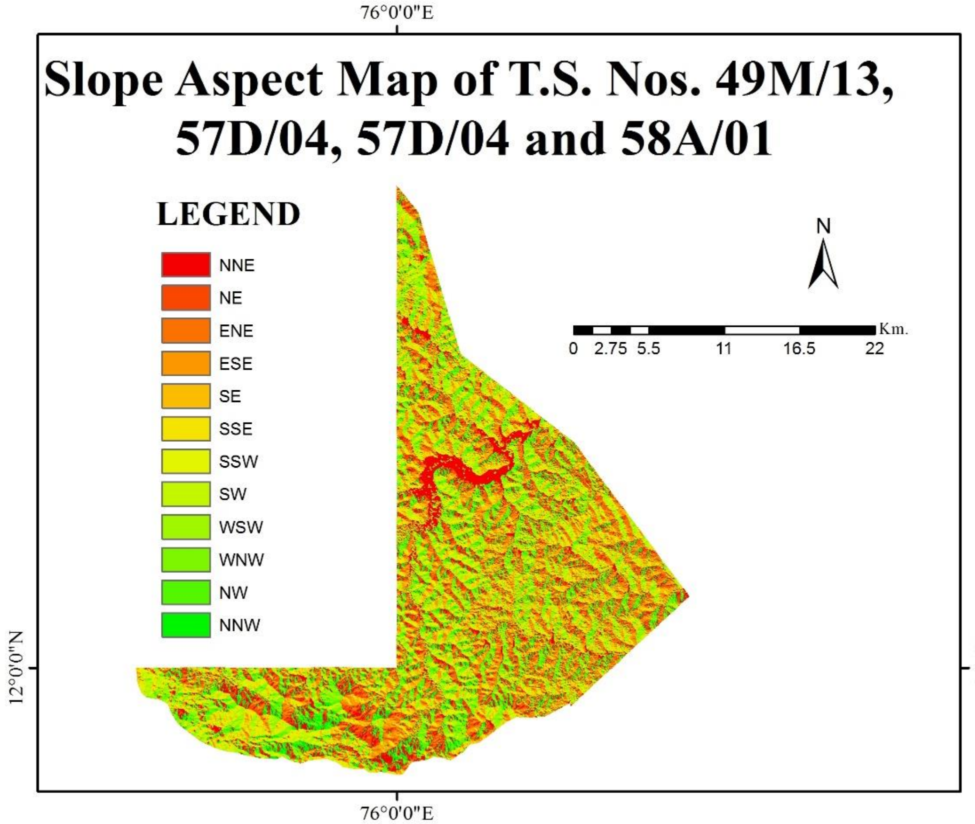


Drainage Map of Parts of T.S. Nos. 49M/13, 57D/03, 57D/04
and 58A/01
N
LEGEND
Stream Order
1
2
3
4
5
0 1.75 3.5 7 10.5 14
Km.
75°50'0"E
76°0'0"E
76°10'0"E
12°20'0"N
12°10'0"N
12°0'0"N

PLATE-05

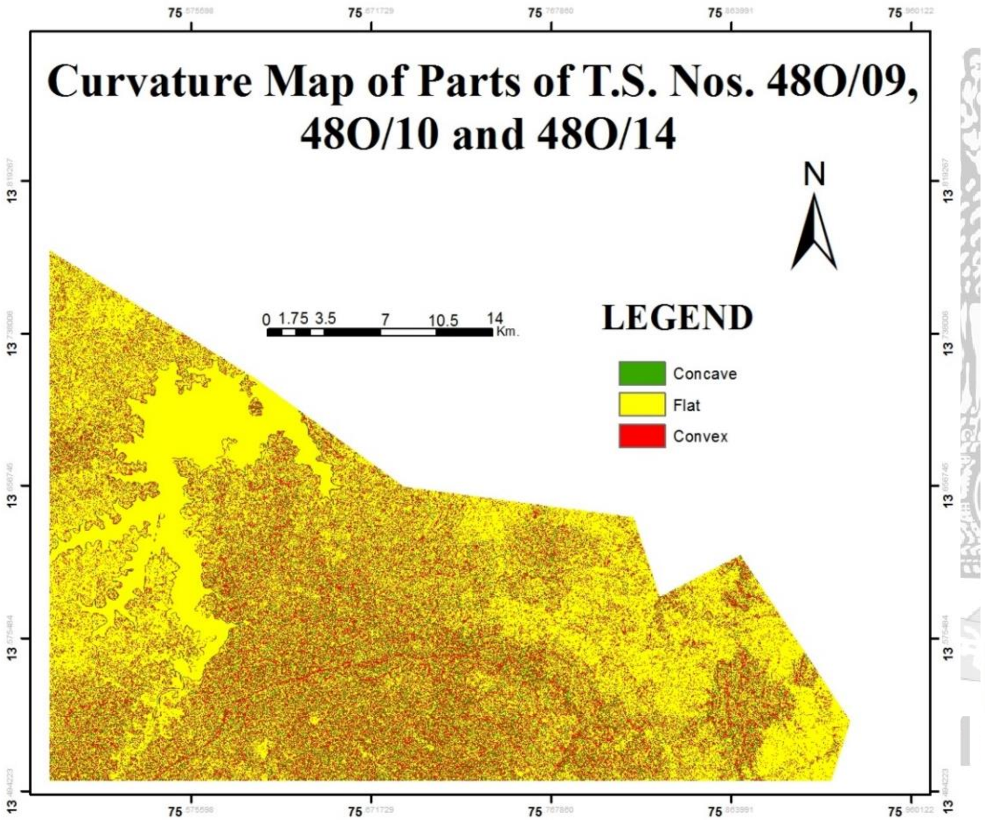


75 .575598
75 .671729
75 .767860
75 .863991
13 .819267
Aspect Map of Parts of T.S. Nos. 48O/09, 48O/10 and 48O/14
N
0 1.75 3.5 7 10.5 14 Km.
LEGEND
NNE
NE
ENE
ESE
SE
NNW
SSE
SSW
SW
WSW
WNW
NW

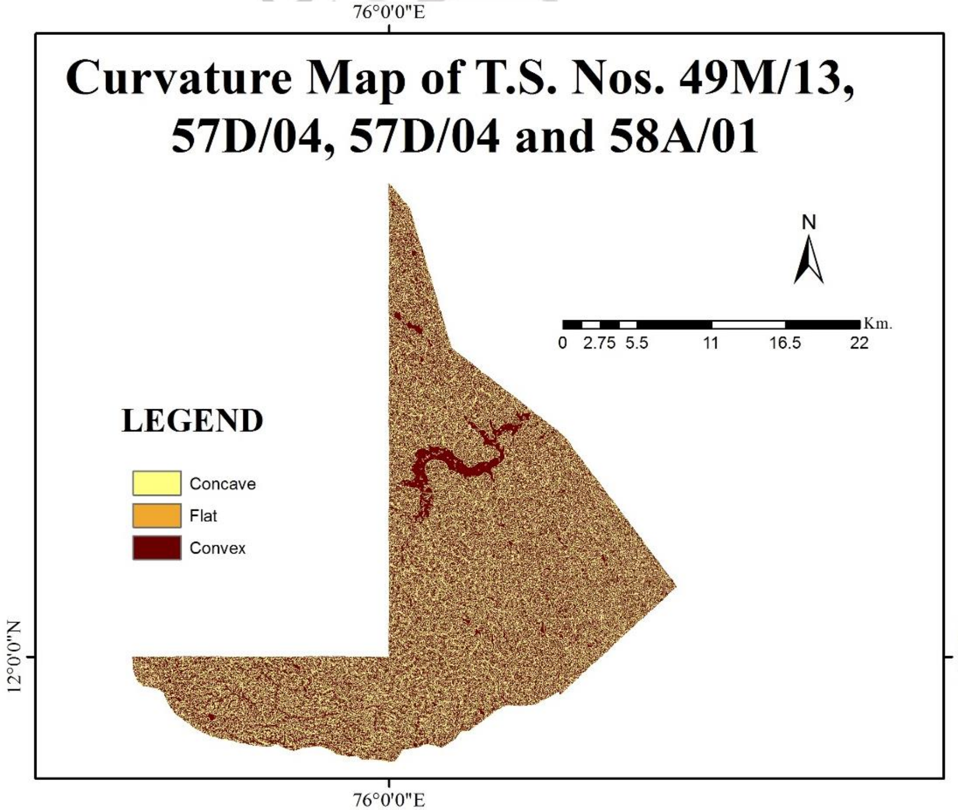


76°0'0"E
Slope Aspect Map of T.S. Nos. 49M/13, 57D/04, 57D/04 and 58A/01
LEGEND
NNE
NE
ENE
ESE
SE
SSE
SSW
SW
WSW
WNW
NW
NNW
N
0 2.75 5.5 11 16.5 22 Km.
12°0'0"N

PLATE-06

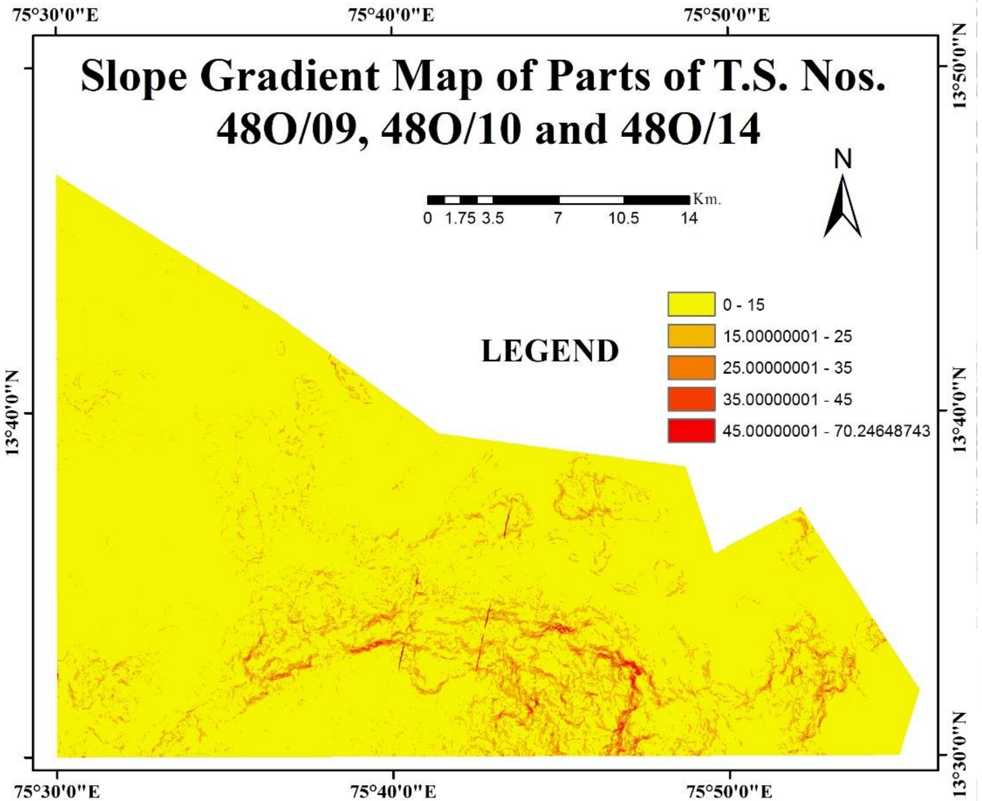


Curvature Map of Parts of T.S. Nos. 48O/09, 48O/10 and 48O/14
N
0 1.75 3.5 7 10.5 14 Km.
LEGEND
Concave
Flat
Convex



76°0'0"E
Curvature Map of T.S. Nos. 49M/13, 57D/04, 57D/04 and 58A/01
N
Km.
0 2.75 5.5 11 16.5 22
LEGEND
Concave
Flat
Convex
12°0'0"N

PLATE-07


Slope Gradient Map of Parts of T.S. Nos. 48O/09, 48O/10 and 48O/14
N
Km.
0 1.75 3.5 7 10.5 14
LEGEND
0 - 15
15.00000001 - 25
25.00000001 - 35
35.00000001 - 45
45.00000001 - 70.24648743
75°30'0"E
75°40'0"E
75°50'0"E
13°50'0"N
13°40'0"N
13°30'0"N

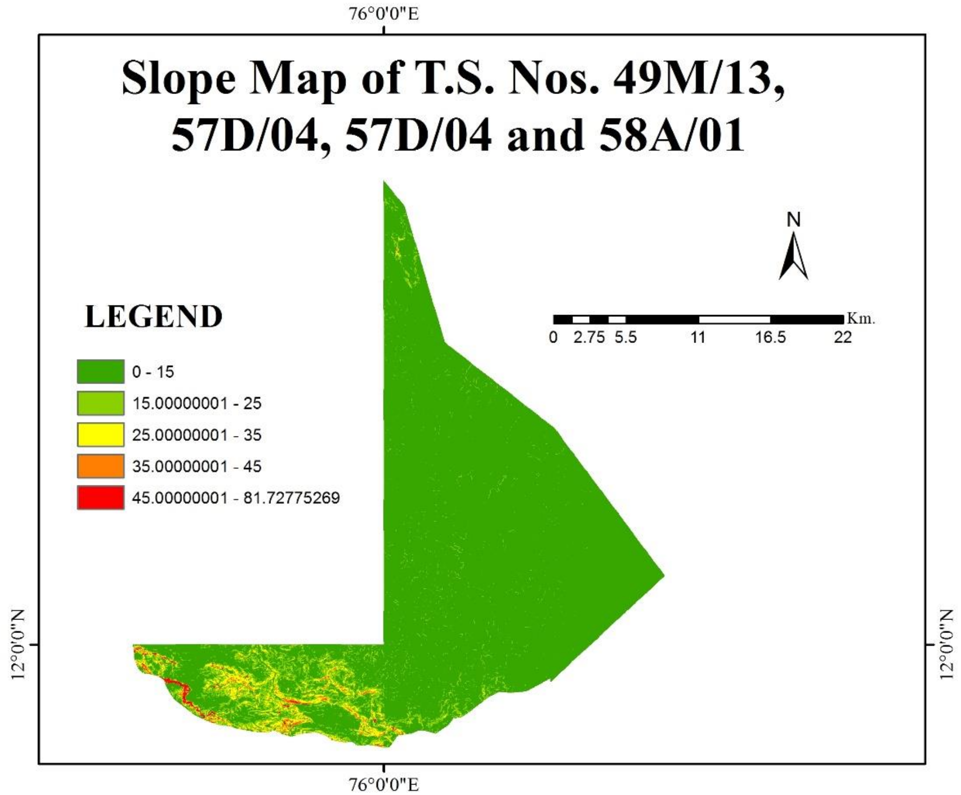
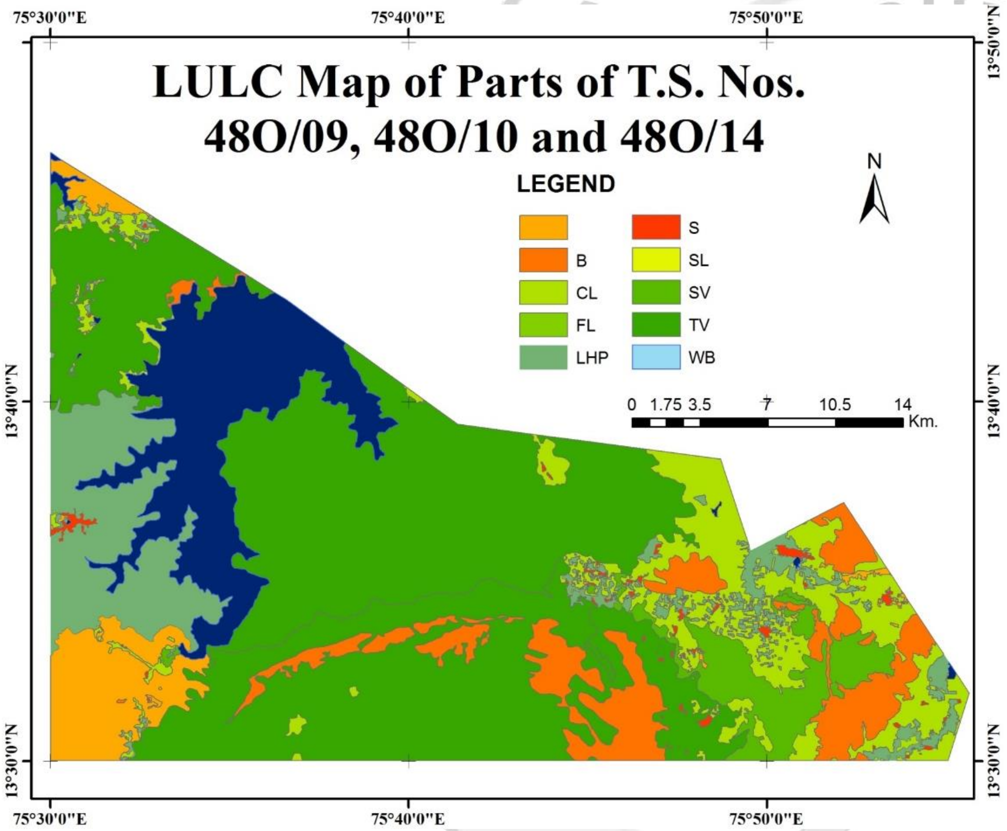

