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Government of India
भारतीय भूवैज्ञानिक सर्वेक्षण
Geological Survey of India

कर्नाटक के कोडागू के जनपद में स्थित भागमंडला और तालकावेरी हिल
टाउनशिप के मेसो पैमाने (1:10000) पर भूस्खलन संवेदनशीलता मानचित्रण

MESO-SCALE (1:10,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN
BHAGAMANDLA AND TALAKAVERI HILL TOWNSHIPS, KODAGU DISTRICT,
KARNATAKA.

टोपोशीट सं: 48P/07(भाग) और 48P/11(भाग) / Toposheet Nos.: 48P/07 (Part) & 48P/11 (Part)
मद संख्या: एम.चार.एल.एस.एस.एम/ एन. सी./ एस. आर./ एस. यू- के. जी./2022/42401
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कार्य सत्र 2022-23 का अंतिम प्रतिवेदन
Final report for Field Season 2022-23

राहुल वडाक्केडथ, वरिष्ठ भूवैज्ञानिक
मनीषा बिश्वाल, वरिष्ठ भूवैज्ञानिक

Rahul Vadakkedath, Senior Geologist
Manisha Biswal, Senior Geologist

मिशन - IV
MISSION-IV

राज्य इकाई: कर्नाटक एवं गोवा /State Unit: Karnataka and Goa
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बेंगलूरु/Bengaluru

सितंबर, 2023
September, 2023

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(कार्य सत्र: 2022-23)

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(Field Season-2022-23)

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(कार्य सत्र: 2022-23)

द्वारा

राहुल वडाककेडथ, वरिष्ठ भूवैज्ञानिक एवं मनीषा बिशवाल, वरिष्ठ भूवैज्ञानिक

भारतीय भूवैज्ञानिक सर्वेक्षण

सारांश

भूस्खलन भारत के पहाड़ी इलाकों का प्रभावित करने वाले सबसे लगातार प्राकृतिक खतरों में से एक है। देश में खासकर पहाड़ी राज्यों में हर साल भूस्खलन से जान-माल का नुकसान हम्रा आम बात हो गई है। हाल के वर्षों में, दक्षिणी भारत में, पश्चिमी घाट में भूस्खलन की घटनाएँ एक सामान्य घटना बन गई हैं, जिनमें से कुछ प्रकृति में विनाशकारी हैं। कोडागू जिले के उपायुक्त के कार्यालय से प्राप्त अनुरोध के अनुसार तालाकावेरी और भागमंडला के कुछ हिस्सों की मेसो स्केल (1:10,000) भूस्खलन संवेदनशीलता मानचित्रण किया जा रहा है।

10 वर्ग किमी में फैला अध्ययन क्षेत्र, एसओआई टोपोग्राफिक संख्या 48P/07 और 48P/11 में स्थित है और अक्षांश 12.353204N से 12.390325N और देशांतर 75.489164E से 75.535502E तक घिरा है। ई क्रमशः और कोडागू जिले में स्थित है। अध्ययन क्षेत्र कावेरी नदी बेसिन का एक हिस्सा है और कावेरी नदी प्रस्तावित क्षेत्र के भीतर से निकलती है। यह क्षेत्र कूर्ग ब्लॉक का हिस्सा है और मुख्य रूप से चार्नोकाइट चट्टानों के समूह द्वारा कब्जा कर लिया गया है। अध्ययन क्षेत्र में प्रमुख लिटाइक इकाई एंडरबाइट है। एंडरबाइट में जगह-जगह सफेद से भूरे रंग का ग्रेनाइट घुस आया है। ग्रेनाइट का शरीर कतरा हुआ है और लम्बे क्वार्ट्ज़ दाने दिखाता है। एंडरबाइट में भी परिवर्तन आया है जिसे परिवर्तित एंडरबाइट के रूप में वर्गीकृत किया गया है।

अध्ययन क्षेत्र में कुल 45 भूस्खलन/ढलान अस्थिरता की पहचान की गई है, जिसमें 22 मलबे की स्लाइड और 23 रॉक स्लाइड शामिल हैं। अध्ययन क्षेत्र में अधिकांश भूस्खलन सड़क के कटे हुए ढलानों और कुछ बस्तियों के पीछे के ढलानों पर हैं, जहां ढलान का संशोधित किया गया है और उनके प्रेरक कारक मानवजनित गतिविधियों से जुड़े हैं। ये भूस्खलन आकार में छोटे देखे गए हैं; हालाँकि, वे लगातार बारिश के

दौरान पुनः सक्रिय हो सकते हैं। सबसे प्रमुख भूस्खलन ताला कावेरी स्लाइड है जो एक मलबे की स्लाइड है जो वर्ष 2020 में हुई थी। स्लाइड की लंबाई ~ 60 मीटर है और इसकी रनआउट दूरी > 1000 मीटर है।

इस अध्ययन के लिए, ढलान, सापेक्ष राहत (आरआर), जियाग्रॉफन/लैंडफॉर्म, स्ट्रीम पावर इंडेक्स (एसपीआई), भूमि उपयोग भूमि कवर (एलयूएससी), ढलान बनाने वाली सामग्री (एसएफएम), ओवरबर्डन माप्टाई, भू-तकनीकी संपत्ति (जीटी), और गतिज स्वभाव जड़ों का उपयोग विभिन्न चर के रूप में किया गया था। ढलान, सापेक्ष राहत, जियाग्रॉफन/लैंडफॉर्म और एसपीआई के अलावा, जो डीईएम व्युत्पन्न उत्पाद हैं, अन्य सभी विषयगत मानचित्र क्षेत्र आधारित हैं।

रेटिंग क्षेत्र अवलोकनों, भूस्खलन सूची डेटा और इलाके की स्थितियों के बारे में ज्ञान के आधार पर अनुमानी ढंग से दी जाती है। चूंकि चट्टानी ढलानों, मलबे से ढकी ढलानों और कटी हुई ढलानों में भूस्खलन की शुरुआत का नियंत्रित करने वाले अलग-अलग कारक होते हैं, इसलिए प्रत्येक मॉडल के लिए उपयोग किए गए विषयगत मानचित्रों के अलग-अलग सेटों के साथ दृष्टियों के लिए संवेदनशीलता मॉडलिंग अलग-अलग की गई थी।