Slope Map of T.S. Nos. 49M/13, 57D/04, 57D/04 and 58A/01
N
Km.
0 2.75 5.5 11 16.5 22
LEGEND
0 - 15
15.00000001 - 25
25.00000001 - 35
35.00000001 - 45
45.00000001 - 81.72775269
76°0'0"E
12°0'0"N

PLATE-08


LULC Map of Parts of T.S. Nos. 48O/09, 48O/10 and 48O/14
LEGEND
B
CL
FL
LHP
S
SL
SV
TV
WB
N
0 1.75 3.5 7 10.5 14 Km.
75°30'0"E
75°40'0"E
75°50'0"E
13°50'0"N
13°40'0"N
13°30'0"N

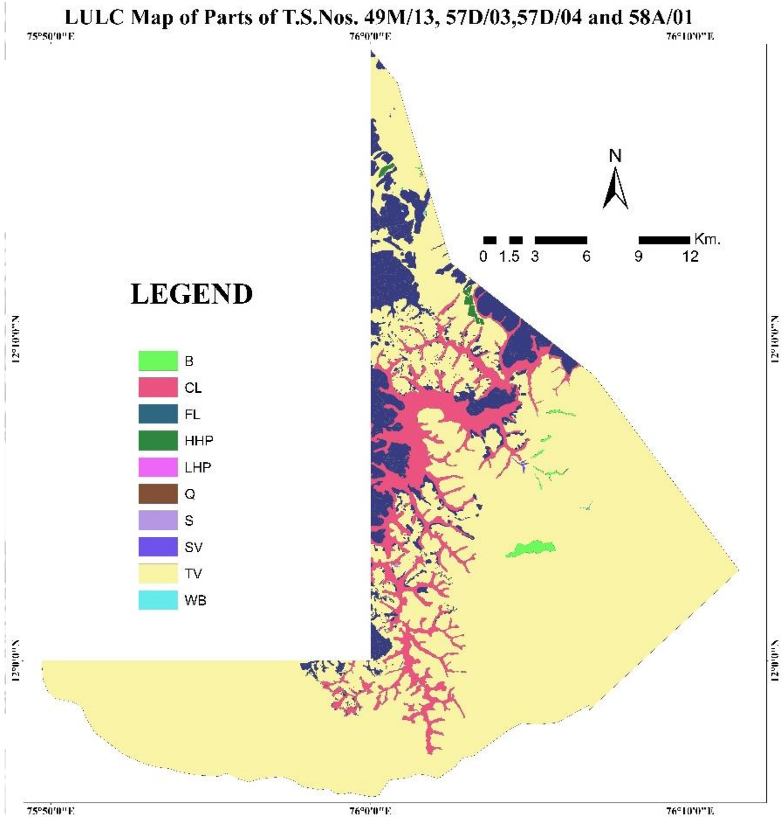
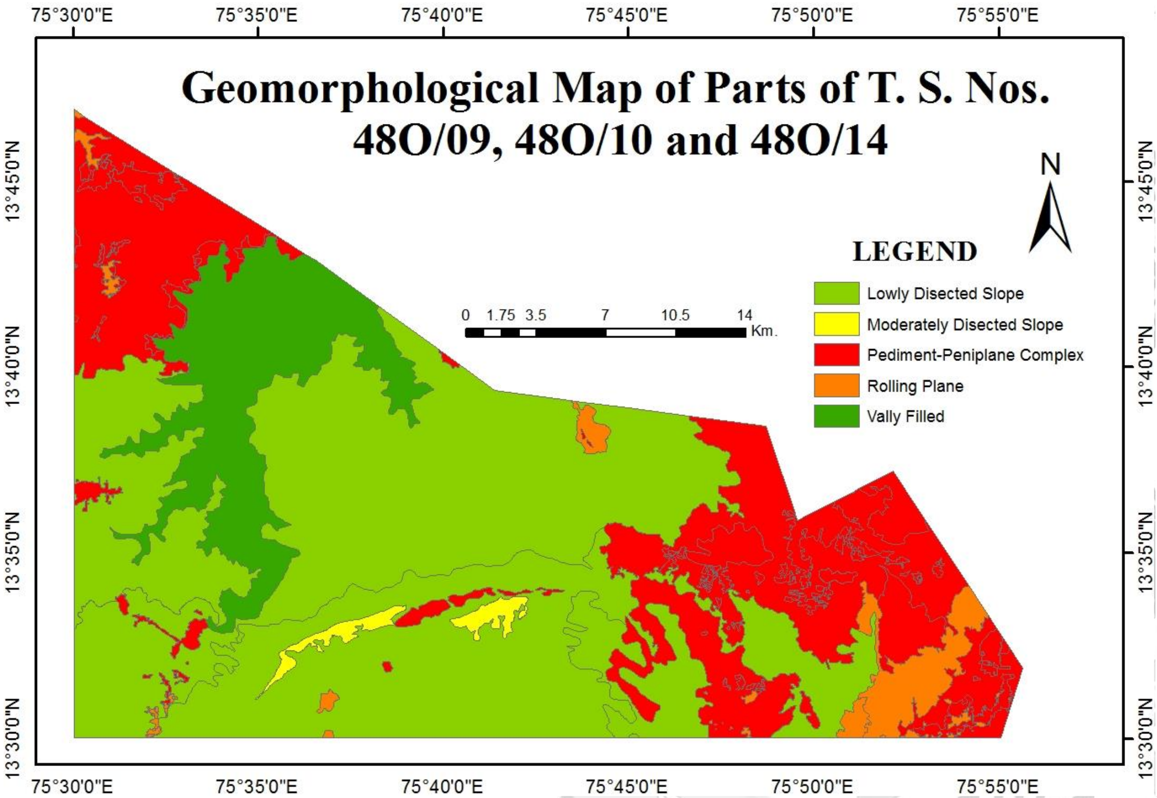

LULC Map of Parts of T.S.Nos. 49M/13, 57D/03,57D/04 and 58A/01
LEGEND
B
CL
FL
HHP
LHP
Q
S
SV
TV
WB
N
0 1.5 3 6 9 12 Km.

PLATE-09


Geomorphological Map of Parts of T. S. Nos. 48O/09, 48O/10 and 48O/14
LEGEND
Lowly Disected Slope
Moderately Disected Slope
Pediment-Peniplane Complex
Rolling Plane
Vally Filled
0 1.75 3.5 7 10.5 14 Km.
N
75°30'0"E
75°35'0"E
75°40'0"E
75°45'0"E
75°50'0"E
75°55'0"E
13°45'0"N
13°40'0"N
13°35'0"N
13°30'0"N

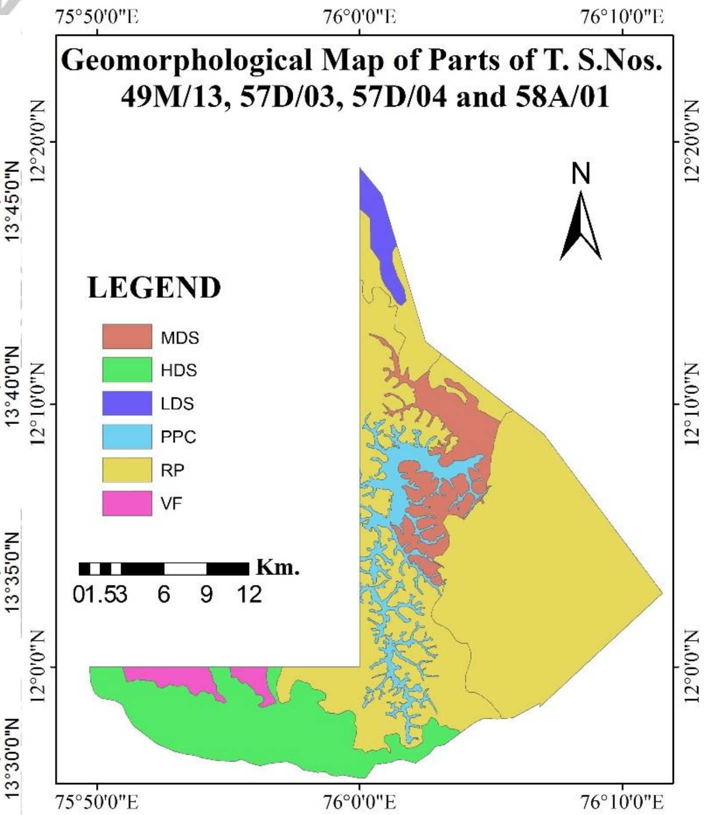
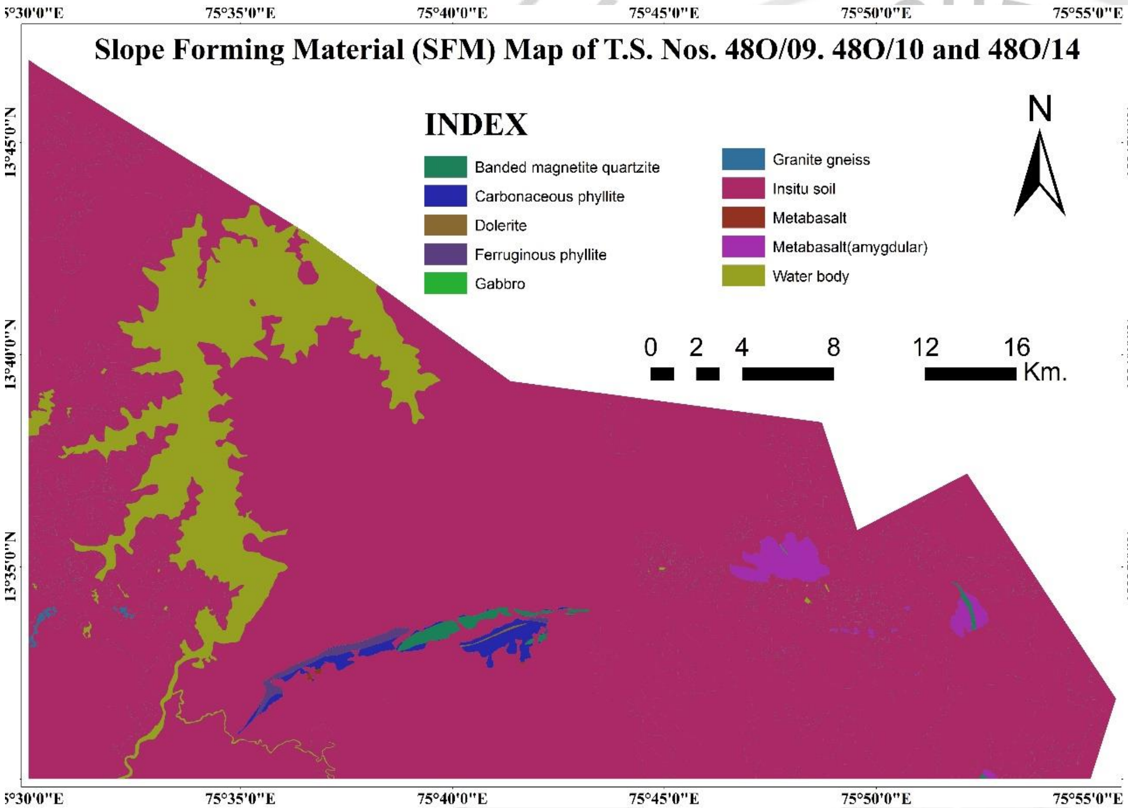
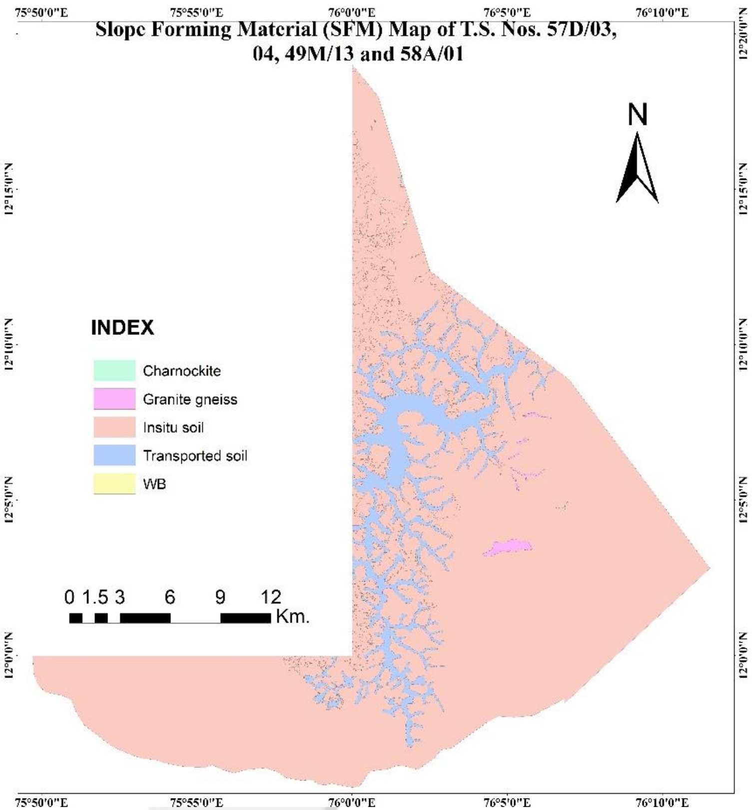

Geomorphological Map of Parts of T. S.Nos. 49M/13, 57D/03, 57D/04 and 58A/01
LEGEND
MDS
HDS
LDS
PPC
RP
VF
01.53 6 9 12 Km.
N
75°50'0"E
76°0'0"E
76°10'0"E
12°20'0"N
12°10'0"N
12°0'0"N

PLATE-10

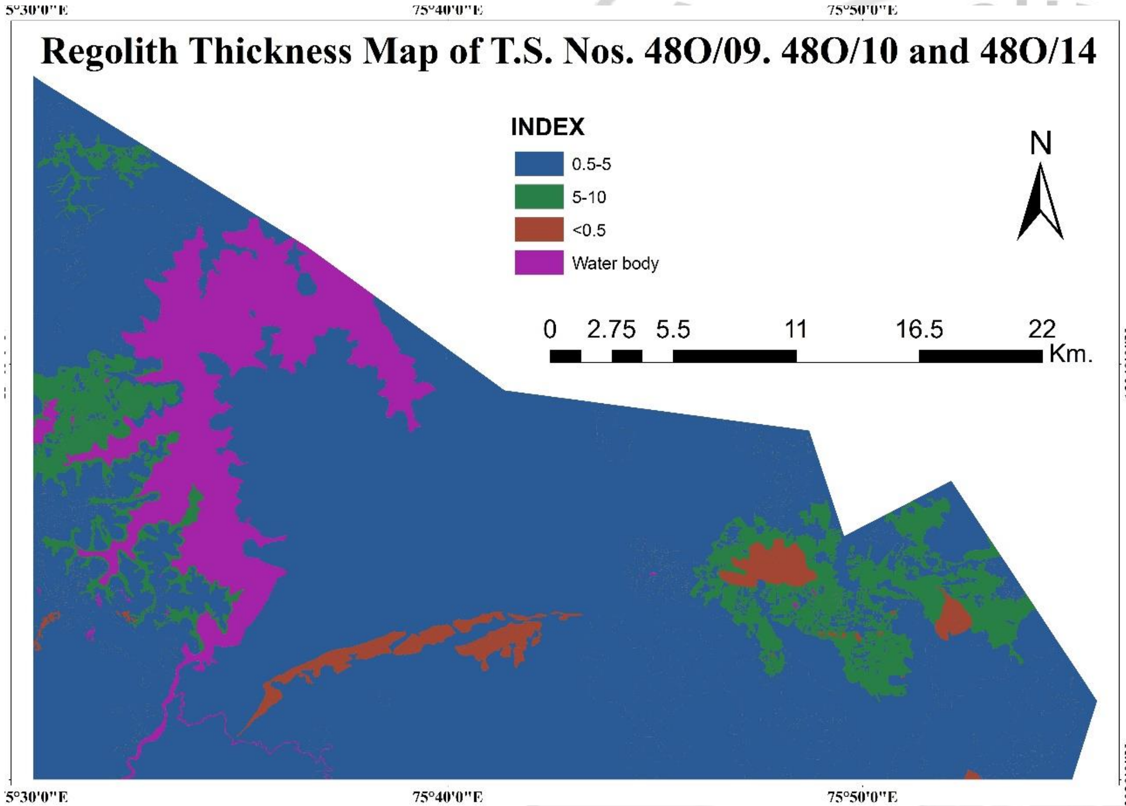


Slope Forming Material (SFM) Map of T.S. Nos. 48O/09. 48O/10 and 48O/14
INDEX
Banded magnetite quartzite
Carbonaceous phyllite
Dolerite
Ferruginous phyllite
Gabbro
Granite gneiss
Insitu soil
Metabasalt
Metabasalt(amygdular)
Water body
N
0 2 4 8 12 16 Km.



Slope Forming Material (SFM) Map of T.S. Nos. 57D/03, 04, 49M/13 and 58A/01
INDEX
Charnockite
Granite gneiss
Insitu soil
Transported soil
WB
N
0 1.5 3 6 9 12 Km.

PLATE-11


Regolith Thickness Map of T.S. Nos. 48O/09. 48O/10 and 48O/14
INDEX
0.5-5
5-10
<0.5
Water body
N
0 2.75 5.5 11 16.5 22
Km.
75°40'0"E
75°50'0"E
5°30'0"E

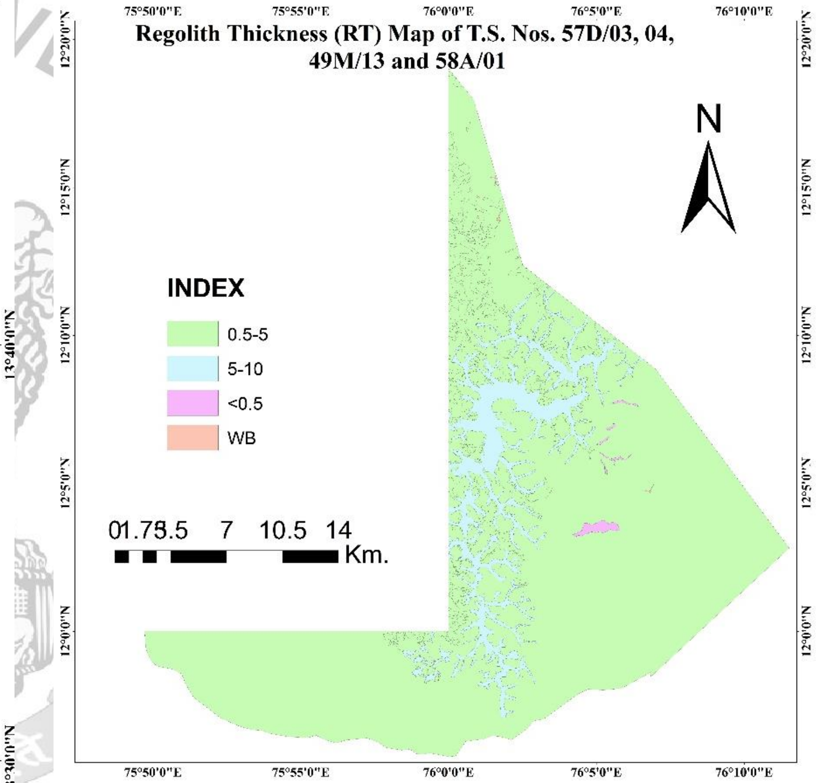
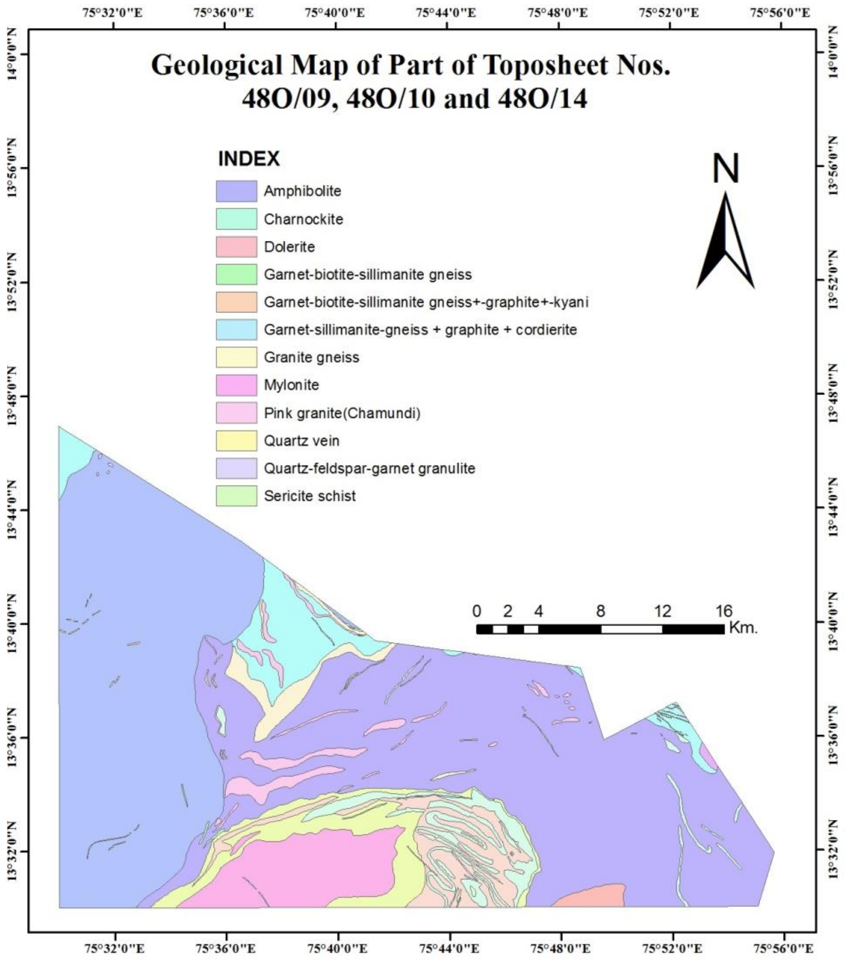
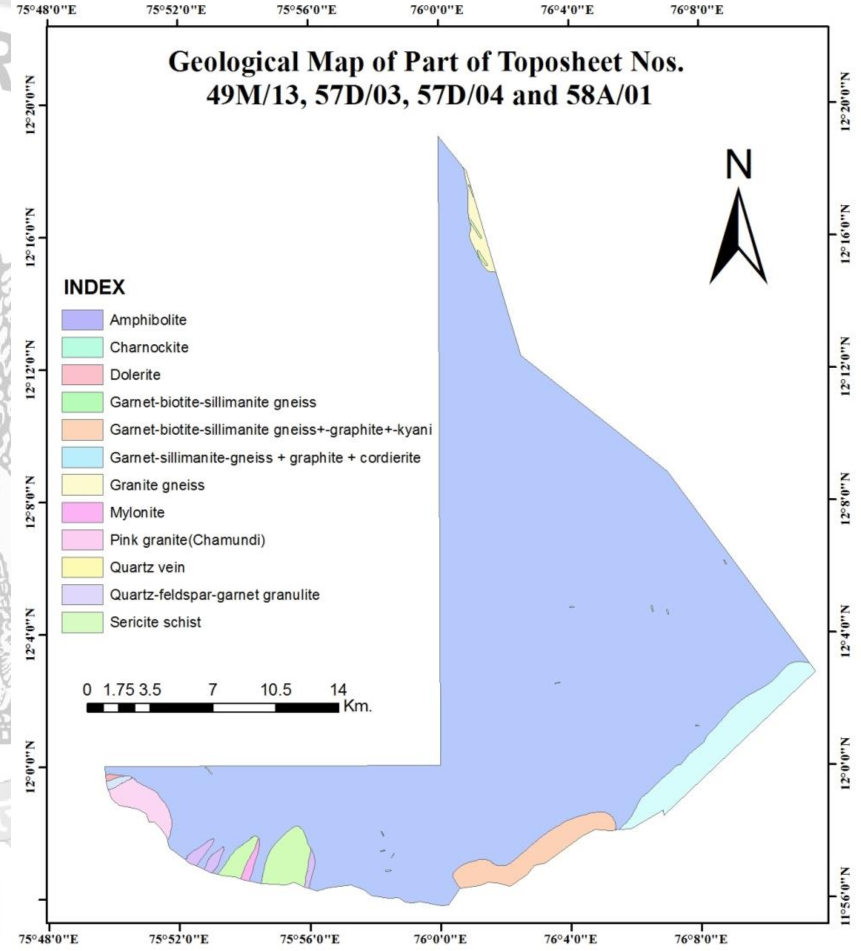

Regolith Thickness (RT) Map of T.S. Nos. 57D/03, 04, 49M/13 and 58A/01
INDEX
0.5-5
5-10
<0.5
WB
N
0 1.75 3.5 7 10.5 14
Km.
75°50'0"E
75°55'0"E
76°0'0"E
76°5'0"E
76°10'0"E
12°20'0"N
12°15'0"N
12°10'0"N
12°5'0"N
12°0'0"N

PLATE-12



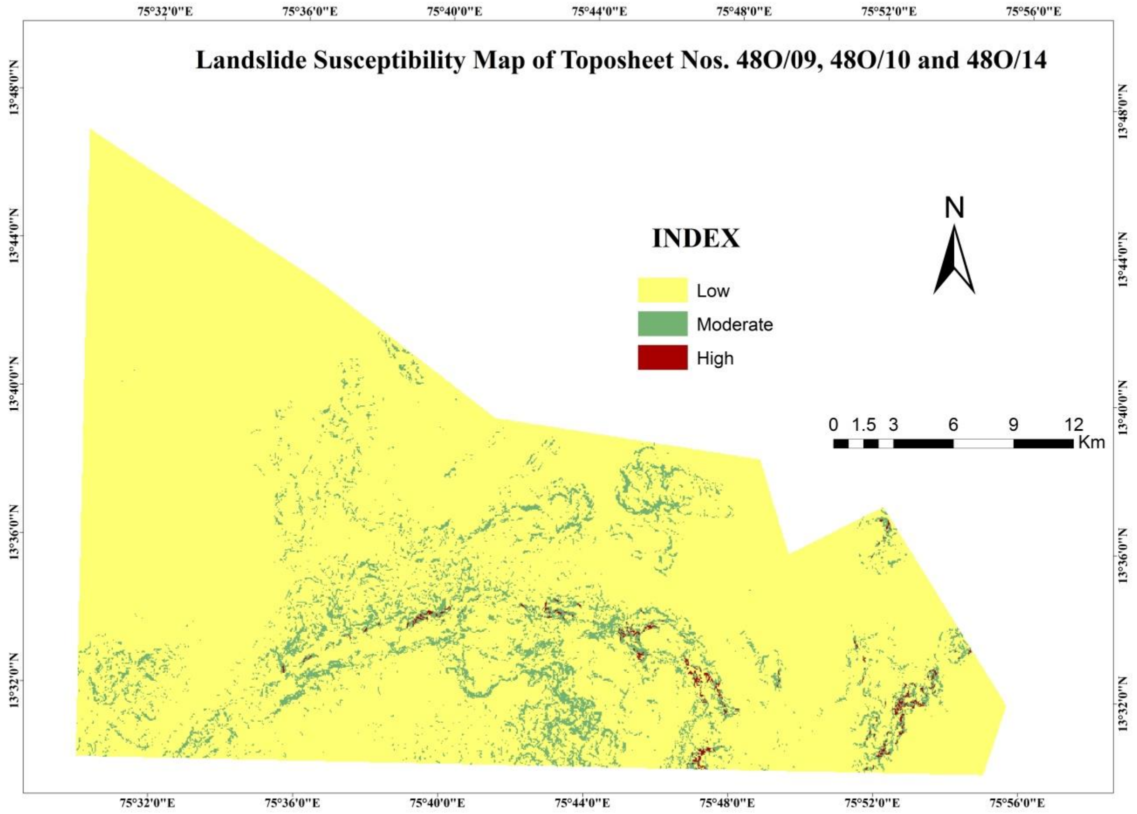
Geological Map of Part of Toposheet Nos.
48O/09, 48O/10 and 48O/14
INDEX
Amphibolite
Charnockite
Dolerite
Garnet-biotite-sillimanite gneiss
Garnet-biotite-sillimanite gneiss+-graphite+-kyani
Garnet-sillimanite-gneiss + graphite + cordierite
Granite gneiss
Mylonite
Pink granite(Chamundi)
Quartz vein
Quartz-feldspar-garnet granulite
Sericite schist
N
0 2 4 8 12 16
Km.
75°32'0"E
75°36'0"E
75°40'0"E
75°44'0"E
75°48'0"E
75°52'0"E
75°56'0"E
14°0'0"N
13°56'0"N
13°52'0"N
13°48'0"N
13°44'0"N
13°40'0"N
13°36'0"N
13°32'0"N

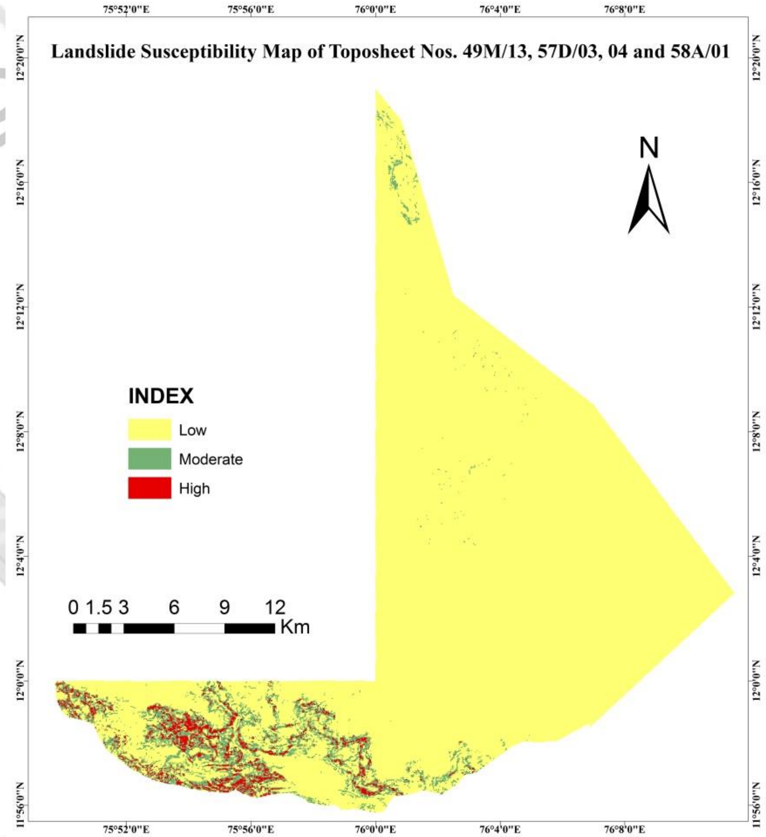


Geological Map of Part of Toposheet Nos.
49M/13, 57D/03, 57D/04 and 58A/01
INDEX
Amphibolite
Charnockite
Dolerite
Garnet-biotite-sillimanite gneiss
Garnet-biotite-sillimanite gneiss+-graphite+-kyani
Garnet-sillimanite-gneiss + graphite + cordierite
Granite gneiss
Mylonite
Pink granite(Chamundi)
Quartz vein
Quartz-feldspar-garnet granulite
Sericite schist
N
0 1.75 3.5 7 10.5 14
Km.
75°48'0"E
75°52'0"E
75°56'0"E
76°0'0"E
76°4'0"E
76°8'0"E
12°20'0"N
12°16'0"N
12°12'0"N
12°8'0"N
12°4'0"N
12°0'0"N
11°56'0"N

Landslide Inventory Map of the Study Area

PLATE-13





PHOTOGRAPHS

Photo- 1: Cultivation (Paddy crops) near T. Shettigeri

Photo- 2: Cultivation (Paddy crops) near Balele

Photo- 3: Low Height Plantation (LHP) near Gonigadde

Photo- 4: LHP (Coffee) near NR Pura

Photo- 5: Thick Vegetation (TV) near Paldala

Photo- 6: Thick Vegetation near Santaveri

Photo- 7: LHP and Cultivation near Salugodu

Photo- 8: High Height Plantation (HHP) near Bettattur

Photo- 9: Water Body (WB) near Bettattur

Photo- 10: WB near NR Pura

Photo- 11: Profile of In-situ Soil near Karmadu

Photo- 12: Thick Vegetation near Santaveri

Photo- 13: Sparse Vegetation (SV) near Santaveri

Photo- 14: SV near Gonigadde

Photo- 15: Moderate Vegetation (MV) near Theralu

Photo- 16: MV near Hosa Gangur

Photo- 17: HHP near Soosalavani

Photo- 18: LHP near Soosalavani

Photo- 19: A glimpse of Bhadra Reservoir

Photo- 20: Extensive Cut Slope (ECS) Kemmannugundi-Hebbe road section

Photo- 21: ECS on Santaveri-Chikmagalur road section

Photo- 22: ECS on Vartigundi-Dupadakan road section

Photo- 23: ECS on Guladamane-NR Pura road section

Photo- 24: ECS on Guladamane-NR Pura road section

Annexure – I: LOFS Calculations

Geo-factor: Land Use Land Cover (LULC)

Rank of LULC Classes

Sl. No.	Class Name	Code	Rank
1	Barren	B	**1**
2	Barren Sand	BS	0
3	Cultivation	CL	**2**
4	Extensive Slope Cut	ESC	**9**
5	Fallow Land	FL	**1**
6	Moderate Vegetation	MV	**5**
7	Plantation (HHP)	HHP	**4**
8	Plantation (LHP)	LHP	**3**
9	Quarry	QR	**5**
10	Settlement	S	**1**
11	Settlement on modified slope	SM	**7**
12	Swamp	SW	0
13	Thick Vegetation	TV	**4**
14	Sparse Vegetation	SV	**7**
15	Water body	WB	0
16	Salt Pan	SP	0

Geo-factor: Land Use Land Cover (LULC)

Matrix of Pairwise Ratings of LULC Class

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 Column	**49.00**	**38.50**	**3.00**	**49.00**	**15.18**	**21.58**	**29.50**	**15.48**	**49.00**	**6.96**	**21.58**	**6.96**

Geo-factor: Land Use Land Cover (LULC)

Estimated Eigen values, fraction rate and LOFS for LULC classes

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV	Sum Rows	Frac Weight	LOFS
B	0.0204	0.0130	0.0370	0.0204	0.0132	0.0116	0.0113	0.0129	0.0204	0.0205	0.0116	0.0205	0.2128	0.0177	0.0626
CL	0.0408	0.0260	0.0417	0.0408	0.0165	0.0154	0.0169	0.0161	0.0408	0.0239	0.0154	0.0239	0.3184	0.0265	0.0937
ESC	0.1837	0.2078	0.3332	0.1837	0.3293	0.2780	0.2373	0.3229	0.1837	0.4309	0.2780	0.4309	3.3994	0.2833	1.0000
FL	0.0204	0.0130	0.0370	0.0204	0.0132	0.0116	0.0113	0.0129	0.0204	0.0205	0.0116	0.0205	0.2128	0.0177	0.0626
MV	0.1020	0.1039	0.0666	0.1020	0.0659	0.0927	0.1017	0.0646	0.1020	0.0479	0.0927	0.0479	0.9899	0.0825	0.2912
HHP	0.0816	0.0779	0.0555	0.0816	0.0329	0.0463	0.0678	0.0323	0.0816	0.0359	0.0463	0.0359	0.6759	0.0563	0.1988
LHP	0.0612	0.0519	0.0476	0.0612	0.0220	0.0232	0.0339	0.0215	0.0612	0.0287	0.0232	0.0287	0.4644	0.0387	0.1366
QR	0.1020	0.1039	0.0666	0.1020	0.0659	0.0927	0.1017	0.0646	0.1020	0.0479	0.0927	0.0479	0.9899	0.0825	0.2912
S	0.0204	0.0130	0.0370	0.0204	0.0132	0.0116	0.0113	0.0323	0.0204	0.0205	0.0116	0.0205	0.2322	0.0194	0.0683
SM	0.1429	0.1558	0.1111	0.1429	0.1976	0.1853	0.1695	0.1938	0.1429	0.1436	0.1853	0.1436	1.9143	0.1595	0.5631
TV	0.0816	0.0779	0.0555	0.0816	0.0329	0.0463	0.0678	0.0323	0.0816	0.0359	0.0463	0.0359	0.6759	0.0563	0.1988
SV	0.1429	0.1558	0.1111	0.1429	0.1976	0.1853	0.1695	0.1938	0.1429	0.1436	0.1853	0.1436	1.9143	0.1595	0.5631

Geo-factor: Land Use Land Cover (LULC)

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

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV	Sum Rows	CV
B	0.0177	0.0133	0.0315	0.0177	0.0165	0.0141	0.0129	0.0165	0.0194	0.0228	0.0141	0.0228	0.2192	12.3591
CL	0.0355	0.0265	0.0354	0.0355	0.0206	0.0188	0.0193	0.0206	0.0387	0.0266	0.0188	0.0266	0.3229	12.1696
ESC	0.1596	0.2123	0.2833	0.1596	0.4125	0.3379	0.2709	0.4125	0.1742	0.4786	0.3379	0.4786	3.7177	13.1239
FL	0.0177	0.0133	0.0315	0.0177	0.0165	0.0141	0.0129	0.0165	0.0194	0.0228	0.0141	0.0228	0.2192	12.3591
MV	0.0887	0.1061	0.0567	0.0887	0.0825	0.1126	0.1161	0.0825	0.0968	0.0532	0.1126	0.0532	1.0496	12.7240
HHP	0.0709	0.0796	0.0472	0.0709	0.0412	0.0563	0.0774	0.0412	0.0774	0.0399	0.0563	0.0399	0.6984	12.4001
LHP	0.0532	0.0531	0.0405	0.0532	0.0275	0.0282	0.0387	0.0275	0.0581	0.0319	0.0282	0.0319	0.4718	12.1921
QR	0.0887	0.1061	0.0567	0.0887	0.0825	0.1126	0.1161	0.0825	0.0968	0.0532	0.1126	0.0532	1.0496	12.7240
S	0.0177	0.0133	0.0315	0.0177	0.0165	0.0141	0.0129	0.0412	0.0194	0.0228	0.0141	0.0228	0.2439	12.6068
SM	0.1241	0.1592	0.0944	0.1241	0.2475	0.2253	0.1935	0.2475	0.1355	0.1595	0.2253	0.1595	2.0954	13.1358
TV	0.0709	0.0796	0.0472	0.0709	0.0412	0.0563	0.0774	0.0412	0.0774	0.0399	0.0563	0.0399	0.6984	12.4001
SV	0.1241	0.1592	0.0944	0.1241	0.2475	0.2253	0.1935	0.2475	0.1355	0.1595	0.2253	0.1595	2.0954	13.1358
Sum CV														151.33
Mean Consistency Vector (Mean CV) = Total CV/ Nos. Of factor class (151.33/12) =														12.6109
Consistency Index (CI) = (Mean CV - No. Of criteria/ factor class) / (No. Of factor class - 1) =														0.0555
Consistency Ratio (CR) = CI/ RI = 0.0555 / 1.49 =														0.0373

Geo-factor: 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

Geo-factor: 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

Geo-factor: 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

Geo-factor: 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

Geo-factor: Slope Forming Material (SFM)

Matrix of Pairwise 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

Geo-factor: 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

Geo-factor: 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**

Geo-factor: 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

Geo-factor: 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**

Geo-factor: 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**

Geo-factor: 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**

Geo-factor: 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**

Geo-factor Maps
Weightage of Geo-factor Maps

Sl No	Factor Map Name	Code	Weightage
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 Map

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 Map

Estimated Eigen values, fraction rate and Weight for Factor Map

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 Map

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

1.	Name	KAR/KDG/48M13/2019-20/L1
2.	Latitude (N) (DMS)	11°58´12.30″
3.	Longitude (E) (DMS)	75°59´06.61″
4.	Toposheet No.	48M13
5.	Village Name	Irppu
6.	Road	In the course of Irppu Fall
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	PGC
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Vegetation cover with 1st and 2nd order drainage towards the downstream
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	250 m
24.	Landslide Width	60 m
25.	Landslide Height	150 m
26.	Landslide Run Out	400 m
27.	Landslide Material	Debris
28.	Movement Type	Flow
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Reactivated
31.	Landslide Distribution	Widening and Enlarging
32.	Landslide Style	Single
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	40°
36.	Downslope	70°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Supersaturation due to heavy rain
40.	Remedial Measures	Soil nailing and lined drainage
41.	Remarks	Removal of obstacle in the 2nd order stream course leading to the soil nailing.

42.	Photographs	

1.	Name	KAR/CHK/48O14/2019-20/L2
2.	Latitude (N) (DMS)	13°30´20.13″
3.	Longitude (E) (DMS)	75°48´05.96″
4.	Toposheet No.	48O14
5.	Village Name	Santaveri
6.	Road	Lingadahalli-Chickmangaluru
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Laterite
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	18 m
24.	Landslide Width	170 m
25.	Landslide Height	14 m
26.	Landslide Run Out	10 m
27.	Landslide Material	Debris
28.	Movement Type	Subsidence
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Reactivated
31.	Landslide Distribution	Widening and Enlarging
32.	Landslide Style	Multiple/Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	40°
36.	Downslope	65°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe removal and for the road widening and rain
40.	Remedial Measures	Soil nailing and lined drainage
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O14/2019-20/L3
2.	Latitude (N) (DMS)	13°30´09.76″
3.	Longitude (E) (DMS)	75°48´01.79″
4.	Toposheet No.	48O14
5.	Village Name	Santaveri
6.	Road	Lingadahalli-Chickmangaluru
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Laterite
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	11 m
24.	Landslide Width	135 m
25.	Landslide Height	8 m
26.	Landslide Run Out	6 m
27.	Landslide Material	Debris
28.	Movement Type	Fall/Topple
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Reactivated
31.	Landslide Distribution	Widening and Enlarging
32.	Landslide Style	Multiple/Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	35°
36.	Downslope	55°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe removal and for the road widening and rain
40.	Remedial Measures	Soil nailing and lined drainage
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O14/2019-20/L4
2.	Latitude (N) (DMS)	13°32´54.40″
3.	Longitude (E) (DMS)	75°45´33.9″
4.	Toposheet No.	48O14
5.	Village Name	Kemmannugundi
6.	Road	Kemmannugundi –Raj Bhawan
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Lateritic PGC
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	16 m
24.	Landslide Width	170 m
25.	Landslide Height	11 m
26.	Landslide Run Out	10 m
27.	Landslide Material	Debris
28.	Movement Type	Slide/Topple
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Reactivated
31.	Landslide Distribution	Widening and Enlarging
32.	Landslide Style	Multiple/Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	35°
36.	Downslope	60°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe removal and for the road widening and rain
40.	Remedial Measures	Soil nailing and lined drainage
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O10/2019-20/L5
2.	Latitude (N) (DMS)	13°34´25012″
3.	Longitude (E) (DMS)	75°40´50.81″
4.	Toposheet No.	48O10
5.	Village Name	Lalbagh Coffee Estate
6.	Road	Lalbagh Coffee State – Maskalmardi Coffee Estate
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Laterite
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	14 m
24.	Landslide Width	170 m
25.	Landslide Height	9 m
26.	Landslide Run Out	25 m
27.	Landslide Material	Debris
28.	Movement Type	Lateral Spread
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Reactivated
31.	Landslide Distribution	Widening
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	35°
36.	Downslope	70°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening and rain
40.	Remedial Measures	Soil nailing and lined drainage
41.	Remarks	

42.	Photographs	 

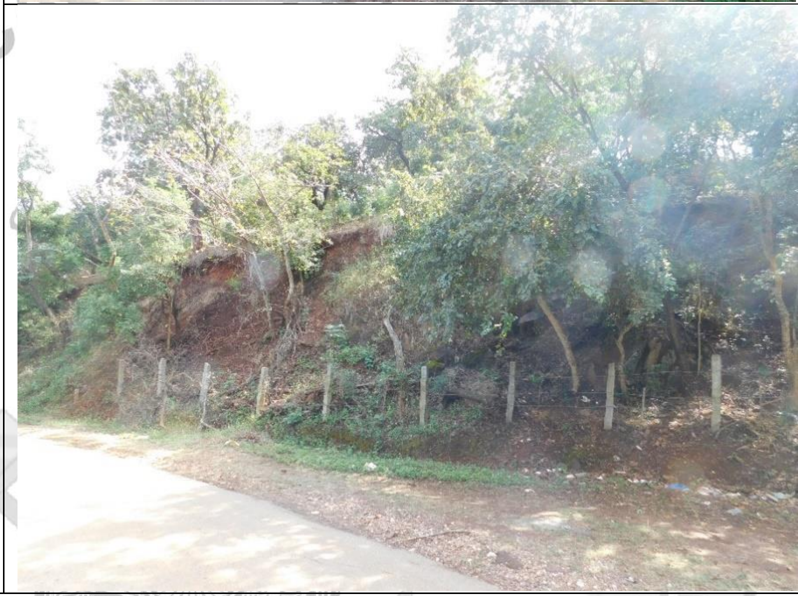
1.	Name	KAR/CHK/48O10/2019-20/L6
2.	Latitude (N) (DMS)	13°34´25″
3.	Longitude (E) (DMS)	75°42´19.87″
4.	Toposheet No.	48O10
5.	Village Name	Sampigekan Coffee Estate
6.	Road	Sampigekan Coffee Estate-Lalbagh Coffee State
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	PGC
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	45 m
24.	Landslide Width	160 m
25.	Landslide Height	25 m
26.	Landslide Run Out	15 m
27.	Landslide Material	Rock
28.	Movement Type	Slide
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Active
31.	Landslide Distribution	Widening and Enlarging
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	45°
36.	Downslope	60°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening and rain
40.	Remedial Measures	Lined drainage with retaining wall
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O10/2019-20/L7
2.	Latitude (N) (DMS)	13°34´19.8″
3.	Longitude (E) (DMS)	75°44´45.60″
4.	Toposheet No.	48O10
5.	Village Name	Dupakan Coffee Estate
6.	Road	Kaimara-Dupakan Coffee Estate
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	PGC
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	16 m
24.	Landslide Width	160 m
25.	Landslide Height	11 m
26.	Landslide Run Out	8 m
27.	Landslide Material	Debris
28.	Movement Type	Flow
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Suspended
31.	Landslide Distribution	Widening
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	30°
36.	Downslope	50°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening and rain
40.	Remedial Measures	Lined drainage and soil nailing
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O10/2019-20/L8
2.	Latitude (N) (DMS)	13°34´17.8″
3.	Longitude (E) (DMS)	75°44´54.80″
4.	Toposheet No.	48O10
5.	Village Name	Dupakan Coffee Estate
6.	Road	Kaimara-Dupakan Coffee Estate
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Laterite
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	15 m
24.	Landslide Width	210 m
25.	Landslide Height	9 m
26.	Landslide Run Out	6 m
27.	Landslide Material	Debris
28.	Movement Type	Slide
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Suspended
31.	Landslide Distribution	Widening
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	30°
36.	Downslope	50°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening and rain
40.	Remedial Measures	Lined drainage and soil nailing
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O14/2019-20/L9
2.	Latitude (N) (DMS)	13°33´36.8″
3.	Longitude (E) (DMS)	75°45´27″
4.	Toposheet No.	48O14
5.	Village Name	Sannakah Coffee Estate
6.	Road	Sannakah Coffee Estate – Hebbe Fall
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Laterite
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	16 m
24.	Landslide Width	160 m
25.	Landslide Height	9 m
26.	Landslide Run Out	6 m
27.	Landslide Material	Debris
28.	Movement Type	Slide
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Suspended
31.	Landslide Distribution	Widening
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	60°
36.	Downslope	40°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening and rain
40.	Remedial Measures	Lined drainage and soil nailing
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O14/2019-20/L10
2.	Latitude (N) (DMS)	13°33´29.70″
3.	Longitude (E) (DMS)	75°45´27.6″
4.	Toposheet No.	48O14
5.	Village Name	Sannakah Coffee Estate
6.	Road	Sannakah Coffee Estate – Hebbe Fall
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	PGC
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	22 m
24.	Landslide Width	45 m
25.	Landslide Height	9 m
26.	Landslide Run Out	220 m
27.	Landslide Material	Rocks
28.	Movement Type	Topple
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Active
31.	Landslide Distribution	Widening
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	65°
36.	Downslope	40°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening and rain
40.	Remedial Measures	Retaining wall with lined drainage
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O14/2019-20/L11
2.	Latitude (N) (DMS)	13°33´32.01″
3.	Longitude (E) (DMS)	75°45´1.80″
4.	Toposheet No.	48O14
5.	Village Name	Sannakah Coffee Estate
6.	Road	Sannakah Coffee Estate – Hebbe Fall
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	PGC/BIF
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	50 m
24.	Landslide Width	80 m
25.	Landslide Height	35 m
26.	Landslide Run Out	60 m
27.	Landslide Material	Debris
28.	Movement Type	Subsidence
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Reactivated
31.	Landslide Distribution	Enlarging
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	70°
36.	Downslope	40°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening
40.	Remedial Measures	Retaining wall with lined drainage
41.	Remarks	

42.	Photographs	 
		

1.	Name	KAR/CHK/48O10/2019-20/L12
2.	Latitude (N) (DMS)	13°33´41.60″
3.	Longitude (E) (DMS)	75°44´60.90″
4.	Toposheet No.	48O10
5.	Village Name	Sannakah Coffee Estate
6.	Road	Sannakah Coffee Estate – Hebbe Fall
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Laterite
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	14 m
24.	Landslide Width	70 m
25.	Landslide Height	8m
26.	Landslide Run Out	6 m
27.	Landslide Material	Debris
28.	Movement Type	Slide
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Reactivated
31.	Landslide Distribution	Widening
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	40°
36.	Downslope	50°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Toe cutting for the road widening
40.	Remedial Measures	Concrete lined drainage
41.	Remarks	

42.	Photographs	 

1.	Name	KAR/CHK/48O10/2019-20/L13
2.	Latitude (N) (DMS)	13°33´41.60″
3.	Longitude (E) (DMS)	75°44´60.90″
4.	Toposheet No.	48O10
5.	Village Name	Sannakah Coffee Estate
6.	Road	Sannakah Coffee Estate – Hebbe Fall
7.	Geomorphic Process	Gravitational
8.	Geomorphic Form	Moderately Dissected Slope
9.	Rock	Laterite
10.	Weathering	Moderate
11.	Rock Character	Massive
12.	Dip Foliation	Not available
13.	Dip Direction Foliation	Not available
14.	Dip J1	Not available
15.	Dip Direction J1	Not available
16.	Overburden Type	Soil
17.	Thickness	0.5 m to 5 m
18.	Landuse	Extensive Cut Slope for the road widening
19.	Hydrology	Damp
20.	Erosion	Toe Erosion
21.	Susceptibility	High
22.	Risk	Moderate
23.	Landslide Length	18 m
24.	Landslide Width	80 m
25.	Landslide Height	15 m
26.	Landslide Run Out	12 m
27.	Landslide Material	Debris
28.	Movement Type	Slide
29.	Failure Depth	Shallow (< = 5m)
30.	Landslide Activity	Suspended
31.	Landslide Distribution	Widening
32.	Landslide Style	Successive
33.	Landslide Mechanism	Shallow Translational Failure
34.	Landslide Initiation	Not available
35.	Upslope	70°
36.	Downslope	40°
37.	Triggering Factor	Rain
38.	Casualties	Not available
39.	Geo-scientific Cause	Road cutting
40.	Remedial Measures	Lined drainage with retaining wall
41.	Remarks	

42.	Photographs	 

Annexure – III: Rain Fall Data

1. Chikmagalur District

Year - 2010

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU	17	0	16	73	119	130	268	279	197	199	207	6	1510
2.	KADUR	2	0	7	65	105	53	102	165	144	141	164	0	948
3.	KOPPA	19	0	18	94	74	380	823	636	376	188	212	2	2821
4.	MUDIGERE	7	0	2	93	97	385	636	528	369	222	246	3	2588
5.	NARASIMHARAJAPURA	9	0	17	84	101	189	462	319	277	217	168	8	1851
6.	SRINGERI	26	0	5	85	74	534	1149	774	510	265	261	6	3687
7.	TARIKERE	8	0	13	76	96	84	192	225	184	109	199	0	1185
	DISTRICT AVERAGE	11	0	12	83	107	202	406	364	262	188	215	3	1852

Year - 2011

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU	2	9	10	124	104	204	197	212	132	154	53	1	1201
2.	KADUR	0	1	3	39	46	59	53	50	33	164	29	1	479
3.	KOPPA	0	1	0	56	34	649	846	681	384	145	31	0	2826
4.	MUDIGERE	1	31	11	156	89	658	646	586	436	214	77	0	2905
5.	NARASIMHARAJAPURA	0	39	6	108	113	279	391	366	187	210	44	0	1742
6.	SRINGERI	0	0	5	98	43	977	1328	1035	625	199	35	0	4345
7.	TARIKERE	0	3	1	61	60	125	165	106	66	185	26	0	800
	DISTRICT AVERAGE	1	10	6	95	76	331	381	329	209	187	45	0	1669

Year - 2012

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU	1	0	0	115	36	96	124	351	100	56	100	4	982
2.	KADUR	0	0	0	118	29	44	30	129	35	44	62	1	492
3.	KOPPA	0	0	0	121	30	303	469	903	288	35	145	0	2295
4.	MUDIGERE	2	2	1	146	47	315	374	660	283	98	80	1	2008
5.	NARASIMHARAJAPURA	0	0	1	128	54	167	281	543	167	36	95	0	1470
6.	SRINGERI	0	0	0	95	15	541	683	1119	314	41	99	0	2906
7.	TARIKERE	0	0	0	139	25	29	57	158	64	30	70	1	573
	DISTRICT AVERAGE	0	0	0	132	35	162	212	441	147	54	92	2	1279

Year – 2013

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU	3	27	43	31	141	226	601	200	212	68	25	9	1586
2.	KADUR	0	16	11	12	109	51	122	36	171	41	7	3	579
3.	KOPPA	1	24	16	16	104	695	1717	634	284	68	24	1	3584
4.	MUDIGERE	8	23	34	37	97	706	1306	546	351	184	40	16	3347
5.	NARASIMHARAJAPURA	1	17	19	22	121	384	963	348	213	42	13	2	2146
6.	SRINGERI	2	7	11	16	141	886	1908	808	263	162	16	1	4222
7.	TARIKERE	0	10	18	2	131	157	355	125	141	37	4	0	980
	DISTRICT AVERAGE	2	20	26	21	128	354	792	300	233	82	19	6	1982

Year - 2014

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU	0.9	0.7	8.5	93.0	210.7	84.2	414.5	338.4	163.3	119.3	12.1	12.9	1458.4
2.	KADUR	0.0	0.1	6.9	45.5	145.9	29.2	70.5	186.1	126.6	174.1	25.1	5.5	815.4
3.	KOPPA	0.9	8.2	15.8	96.6	137.5	293.4	1204.8	989.0	341.0	121.5	16.0	12.5	3237.3
4.	MUDIGERE	2.3	0.3	18.7	91.3	233.2	385.0	1280.2	699.2	436.6	157.8	26.5	33.4	3364.4
5.	NARASIMHARAJAPURA	0.1	1.8	14.6	106.1	145.2	143.3	779.6	606.1	225.2	106.4	13.2	19.2	2160.7
6.	SRINGERI	0.0	15.4	3.8	114.3	131.0	495.0	1743.5	1054.4	455.9	153.3	18.5	28.8	4213.8
7.	TARIKERE	0.1	0.2	2.6	62.8	152.9	54.7	239.0	248.6	127.1	156.1	23.5	13.8	1081.4
	DISTRICT AVERAGE	0.7	2.1	9.9	83.5	184.4	166.2	636.7	483.5	239.0	154.9	21.3	16.6	1998.8

Year - 2015

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU	0	0	47	122	97	284	141	181	142	131	140	8	1293
2.	KADUR	0	0	33	82	82	111	42	74	189	133	163	6	915
3.	KOPPA	1	0	63	79	166	678	628	397	148	153	123	13	2450
4.	MUDIGERE	1	1	36	116	170	908	400	318	192	139	151	11	2442
5.	NARASIMHARAJAPURA	0	0	43	94	128	383	293	237	135	124	80	5	1521
6.	SRINGERI	0	0	13	75	176	894	1097	700	177	197	161	19	3510
7.	TARIKERE	0	0	15	59	150	173	122	137	141	126	113	3	1040
	DISTRICT AVERAGE	0	0	38	98	134	416	277	235	173	146	147	8	1673

Year - 2016

Sl. No	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU TALUK	1.4	2.9	3.9	30.3	132.7	229.6	242.0	139.9	85.8	21.3	17.0	38.3	945.1
2.	KADUR TALUK	1.1	0.1	0.2	11.1	84.8	103.0	70.5	12.0	30.3	17.5	5.3	40.7	376.7
3.	KOPPA TALUK	1.6	0.0	11.1	20.1	93.5	514.9	688.7	522.1	186.4	31.0	13.8	7.4	2090.5
4.	MUDIGERE TALUK	2.8	1.3	5.4	29.2	149.3	518.2	647.6	329.9	147.5	50.9	35.8	18.2	1936.1
5.	NARASIMHARAJAPUR TALUK	1.6	0.0	6.0	14.3	77.3	293.6	365.9	279.3	112.0	29.1	15.0	6.5	1200.7
6.	SRINGERI TALUK	1.5	0.4	4.3	19.3	94.6	860.5	1016.2	821.3	282.2	65.5	19.5	5.8	3190.9
7.	TARIKERE TALUK	1.9	0.4	0.4	6.6	65.1	179.5	165.0	78.4	82.4	19.3	5.9	27.0	631.8
8	DISTRICT AVERAGE	1.7	1.0	1.7	19.1	102.9	310.6	356.5	222.1	107.0	29.3	15.5	25.7	1192.9

Year - 2017

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU TALUK	1.1	0.4	10.1	36.5	115.3	260.1	316.8	343.8	205.8	124	18	2	1434
2.	KADUR TALUK	1.5	0.1	11.9	63.7	136.4	133.7	225.7	270.3	220.9	110	24	3	1201
3.	KOPPA TALUK	0.9	0.0	3.3	34.3	82.0	35.2	37.2	67.2	197.2	112	15	1	586
4.	MUDIGERE TALUK	0.9	0.5	4.9	23.8	135.4	484.5	618.1	601.7	224.1	118	18	2	2232
5.	NARASIMHARAJAPUR TALUK	2.8	1.8	32.5	42.2	155.5	622.6	551.6	574.6	246.1	170	15	2	2417
6.	SRINGERI TALUK	0.2	0.1	5.9	23.3	106.8	223.3	361.5	350.9	168.1	91	19	2	1352
7.	TARIKERE TALUK	0.5	0.2	1.7	18.3	164.9	811.2	992.6	1121.3	276.0	197	28	6	3617
8.	DISTRICT AVERAGE	0.3	0.0	2.6	19.4	67.1	65.5	125.7	137.7	148.8	111	13	1	692

Year – 2018

Sl. No.	Taluk Name	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	CHIKKAMAGALURU TALUK	0.2	3.7	35	61	229	320	438	543	111	116	27	10	2278
2.	KADUR TALUK	0.2	5.6	47	64	199	82	78	400	134	97	24	6	1766
3.	KOPPA TALUK	0.1	10.4	19	32	332	977	1362	55	111	116	30	10	742
4.	MUDIGERE TALUK	0.4	0.7	64	88	285	1040	1057	1121	105	116	24	16	4207
5.	NARASIMHARAJAPUR TALUK	0.4	0.4	51	77	288	562	742	896	115	150	21	9	3701
6.	SRINGERI TALUK	0.2	0.6	36	84	249	1219	1975	593	101	85	17	7	2516
7.	TARIKERE TALUK	0.0	0.7	31	76	229	147	229	1871	118	165	26	25	5756
8.	DISTRICT AVERAGE	0.0	0.8	11	40	229	318	412	183	85	108	25	7	1065

Year – 2019

SL. No.	District/Taluk	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	Chikmagalur	0	5	3	41	55	186	364	768	321	367	36	36	2182
2.	Chikmagalur Taluk	0	15	6	53	75	136	181	613	233	357	28	36	1733
3.	Kadur Taluk	0	4	0	28	68	98	42	215	109	362	27	61	1014
4.	Koppa Taluk	0	0	7	54	30	261	751	1325	561	350	30	13	3382
5.	Mudigere Taluk	0	2	3	63	66	358	747	1466	551	461	65	28	3810
6.	Narasimharajapur Taluk	1	0	3	37	24	154	383	778	352	305	29	17	2083
7.	Sringeri Taluk	0	1	5	35	30	486	1250	1542	786	432	35	19	4621
8.	Tarikere Taluk	0	5	2	20	45	68	104	412	166	320	35	42	1219

Year – 2020

SL. No.	District/Taluk	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Annual (mm)
1.	Chikmagalur	1	0	6	40	137	201	300	518	336	167	28	20	1754
2.	Chikmagalur Taluk	1	1	7	56	154	143	230	394	254	185	31	19	1473
3.	Kadur Taluk	0	0	1	35	102	58	102	82	175	98	33	27	713
4.	Koppa Taluk	1	0	6	41	144	338	501	1030	505	166	30	6	2766
5.	Mudigere Taluk	1	0	16	48	180	391	560	977	571	270	36	15	3066
6.	Narasimharajapur Taluk	1	0	3	37	143	205	286	582	283	137	27	14	1716
7.	Sringeri Taluk	1	0	12	55	157	553	692	1289	758	272	31	8	3826
8.	Tarikere Taluk	0	0	0	14	95	87	174	250	208	120	14	28	990

2. Shivamoga District

Year – 2010

Sl. Nos.	Talluk Name	Annual Rain Fall (mm)
1.	Tirthahalli	1338.2
2.	Agrahara	837.0
3.	Agumbe	897.8
4.	Mandagadde	895.2
5.	Malur	757.9

Year – 2011

Sl. Nos.	Talluk Name	Annual Rain Fall (mm)
1.	TIRTHAHALLI	3461.3
2.	AGRAHARA	2847.1
3.	AGUMBE	5425.0
4.	MANDAGADDE	1769.1
5.	MALUR	2506.4

Year - 2012

Sl. Nos.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (mm)
1.	0.00	0.00	0.00	0.00	0.00	0.00	22.10	7.80	47.30	13.00	8.10	0.00	
2.	0.00	0.00	0.00	2.10	0.30	0.10	46.20	8.40	1.20	6.40	67.50	0.00	
3.	0.00	0.00	0.00	2.10	0.00	0.10	8.50	34.70	38.90	13.30	6.60	0.00	
4.	0.00	0.00	0.00	0.00	0.00	0.30	1.50	58.40	1.90	6.80	3.80	0.00	
5.	0.00	0.00	0.00	0.50	0.00	17.10	8.50	35.40	4.80	4.20	0.00	0.00	
6.	0.00	0.30	0.00	0.00	0.00	6.80	1.50	97.90	9.30	0.30	0.20	0.00	

7.	0.00	0.00	0.00	0.00	0.00	8.20	6.30	92.70	8.80	0.00	0.00	0.00	
8.	0.00	0.00	0.00	0.00	0.00	3.00	21.90	40.90	11.30	0.00	0.00	0.00	
9.	0.30	0.00	0.00	1.30	0.00	2.90	10.60	21.30	3.00	0.00	0.30	0.00	
10.	0.00	0.00	0.00	0.00	0.00	16.70	14.10	13.10	12.80	0.00	2.00	0.00	
11.	0.00	0.00	0.00	0.00	4.70	0.90	10.80	40.90	35.30	0.00	0.00	0.00	
12.	0.00	0.00	0.00	0.50	0.00	9.90	11.90	59.70	22.70	0.00	2.40	0.00	
13.	0.00	0.00	0.00	0.00	0.00	14.00	7.20	50.30	16.20	0.00	0.00	0.00	
14.	0.00	0.00	0.00	2.10	0.00	1.70	0.60	7.50	2.80	0.00	0.00	0.30	
15.	0.00	0.00	0.00	0.10	0.20	2.10	7.70	23.90	7.60	0.00	0.00	0.00	
16.	0.00	0.00	0.00	19.90	0.00	0.10	12.60	2.40	7.60	0.00	0.00	0.00	
17.	0.00	0.00	0.00	0.10	0.00	9.00	6.50	4.70	5.60	0.00	0.00	0.00	
18.	0.00	0.00	0.00	6.70	0.00	62.10	11.70	1.50	3.10	0.00	0.00	0.00	
19.	0.00	0.00	0.00	3.40	0.00	32.00	14.70	3.40	0.50	0.00	0.00	0.00	
20.	0.00	0.00	0.00	0.00	0.00	42.10	15.10	0.70	0.00	0.00	0.00	0.00	
21.	0.00	0.00	0.00	0.60	0.00	3.70	55.30	0.70	0.10	8.30	0.00	0.00	
22.	0.00	0.00	0.00	0.00	0.00	17.70	82.00	0.30	0.00	0.10	0.00	0.00	
23.	0.00	0.00	0.00	0.10	0.00	6.30	24.10	0.80	0.00	0.00	0.00	0.00	
24.	0.00	0.00	0.00	0.00	0.00	23.50	38.00	0.00	0.00	0.00	0.00	0.00	
25.	0.00	0.00	0.00	12.60	0.00	28.70	7.10	0.00	0.20	0.00	0.00	0.00	
26.	0.00	0.00	0.00	26.30	0.00	4.90	47.10	15.00	0.00	0.30	0.00	0.00	
27.	0.00	0.00	0.00	4.10	0.00	22.90	104.50	12.20	0.00	0.00	0.00	0.00	
28.	0.00	0.00	0.00	8.70	0.00	11.00	32.00	3.50	0.00	0.00	0.00	0.00	
29.	0.00		0.00	0.70	0.00	12.30	19.50	65.90	0.90	0.10	0.00	0.00	
30.	0.30		0.00	0.00	0.10	32.37	8.90	21.70	3.40	0.00	0.00	0.00	
31.	0.00		0.00		0.00		4.60	36.00		0.00		0.10	
Total	0.60	0.30	0.00	91.90	5.30	392.47	663.10	761.70	245.30	52.80	90.90	0.40	2304.77

Year - 2013

Sl. Nos.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (mm)
1.	1.83	0	0	0	0	14.4	12.15	67.12	0	0.37	0	0	
2.	0	0	0	0	0	3.36	42.6	87.15	0.06	0.24	0	0	
3.	0	0	0	0	0.85	0.9	227.45	17.56	0.33	0	2.59	3.73	
4.	0.28	0	0	0	0	1.01	118.59	29.49	3.87	0.28	0.28	0.01	
5.	0.01	0	0	0	0	0	33.92	10.55	3.42	2.73	0.28	0	
6.	0	0	0	0	0.06	0.27	68.52	11.53	5.48	31.18	0	0	
7.	0	0	0	0	0	0.72	34.42	16.16	1.65	0.14	0	0	
8.	0	0	0	0.01	0	16.97	14.65	18.91	6.82	0.06	0	0	
9.	0.01	0	0	0	4.4	15.03	6.6	7.62	1.26	0.01	0	0	
10.	0	1.63	0	0	0	17.4	22.15	5.14	2.87	0.01	0	0	
11.	0	0	0	0	0	35.9	38.85	20.93	3.6	0.34	0	0	
12.	0	0	0	0	0	8.11	57.95	4.92	1.21	0.01	0	0	
13.	0	0	0	0	0	7.71	14.31	9.91	0.63	6.55	0	0	
14.	0	0	0	0	0	63.78	7.92	29.52	2.86	4.8	0.01	0	
15.	0	3.27	0	0	0	15.88	14.82	9.75	2.46	0.04	0	0	
16.	0	0.12	0	0	0	28.5	26.1	20.65	0	0	0	0	
17.	0	18.46	0.01	0	0	27.3	39.06	54.89	6.74	15.05	0	0	
18.	0	0.58	0	0	0	31.68	76.28	34.14	107.25	1.51	0	0	
19.	0	0	0	0	0.84	13.07	67.59	8.6	6.95	12.15	0	0	
20.	0	0	0.03	0	0	17.74	106.14	24.68	42.67	0.08	0	0	
21.	0	0	0	0	4.84	5.17	36.27	24.33	25.24	0	0	0	
22.	0	0	0	0	0	28.63	37.95	15.84	13.1	0	0	0	
23.	0	0	0	0	0	9.68	69.35	45.97	0.85	1.14	0	0	
24.	0	0	0	0	0	59.83	49.13	5.79	9.76	32.58	0	0	
25.	0	0.01	0	0.82	0.01	57.16	59.61	10.9	3.88	0.5	0.28	0	
26.	0	0	0	2.1	0	53.57	64.96	2.81	0.18	3.36	0.03	0	

27.	0	0	0	0	0	26.03	25.69	0.59	0.02	0.31	0.48	0	
28.	0.01	0.01	0	0	7.62	18.85	46.43	1.69	0.03	0.02	0.01	0	
29.	0		0	7.38	14.88	7.95	46.79	3.72	0.02	0.04	0	0	
30.	0		0	0.48	0	2.37	12.79	0.34	4.77	0.32	0	0	
31.	0		0		3.15		32.98	3.45		0		0	
Total	2.14	24.08	0.04	10.79	36.65	588.97	1512.02	604.65	257.98	113.82	3.96	3.74	3158.84

Year - 2014

Sl. Nos.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (mm)
1.	0	0	0	0	0.35	0	0	129.32	22.85	22.74	0	0	
2.	0	0	0	0.09	6.81	0.02	9.53	62.09	17.79	9.6	0	0	
3.	0	0	0	0	0	4.43	0.89	20.74	20.15	0.02	0	0	
4.	0	0	0	0.02	0.2	0.53	4.1	37.7	13.64	0.01	0	0	
5.	0	0	0	0	0	0	0.58	82.49	16.08	0	0.01	0	
6.	0.01	0	0	0	2.61	0	0.5	111.26	18.08	5.42	0	0	
7.	0	0	0	0	3.97	0	1.53	57.04	46.79	1.78	0.01	0	
8.	0	0	0	0.06	23.14	0	15.11	44.58	9.44	0.02	0	0	
9.	0	0	0	0	33.05	0.35	6.59	11.74	7.02	0.21	0	0	
10.	0	0	0.06	0	0.02	2.16	18.94	16.52	2.2	2.45	0	0.93	
11.	0	0	0.02	0	0	2.85	9.41	9.32	4.13	5.53	0	0.59	
12.	0	0	0.35	0	0	13.69	18.11	17.87	3.27	21.37	0	1.17	
13.	0	0	0	0	0.01	11.91	56.09	15.12	0.67	0.01	0	24.41	
14.	0	0	0	0	0	2.93	133.9	4.78	2.11	0.01	0.22	9.02	
15.	0	0	0	0	0.02	27.3	42.85	6.78	0.01	0	14.09	0.35	
16.	0	0	0	0.12	0	0.93	80.12	4.14	0.76	0	0.01	0	
17.	0	0	0	0	0	36.45	22.18	16.98	2.17	0	0	0	
18.	0	0	0	0	0	10.61	25.29	1.56	0	0	0	0	
19.	0	0	0	1.43	0	41.52	62.41	0.37	0.58	0	0	0	

20.	0	0	0.01	0.53	0.66	44.98	20.14	1.76	1.9	0.17	0	0	
21.	0	0	0	0	0	54.15	46.43	3.4	2.33	0.07	0	0	
22.	0	0	0	0	0.1	69.65	94.09	4.95	0.64	0	0	0	
23.	0	0	0	0	0	28.26	77.77	42.41	0.25	0	0	0	
24.	0	0	0	0	0	7.98	55.72	0.36	0.12	0.12	0	0.01	
25.	0	0	0.01	0.36	0.05	0.64	45.13	4.29	1.81	19.93	0	0	
26.	0	0.68	0	0.35	0	0	56.3	16.2	30.87	16.61	0	0.01	
27.	0	0.01	0	7.15	0.06	0	16.84	20.19	7.43	1.67	0.01	0	
28.	0	0	0	0.65	0.13	0	36.81	15.28	0	2.85	0	0	
29.	0		0	0	0.18	0	17.95	30.24	15.34	0.01	0	0	
30.	0		0	29.9	15.4	0	29.83	16.01	36.44	0	0	0	
31.	0		0		0.01		89.32	43.34		0.01		0	
Total	0.01	0.69	0.45	40.66	86.77	361.34	1094.46	848.83	284.87	110.61	14.35	36.49	2879.53

Year - 2015

Sl. Nos.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (mm)
1.	0	0	0	0.66	0.0	0.1	2.8	13.7	0.3	10.6	2.5	0.0	
2.	0	0.01	0.57	6.54	0.0	0.0	7.2	11.1	0.0	8.0	0.4	0.0	
3.	0	0	0.28	0.13	0.0	0.1	8.1	10.9	0.5	0.1	24.8	0.0	
4.	0.58	0	0	0.04	0.0	0.0	9.4	8.6	1.1	0.1	0.3	0.0	
5.	0.28	0	0	0.01	1.7	0.4	1.4	33.9	0.6	6.2	7.6	0.0	
6.	0	0	0	0	9.8	0.4	0.2	51.4	0.1	15.1	0.2	0.0	
7.	0	0	0	0	0.0	0.0	0.7	55.1	2.8	15.0	0.1	0.0	
8.	0	0	0.17	0	6.6	4.3	13.1	14.7	2.3	2.5	0.0	0.0	
9.	0	0	7.44	0	0.0	9.9	16.9	8.4	2.0	0.0	0.0	0.0	
10.	0.28	0	20.5	0.04	6.4	8.3	45.0	12.2	2.7	0.1	0.0	0.0	
11.	0	0	0.01	0	0.0	0.0	14.9	17.8	8.7	0.0	0.0	0.0	
12.	0	0	0	0.04	3.4	3.1	24.7	24.9	0.2	1.1	0.0	0.0	

13.	0	0	0	0.5	13.9	0.2	3.1	22.0	3.6	0.0	0.0	0.0	
14.	0	0	0	0.82	13.3	18.1	4.0	15.0	18.0	0.8	0.0	0.0	
15.	0	0	1.69	0	0.0	16.7	1.8	13.1	31.5	0.0	0.0	0.0	
16.	0	0.08	0	0.07	13.5	1.3	10.6	8.0	32.0	0.0	0.0	0.0	
17.	0	0.17	0	0	31.5	6.2	24.1	4.0	4.0	0.0	0.0	0.0	
18.	0	0	0	0.03	0.3	18.5	30.4	1.4	21.8	0.0	0.0	0.0	
19.	0	0	0	0	0.0	19.7	21.6	0.4	7.4	0.0	0.0	0.0	
20.	0	0	0	0.03	0.0	50.3	68.9	5.4	3.9	0.0	0.0	0.1	
21.	0	0	0	0	0.0	66.4	11.1	0.0	2.4	0.1	1.0	0.1	
22.	0	0	0	0	0.0	94.4	22.4	6.7	0.0	0.0	0.0	0.0	
23.	0	0	0	0	0.0	66.7	12.6	9.5	0.4	0.1	0.0	0.0	
24.	0.01	0	0	14.75	0.0	87.3	7.4	2.8	0.0	0.0	0.0	0.0	
25.	0.01	0	0	0.03	0.0	56.1	3.1	4.4	0.0	0.0	0.0	0.1	
26.	0.01	0	2.32	0	0.0	50.8	11.5	4.1	0.2	0.0	0.0	0.0	
27.	0.01	0	0.53	1.11	0.0	8.5	11.1	21.0	0.0	0.0	0.0	0.0	
28.	0.01	0	0	0.32	0.0	12.3	5.8	8.1	1.0	0.0	0.0	0.0	
29.	0		0	3.72	0.0	4.7	3.7	2.2	1.3	0.0	0.0	0.0	
30.	0		0	0	25.1	1.7	2.9	8.3	2.9	0.2	0.0	0.0	
31.	0		13.69		0.0		14.3	0.3		1.0		0.0	
Total	1.19	0.26	47.2	28.84	125.5	606.5	414.6	399.3	151.4	61.0	36.9	0.3	1872.95

Year - 2016

Sl. Nos.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (mm
1.	0.0	0.0	0.0	0.0	0.0	0.0	49.9	9.5	10.1	0.5	0.0	0.0	
2.	0.0	0.0	0.0	0.0	0.0	1.6	23.5	4.6	5.3	0.4	0.1	0.0	
3.	0.0	0.0	0.0	0.0	0.0	9.0	36.1	17.5	3.1	0.0	6.1	0.0	
4.	0.0	0.0	0.0	0.0	0.0	5.6	56.8	30.4	7.9	0.0	0.0	0.1	

5.	0.0	0.0	0.0	0.0	0.0	0.0	63.0	40.9	1.8	0.1	0.0	0.0	
6.	0.0	0.0	0.0	0.0	0.0	0.1	18.1	17.6	3.0	0.1	0.0	0.0	
7.	0.0	0.0	0.0	0.5	0.0	0.2	8.7	21.7	2.8	0.1	0.0	0.0	
8.	0.0	0.0	0.0	0.0	0.0	0.6	4.2	23.9	2.0	0.1	0.0	0.0	
9.	0.0	0.0	0.0	0.0	0.0	33.0	6.3	20.2	0.2	4.4	0.0	0.0	
10.	0.0	0.0	0.0	0.0	0.0	8.2	5.1	10.6	0.0	6.3	0.0	0.0	
11.	0.0	0.0	0.0	0.0	0.0	12.1	20.9	5.1	0.0	13.6	0.0	0.0	
12.	0.0	0.0	0.0	0.0	1.4	9.8	12.6	17.5	0.2	3.4	0.0	0.0	
13.	0.0	0.0	0.0	0.0	18.4	18.3	9.2	11.3	0.0	0.1	0.0	0.0	
14.	0.0	0.0	0.0	0.0	0.0	7.9	8.9	10.3	3.1	9.7	0.0	0.4	
15.	0.0	0.0	0.0	0.0	4.1	1.3	4.8	8.4	4.2	0.2	20.0	1.6	
16.	0.0	0.0	0.0	0.3	0.0	2.4	3.8	12.7	2.8	0.0	28.9	0.0	
17.	0.0	0.0	0.0	0.0	7.6	0.4	4.1	8.2	6.0	0.1	0.0	0.0	
18.	0.0	0.0	0.0	0.0	28.2	0.1	2.2	11.7	5.2	0.0	0.0	0.0	
19.	0.2	0.0	0.0	0.0	0.4	0.1	3.6	10.3	5.1	0.0	0.0	0.0	
20.	2.3	0.0	0.0	0.0	0.7	0.4	6.3	2.9	3.5	0.0	0.0	0.0	
21.	0.0	0.0	0.0	0.0	0.0	32.8	22.5	1.0	5.8	0.1	0.0	0.0	
22.	0.0	0.0	0.0	0.0	0.0	20.7	13.4	15.9	1.1	0.1	0.0	0.0	
23.	0.0	0.0	0.0	0.0	0.0	12.2	20.6	7.7	2.2	0.3	0.1	0.0	
24.	0.0	0.0	0.0	0.0	0.0	8.4	6.7	12.2	9.8	0.0	0.0	0.0	
25.	0.0	0.0	0.0	0.0	0.0	10.2	8.7	13.8	8.9	0.0	0.1	0.0	
26.	0.0	0.0	0.0	0.0	0.0	14.8	2.3	1.6	23.2	0.0	0.0	0.0	
27.	0.0	0.0	0.0	0.0	0.0	55.0	0.2	17.3	3.3	0.0	0.0	0.0	
28.	0.0	0.0	0.0	0.0	0.0	51.9	7.8	4.7	0.0	0.0	0.0	0.0	
29.	0.0	0.0	0.0	0.0	0.0	109.3	1.9	6.9	0.5	0.0	0.1	0.0	
30.	0.0		0.0	0.0	0.0	63.0	7.0	1.3	0.0	0.2	0.1	0.0	
31.	0.0		0.0		0.0		10.2	1.7		0.0		0.0	
Total	2.5	0.0	0.0	0.9	60.7	489.2	449.4	379.0	120.9	39.7	55.3	2.2	1599.8

Year - 2017

Sl. Nos.	Village Name	Annual Rain Fall (mm)
1.	BHADRAVATHI HOBLI	794.76
2.	BHADRAVATHI (2) HOBLI	840.55
3.	HOLEHONNURU (1) HOBLI	703.9
4.	HOLEHONNURU (2) HOBLI	775.9
5.	HOLEHONNURU (3) HOBLI	651.84
6.	KUDALIGERE HOBLI	690.86
7.	HOSANAGAR HOBLI	2034.97
8.	HUNCHA HOBLI	1906.26
9.	KEREHALLI HOBLI	1262.49
10.	NAGAR HOBLI	3739.24
11.	SAGAR HOBLI	1308.75
12.	ANANDAPURAM HOBLI	1127.7
13.	BARAGADDE HOBLI	3449.46
14.	ANAHALLI HOBLI	1456.17
15.	KARAURU HOBLI	3400.49
16.	TALGUPPA HOBLI	1786.29
17.	SHIKARIPUR HOBLI	810.17
18.	ANJANAPURA HOBLI	779.88
19.	HUSURU HOBLI	696.67
20.	UDAGANI HOBLI	892.95
21.	TALAGUNDA HOBLI	909.04
22.	SHIMOGA (1) HOBLI	700.99
23.	SHIMOGA (2) HOBLI	885.61
24.	HARANAHALLI HOBLI	899.22
25.	HOLALUR (1) HOBLI	725.05
26.	HOLALUR (2) HOBLI	724.88
27.	KUMSI HOBLI	851.82
28.	NIDIGE HOBLI	880.38

29.	NIDIGE (2) HOBLI	906.61
30.	SORAB HOBLI	1097.95
31.	ANAVATTI HOBLI	764.7
32.	CHANDRAGUTTI HOBLI	1473.96
33.	JADE HOBLI	774.04
34.	KUPPAGADDE HOBLI	897.61
35.	ULVI HOBLI	1116.89
36.	TIRTHAHALLI HOBLI	2754.55
37.	AGRAHARA HOBLI	2188.17
38.	AGUMBE HOBLI	3805.57
39.	MANDAGADDE HOBLI	1389.22
40.	MALUR HOBLI	1854.59
	Total (average annual rain fall)	1367.753

Year – 2018

	Taluk	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual (mm)**
BHADRAVATHI	BHADRAVATHI	0	1	9	33	75	75	114	152	184	107	106	90	1,022
	BHADRAVATHI (2)	0	1	3	44	77	77	115	153	170	106	96	94	1,016
	HOLE HONNURU (1)	0	1	3	17	89	89	112	148	142	105	84	99	978
	HOLEHONURU (2)	0	3	4	28	69	69	87	101	118	91	82	89	814
	HOLE HONNURU (3)	0	4	3	24	43	43	84	94	123	87	65	56	671
	KUDALIGERE	0	1	2	24	84	84	106	139	195	102	84	99	1,006
HOSANAGAR	HOSANAGAR	0	1	22	21	76	76	786	666	661	266	81	131	2,886
	HUNCHA	0	1	37	38	63	63	658	618	597	201	95	144	2,613
	KEREHALLI	0	1	25	26	71	71	543	514	372	177	70	112	2,075
	NAGAR	0	1	32	25	73	73	740	725	1335	243	94	134	3,580
SAGAR	SAGAR	0	1	25	22	70	70	361	414	550	139	69	119	1,936
	ANANDAPURAM	0	1	40	13	78	78	325	360	426	132	52	142	1,766

	BARAGADDE (BARANGI)	0	1	6	22	64	64	712	760	1399	245	111	91	3,544
	ANAHALLI	0	1	29	30	71	71	562	567	617	207	89	138	2,481
	KARAURU	0	2	10	25	95	95	1047	818	1262	401	83	131	4,077
	TALGUPPA	0	0	26	3	80	80	547	673	825	185	89	131	2,747
SHIKARIPUR	SHIKARIPUR	1	2	23	6	98	98	159	163	252	93	61	143	1,219
	ANJANAPURA	1	2	26	9	76	76	155	158	221	94	58	114	1,090
	HUSURU	0	2	8	8	72	72	143	147	186	96	64	102	980
	UDAGANI	0	2	4	6	98	98	146	152	214	96	65	132	1,113
	TALAGUNDA	0	1	5	12	130	130	131	142	225	102	61	160	1,231
SHIVAMOGA	SHIVAMOGA (1)	0	1	4	7	57	57	121	137	148	94	53	64	806
	SHIVAMOGA (2)	0	1	4	9	67	67	142	166	181	99	85	77	967
	HARANAHALLI	0	1	7	34	50	50	132	152	226	97	50	66	924
	HOLALUR (1)	0	2	6	16	86	86	106	119	121	92	97	100	923
	HOLALUR (2)	0	1	4	36	94	94	118	143	124	99	111	104	1,027
	KUMSI	0	1	37	11	68	68	129	145	323	95	78	116	1,176
	NIDIGE	0	1	3	30	61	61	116	149	188	104	89	72	939
	NIDIGE (2)	0	1	3	46	61	61	167	221	188	117	97	73	1,099
SORAB	SORAB	0	1	17	7	105	105	337	375	359	132	93	155	1,806
	ANAVATTI	0	1	26	16	105	105	222	241	172	108	59	147	1,332
	CHANDRAGUTTI	0	1	22	21	111	111	541	605	507	185	85	168	2,489
	JADE	0	1	14	8	95	95	251	267	244	106	50	120	1,360
	KUPPAGADDE	0	1	35	15	81	81	286	321	284	118	79	146	1,561
	ULVI	0	1	6	0	86	86	262	291	410	113	62	138	1,545
TIRTHAHALLI	TIRTHAHALLI	0	0	13	0	47	47	563	728	909	196	69	66	2,696
	AGRAHARA	0	0	60	0	55	55	599	686	716	198	119	131	2,735
	AGUMBE	0	2	6	0	79	79	1324	1697	1697	538	116	106	5,728
	MANDAGADDE	0	0	8	0	58	58	461	600	466	175	87	74	2,053
	MALUR	0	0	2	0	53	53	524	698	799	200	70	70	2,525

Year – 2019

Sl. No.	District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (MM)
1.	HOLE HONNURU (1)	0.2	7.6	0.0	14.9	30.0	46	142	357	192	339	32	16	1,176.8
2.	HOLEHONURU (2)	0.0	4.9	0.0	27.9	36.2	53	130	265	149	349	56	15	1,085.9
3.	HOLE HONNURU (3)	0.0	0.4	0.0	12.3	20.9	28	106	283	124	400	54	11	1,039.0
4.	KUDALIGERE	0.0	2.6	5.8	18.0	21.1	55	127	488	158	313	37	27	1,252.7
5.	HOSANAGAR	0.7	0.3	2.6	9.6	2.8	362	952	1,413	535	396	16	8	3,698.5
6.	HUNCHA	0.2	0.9	3.2	25.1	2.8	224	803	1,372	549	348	33	8	3,367.8
7.	KEREHALLI	0.4	0.1	8.4	26.4	5.7	138	364	762	250	404	12	6	1,976.3
8.	NAGAR	1.2	2.1	2.7	11.1	8.5	652	1,616	1,962	952	494	21	9	5,731.2
9.	SAGAR	0.5	0.1	4.0	25.9	0.9	194	508	784	265	373	37	11	2,204.1
10.	ANANDAPURAM	0.3	0.4	4.5	25.7	4.3	193	397	757	273	432	18	5	2,109.4
11.	BARAGADDE (BARANGI)	1.2	0.2	0.2	15.1	1.2	701	1,520	1,941	846	388	41	1	5,455.9
12.	ANAHALLI	0.2	0.1	0.1	17.0	0.8	246	701	1,029	419	352	30	2	2,796.9
13.	KARAURU	3.3	1.5	1.7	10.3	2.7	798	1,733	2,081	734	394	35	5	5,798.1
14.	TALGUPPA	0.1	0.2	0.1	25.9	0.2	280	767	1,073	434	347	28	2	2,956.9
15.	SHIKARIPUR	0.0	0.2	1.1	30.7	4.5	112	194	440	143	307	13	6	1,250.1
16.	ANJANAPURA	0.2	0.0	7.3	36.5	16.5	101	168	409	134	294	9	5	1,181.1
17.	HUSURU	0.0	0.1	5.4	21.6	7.7	78	151	371	150	291	23	4	1,102.7
18.	UDAGANI	0.0	0.0	1.3	39.0	3.7	81	200	454	148	329	12	1	1,269.5
19.	TALAGUNDA	1.4	0.5	0.5	25.4	3.0	73	228	493	160	294	6	2	1,286.6
20.	SHIVAMOGA (1)	0.0	1.1	1.8	16.3	12.4	67	182	489	114	282	68	16	1,249.2
21.	SHIVAMOGA (2)	0.0	1.5	1.4	18.0	6.1	62	248	573	156	298	56	18	1,438.4
22.	HARANAHALLI	0.4	0.7	1.9	31.7	8.3	72	275	640	156	297	44	15	1,542.2
23.	HOLALUR (1)	0.0	8.7	2.6	41.2	19.1	37	127	318	124	260	44	13	993.8

24.	HOLALUR (2)	0.1	7.6	3.8	34.0	16.3	50	145	363	156	252	19	16	1,062.5
25.	KUMSI	1.3	0.0	23.5	23.3	26.0	113	253	606	176	302	8	7	1,539.1
26.	NIDIGE	0.0	0.3	3.0	3.3	13.2	49	185	500	155	289	52	18	1,267.5
27.	NIDIGE (2)	0.2	0.4	2.0	9.9	4.9	63	224	628	211	284	39	21	1,487.5
28.	SORAB	0.4	0.1	0.8	27.8	0.5	122	399	678	263	327	8	12	1,837.4
29.	ANAVATTI	0.0	0.0	3.1	24.4	0.6	92	254	537	190	223	9	3	1,335.0
30.	CHANDRAGUTTI	0.2	0.3	3.5	21.6	0.0	207	610	994	409	293	11	12	2,562.4
31.	JADE	3.4	0.1	3.8	38.0	0.2	137	373	589	217	241	8	1	1,611.2
32.	KUPPAGADDE	0.6	0.1	0.8	31.5	0.7	114	350	685	263	275	3	3	1,726.9
33.	ULVI	0.5	0.2	0.3	27.0	0.4	166	388	752	293	317	14	16	1,974.3
34.	TIRTHAHALLI	0.3	0.2	0.6	20.7	0.4	273	941	1,305	573	299	8	6	3,426.8
35.	AGRAHARA	0.3	0.2	0.7	49.7	1.4	243	923	1,722	568	354	26	19	3,906.1
36.	AGUMBE	0.4	0.3	0.0	28.1	1.5	521	1,440	1,798	762	390	19	8	4,968.6
37.	MANDAGADDE	0.0	0.0	0.8	25.9	4.1	122	484	957	383	332	25	22	2,355.3
38.	MALUR	0.4	0.4	0.3	44.5	4.9	193	650	1,034	470	265	10	11	2,682.9

Year - 2020

Sl. No.	District/Taluk	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (MM)
1.	Bhadravathi	1	1	8	3	37	66	111	113	107.2	198.9	161	25	831
2.	Bhadravathi	1	1	8	0	36	68	112	114	124.8	220.3	181	24	890
3.	Bhadravathi	0	1	8	4	39	69	115	117	120.7	193.9	158	8	833
4.	Bhadravathi	1	1	8	4	38	69	114	116	107.6	181.5	149	10	798
5.	Bhadravathi	1	1	8	2	37	67	113	115	101.2	156.2	134	6	743
6.	Bhadravathi	1	1	8	6	37	68	114	116	113.6	196.8	161	19	842
7.	Hosanagara	1	1	11	2	48	110	170	172	661.0	1162.7	624	7	2971
8.	Hosanagara	1	1	8	2	44	85	137	138	516.2	813.5	610	11	2366

9.	Hosanagara	0	0	13	8	53	81	147	148	328.1	538.5	385	11	1714
10.	Hosanagara	1	1	9	0	30	127	167	168	1158.3	1822.7	1325	5	4815
11.	Sagara	1	1	9	0	33	78	119	121	490.9	847.7	623	2	2325
12.	Sagara	1	1	9	3	56	83	148	150	297.8	521.1	383	3	1655
13.	Sagara	1	0	4	0	12	85	100	101	973.8	1398.9	1025	2	3702
14.	Sagara	1	1	9	0	36	89	134	136	560.9	923.6	636	4	2531
15.	Sagara	2	1	8	0	27	110	145	147	971.2	1438.9	1000	3	3852
16.	Sagara	2	1	6	0	17	80	103	105	544.3	973.2	703	2	2536
17.	Shikaripura	1	2	10	0	52	79	141	143	145.8	257.7	178	0	1010
18.	Shikaripura	1	1	11	8	44	72	126	127	196.1	318.6	239	1	1142
19.	Shikaripura	1	1	10	7	43	70	122	124	126.3	199.1	146	1	848
20.	Shikaripura	1	2	7	0	37	60	105	107	163.2	309.2	202	1	993
21.	Shikaripura	1	1	8	1	37	62	107	108	167.5	309.7	205	0	1007
22.	Shivamoga	1	1	6	6	40	67	112	114	111.6	204.7	136	6	806
23.	Shivamoga	1	1	8	5	37	69	114	115	191.5	312.5	237	10	1102
24.	Shivamoga	1	0	7	1	36	67	110	111	176.2	272.4	202	4	987
25.	Shivamoga	0	1	8	9	38	68	114	115	114.3	180.2	145	5	797
26.	Shivamoga	0	1	8	7	39	70	116	118	126.7	205.1	168	8	867
27.	Shivamoga	1	1	13	4	31	63	107	108	167.1	260.2	203	6	962
28.	Shivamoga	0	1	8	2	40	69	117	119	133.9	221.0	180	18	909
29.	Shivamoga	1	1	8	2	38	69	115	117	185.3	319.4	257	22	1133
30.	Shivamoga	1	0	4	8	36	68	108	109	180.1	273.8	203	4	995
31.	Soraba	2	0	12	1	27	69	108	111	275.5	535.2	329	0	1470
32.	Soraba	1	1	9	0	30	58	98	100	229.5	384.5	266	0	1177
33.	Soraba	2	1	8	5	24	70	102	104	477.1	828.9	561	0	2182
34.	Soraba	1	1	9	5	24	51	84	86	288.2	478.2	333	0	1361
35.	Soraba	2	1	10	0	28	61	99	101	258.0	457.8	310	0	1327

36.	Soraba	2	0	5	0	23	60	88	90	330.3	615.4	505	0	1719
37.	Tirthahalli	2	2	9	1	28	81	118	122	564.8	1017.9	782	6	2733
38.	Tirthahalli	1	1	9	3	41	87	137	139	555.2	912.9	681	9	2575
39.	Tirthahalli	3	2	16	4	34	171	221	225	1639.6	2567.6	2078	5	6966
40.	Tirthahalli	1	2	9	3	42	76	127	130	297.3	524.0	405	10	1627
41.	Tirthahalli	1	2	11	3	38	82	131	134	494.6	880.6	686	9	2471

3. Kodagu District

Sl. No.	Year	2010	2011	2012	2013	2014
1.	**Talakaveri**	6813.6	6865.6	5722.2	8571.7	7849.6
2.	**Baghamandala**	4727.9	5324.7	3738.6	6239.6	5381.1
3.	**Dabbadka**	4991.8	5317	5317	5006.1	4829.1
4.	**Galibeedu**	3600.3	4293.4	2156.8	5811.7	4183.4
5.	**Madikeri**	2836.6	3442	2478	4218.4	3123.6
6.	**Napoklu**	2539.9	2650.8	1953.6	3365.6	2656.2
7.	**Virajpet**	1947.00	2484.00	1377.00	2178.00	2164.00
8.	**Sampaje**	4190.4	4383.5	2859.2	5229.5	4039.1

Year: 2015

Sl. No.	KODAGU DIST.	Jan to May	June to Sept	Oct	Nov	Dec	Annual (MM)
1.	MADIKERI TALUK	425.8	2368	200.7	131.0	16.3	3141.8
2.	MADIKERI HOBLI	360.3	1875.2	152.5	88.3	9.1	2485.4
3.	BHAGAMANDALA HOBLI	445.4	2880.5	251.7	174.9	20.6	3773.0
4.	NAPOKLU HOBLI	533.5	2221.1	197.0	140.5	15.0	3107.0
5.	SAMPAJE HOBLI	395.4	2386.5	185.6	98.8	23.1	3089.3
6.	SOMWARPET TALUK	332.6	1355	92.0	92.9	8.2	1880.7
7.	SOMWARPET HOBLI	366.3	1225.2	86.3	77.9	11.3	1766.9
8.	KODLIPET HOBLI	246.4	913.3	50.0	87.0	9.8	1306.5
9.	KUSHALNAGAR HOBLI	301.3	771.5	63.7	85.6	8.9	1230.9
10.	SANIVARSANTE HOBLI	297.2	992.6	91.4	79.3	5.2	1465.7
11.	SANTHAHALLI HOBLI	323.9	2344.7	157.2	113.3	7.4	2946.5
12.	SUNTIKOPPA HOBLI	368.0	1662.6	97.2	103.2	7.5	2238.6

13.	VIRAJPET TALUK	330.2	1337.4	131.7	127.9	3.6	1930.8
14.	VIRAJPET HOBLI	367.1	1727.0	175.8	131.0	3.2	2404.1
15.	AMMATI HOBLI	340.4	1060.4	151.3	135.9	7.5	1695.6
16.	BLALE HOBLI	338.4	967.8	96.3	154.1	2.7	1559.2
17.	HUDAKERE HOBLI	319.1	1608.0	155.2	148.8	2.2	2233.3
18.	PONNAMPET HOBLI	341.5	1253.5	101.8	133.8	2.8	1833.4
19.	SRIMANGALA HOBLI	310.3	1360.3	109.8	84.9	2.9	1868.3

Year: 2016

Sl. No.	**KODAGU DIST.**	**Jan to May**	**June to Sept**	**Oct**	**Nov**	**Dec**	**Annual (MM)**
1.	MADIKERI TALUK	202.2	2231.0	54.7	40.8	33.2	2561.8
2.	MADIKERI HOBLI	160.7	1953.7	44.0	31.0	39.6	2229.1
3.	BHAGAMANDALA HOBLI	216.9	2686.7	78.4	52.2	23.6	3057.8
4.	NAPOKLU HOBLI	236.6	1874.3	32.5	39.6	44.6	2227.6
5.	SAMPAJE HOBLI	189.3	2369.0	61.0	36.3	22.2	2677.8
6.	SOMWARPET TALUK	132.9	1374.0	17.6	16.0	51.2	1591.7
7.	SOMWARPET HOBLI	122.9	1240.2	12.5	15.8	57.4	1448.8
8.	KODLIPET HOBLI	121.7	937.0	4.1	6.9	48.7	1118.4
9.	KUSHALNAGAR HOBLI	129.0	625.0	25.5	15.7	44.8	840.1
10.	SANIVARSANTE HOBLI	121.2	860.1	3.7	11.1	61.7	1057.9
11.	SANTHAHALLI HOBLI	151.6	2679.2	14.7	18.6	46.8	2910.8
12.	SUNTIKOPPA HOBLI	139.9	1757.7	25.2	20.0	52.3	1995.1
13.	VIRAJPET TALUK	139.0	1079.6	19.3	6.4	55.5	1299.8
14.	VIRAJPET HOBLI	144.2	1202.2	17.7	12.4	69.6	1446.0
15.	AMMATI HOBLI	167.8	818.3	31.7	13.2	53.6	1084.5
16.	BLALE HOBLI	120.7	692.1	12.0	4.0	39.4	868.1
17.	HUDAKERE HOBLI	140.0	1707.8	7.2	1.1	67.6	1923.8

18.	PONNAMPET HOBLI	123.2	942.6	12.5	5.3	59.6	1143.2
19.	SRIMANGALA HOBLI	135.8	1171.0	28.0	1.7	46.8	1383.3

Year: 2017-2020

SL. No.	**Kodagu District**		**Cumulative Rainfall**			
	TALUK	**Station**	**2017**	**2018**	**2019**	**2020**
1.	MADIKERI	BHAGAMANDALA	2086.50	4234.00	1939.00	2078.50
2.	MADIKERI	Aiyamgeri (GP)	#N/A	4312.50	1955.00	1958.50
3.	MADIKERI	Peraje (GP)	1776.50	2863.00	1180.50	1683.50
4.	MADIKERI	NARIYANDADA (GP)	956.00	2970.50	1199.00	1299.00
5.	MADIKERI	Ballamavati (GP)	1436.00	3570.50	1292.00	1418.00
6.	MADIKERI	Kunijala (GP)	1589.50	3946.00	1147.50	1728.50
7.	MADIKERI	GALIBIDU (GP)	1467.00	2978.00	914.00	1385.50
8.	MADIKERI	KARIKE (GP)	1819.00	2637.50	1569.50	1747.50
9.	MADIKERI	Made (GP)	1658.00	2943.50	875.50	1347.50
10.	MADIKERI	Yammemadu (GP)	#N/A	3307.50	797.00	1312.00
11.	MADIKERI	Benguru (GP)	1467.50	3024.50	1398.00	1352.50
12.	MADIKERI	Chembu (GP)	1520.50	2707.50	882.00	1410.50
13.	MADIKERI	Kalakerinidugane (GP)	1258.00	2527.50	799.50	1024.50
14.	MADIKERI	NAPOKLU	830.50	2344.00	784.00	963.00
15.	MADIKERI	Makkanduru (GP)	1021.50	2527.50	709.00	882.00
16.	MADIKERI	Hodduru (GP)	733.50	1978.00	783.00	956.00
17.	MADIKERI	SAMPAJE	1561.50	2746.00	942.00	1190.50
18.	MADIKERI	Konanjageri (GP)	883.50	2265.00	870.50	990.50
19.	MADIKERI	MADIKERI	931.50	2253.50	738.00	880.50
20.	MADIKERI	Kanturumarnadu (GP)	729.00	1851.50	625.00	779.00
21.	MADIKERI	Mekeri (GP)	#N/A	1989.50	801.50	934.00

22.	MADIKERI	Maragodu (GP)	614.50	1304.00	567.50	744.00
23.	MADIKERI	Kadagadalu (GP)	1046.50	1733.50	669.50	924.50
24.	MADIKERI	HAKATTUR (GP)	770.50	1342.50	572.00	861.50
25.	MADIKERI	Arekadu (GP)	#N/A	814.00	464.50	604.00
26.	SOMWARPET	Madapura (GP)	763.00	1574.50	483.00	589.00
27.	SOMWARPET	GARVALE (GP)	1939.00	2909.50	866.50	984.50
28.	SOMWARPET	Vaalnuruthyagathuru (GP)	429.50	960.50	311.00	530.00
29.	SOMWARPET	KODLIPET	617.50	1723.00	547.00	663.50
30.	SOMWARPET	Haradoor (GP)	685.50	1607.00	413.00	531.00
31.	SOMWARPET	Kedakal (GP)	778.50	1535.50	543.50	568.00
32.	SOMWARPET	Belur (GP)	772.50	2067.50	464.50	605.00
33.	SOMWARPET	Haanagallu (GP)	670.50	1966.00	580.50	608.50
34.	SOMWARPET	Byadagotta (GP)	259.00	1537.50	501.00	578.00
35.	SOMWARPET	Bettadalli (GP)	1973.00	2713.00	970.50	1079.00
36.	SOMWARPET	SANTHAHALLI	1542.00	3119.00	970.50	884.50
37.	SOMWARPET	Gowdalli (GP)	662.50	1382.00	368.00	505.00
38.	SOMWARPET	Chowdlu (GP)	696.00	1964.00	473.50	561.00
39.	SOMWARPET	Guddehosuru (GP)	211.50	644.00	233.50	270.00
40.	SOMWARPET	Nanjarayapatna (GP)	408.50	900.50	254.50	422.00
41.	SOMWARPET	Kiraganduru (GP)	1068.50	1976.50	608.50	728.00
42.	SOMWARPET	SUNTIKOPPA	461.00	1086.00	394.50	434.50
43.	SOMWARPET	Nalkursirangala (GP)	449.50	1299.50	379.50	390.50
44.	SOMWARPET	IRALEVALAMUDI (GP)	598.00	1358.50	461.00	458.00
45.	SOMWARPET	Nelliahudikeri (GP)	414.50	1060.50	451.50	509.50
46.	SOMWARPET	Doddamalthe (GP)	626.00	1257.00	285.50	519.50
47.	SOMWARPET	Kodagarahalli (GP)	412.00	1087.00	418.00	425.00
48.	SOMWARPET	SOMWARPET	670.50	1962.50	429.00	534.00
49.	SOMWARPET	Aigur (GP)	523.00	1477.00	290.00	451.50
50.	SOMWARPET	Dundalli (GP)	665.50	1545.50	452.00	430.50

51.	SOMWARPET	SANIVARSANTE	629.00	1515.00	427.50	418.50
52.	SOMWARPET	Nidtha (GP)	499.50	1167.50	327.00	349.50
53.	SOMWARPET	Handli (GP)	564.00	1310.00	384.50	393.00
54.	SOMWARPET	Kambibane (GP)	440.00	1087.50	401.00	400.00
55.	SOMWARPET	Harangi (GP)	368.50	891.00	280.00	330.00
56.	SOMWARPET	KUSHALNAGAR	202.50	612.50	190.50	251.00
57.	SOMWARPET	Nerugalale (GP)	416.00	1320.50	241.50	365.00
58.	SOMWARPET	Mullusoge (GP)	192.50	527.50	202.50	220.50
59.	SOMWARPET	Kudumangalore (GP)	220.00	637.50	215.00	222.50
60.	SOMWARPET	Hoskote (GP)	376.00	1007.00	414.50	359.00
61.	SOMWARPET	Bessur (GP)	466.00	1092.50	401.50	350.50
62.	SOMWARPET	Kudige (GP)	231.50	1053.00	206.50	234.50
63.	SOMWARPET	Shirangala (GP)	195.50	463.50	193.50	284.50
64.	SOMWARPET	Ganaguru (GP)	417.50	1248.00	257.50	355.50
65.	SOMWARPET	Hebbale (GP)	170.50	565.00	180.00	226.50
66.	SOMWARPET	TORENUR (GP)	175.50	514.00	175.50	241.50
67.	SOMWARPET	Alurusiddapura (GP)	366.50	920.50	226.50	352.00
68.	VIRAJPET	BETTOLI (GP)	887.00	2615.00	1613.00	1501.50
69.	VIRAJPET	Arji (GP)	#N/A	2008.00	1261.00	1399.50
70.	VIRAJPET	Kedmulluru (GP)	939.00	2213.50	1242.50	1223.50
71.	VIRAJPET	Bittangala (GP)	1039.00	2029.50	1199.00	1291.50
72.	VIRAJPET	VIRAJPET	741.00	2159.00	1112.50	1249.00
73.	VIRAJPET	Bilugunda (GP)	552.50	1582.00	826.50	853.50
74.	VIRAJPET	HUDAKERE	920.50	2343.00	1218.50	1009.00
75.	VIRAJPET	Aruvthoklu (GP)	668.50	1302.00	844.50	902.00
76.	VIRAJPET	Gonikoopalu (GP)	688.50	1282.50	673.50	809.50
77.	VIRAJPET	Hosuru (GP)	568.00	1391.00	830.00	837.00
78.	VIRAJPET	Kakotuparambu (GP)	660.00	1937.50	741.50	958.50
79.	VIRAJPET	Kadanooru (GP)	730.50	1991.00	833.50	900.00

80.	VIRAJPET	B.Shetteigere (GP)	1100.50	2796.50	1254.50	1102.00
81.	VIRAJPET	Hathuru (GP)	623.50	1604.50	904.00	847.50
82.	VIRAJPET	Birunani (GP)	2206.50	4457.50	1990.50	1527.50
83.	VIRAJPET	Ballyamandooru (GP)	755.00	1888.00	871.00	949.50
84.	VIRAJPET	SRIMANGALA	962.50	1759.50	928.50	954.00
85.	VIRAJPET	Mayamudi (GP)	606.00	1074.00	752.50	715.50
86.	VIRAJPET	Kirugooru (GP)	869.50	1359.00	745.50	805.50
87.	VIRAJPET	T.Shettigeri (GP)	1594.00	2201.00	1316.50	810.00
88.	VIRAJPET	PONNAMPET	878.00	1609.50	854.00	725.00
89.	VIRAJPET	Karmadu (GP)	545.50	1560.50	747.50	754.00
90.	VIRAJPET	DEVAMACHI (GP)	505.50	869.00	647.50	638.50
91.	VIRAJPET	Thithimathi (GP)	326.00	759.50	420.50	538.00
92.	VIRAJPET	Chembebelluru (GP)	540.50	1936.50	754.50	846.00
93.	VIRAJPET	Nitturu (GP)	470.00	1283.00	720.00	676.00
94.	VIRAJPET	Palibetta (GP)	430.50	1223.00	512.50	626.50
95.	VIRAJPET	Halugunda (GP)	667.50	1714.50	627.50	793.50
96.	VIRAJPET	NALKERI (GP)	531.00	1762.50	589.50	568.00
97.	VIRAJPET	AMMATI	493.50	1427.50	585.00	617.50
98.	VIRAJPET	Kanooru (GP)	586.50	1698.50	817.00	786.50
99.	VIRAJPET	Ponappasanthe (GP)	621.50	986.00	671.50	639.00
100.	VIRAJPET	Kutta (GP)	553.00	1816.00	674.00	600.00
101.	VIRAJPET	Kannangala (GP)	627.50	1559.00	569.00	813.50
102.	VIRAJPET	K Badaga (GP)	#N/A	554.50	507.00	615.00
103.	VIRAJPET	Chennayanakote (GP)	332.50	891.00	365.00	414.00
104.	VIRAJPET	Siddapura (GP)	443.00	1082.50	413.50	534.50
105.	VIRAJPET	BLALE	487.50	952.50	564.00	563.00
106.	VIRAJPET	Maldere (GP)	338.00	864.00	311.00	389.00

भारत सरकार
भारतीय भूवैज्ञानिक सर्वेक्षण
GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA

कर्नाटक राज्य के कोडागु, मैसूर, शिमोगा और चिक्मगलुर जिलो में भूआकृति संख्या 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01 और 49M/13 के कुछ हिस्सों में वृहद पैमाने पर (1: 50,000) भूस्खलन संवेदनशीलता मानचित्रण

(कार्य सत्र कोड संख्या: एम4एलएसएसएम/एनसी/एसआर/एसयू-केजी/2019/25179-32984)

(कार्य सत्र: 2019 - 2020)

MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NOS. 48O/09, 48O/10, 48O/14, 57D/03, 57D/04, 58A/01, 49M/13 CHIKMAGALUR, KODAGU, MYSORE AND SHIVAMOGA DISTRICTS, KARNATAKA

(FSP CODE NO: M4LSSM/NC/SR/SU-KG/2019/25179-32984)

FIELD SEASONS: 2019-20, 2020-21

By

जयेश चौरसिया, वरिष्ठ भूवैज्ञानिक
राहुल कुमार चौरसिया, भूवैज्ञानिक

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

2021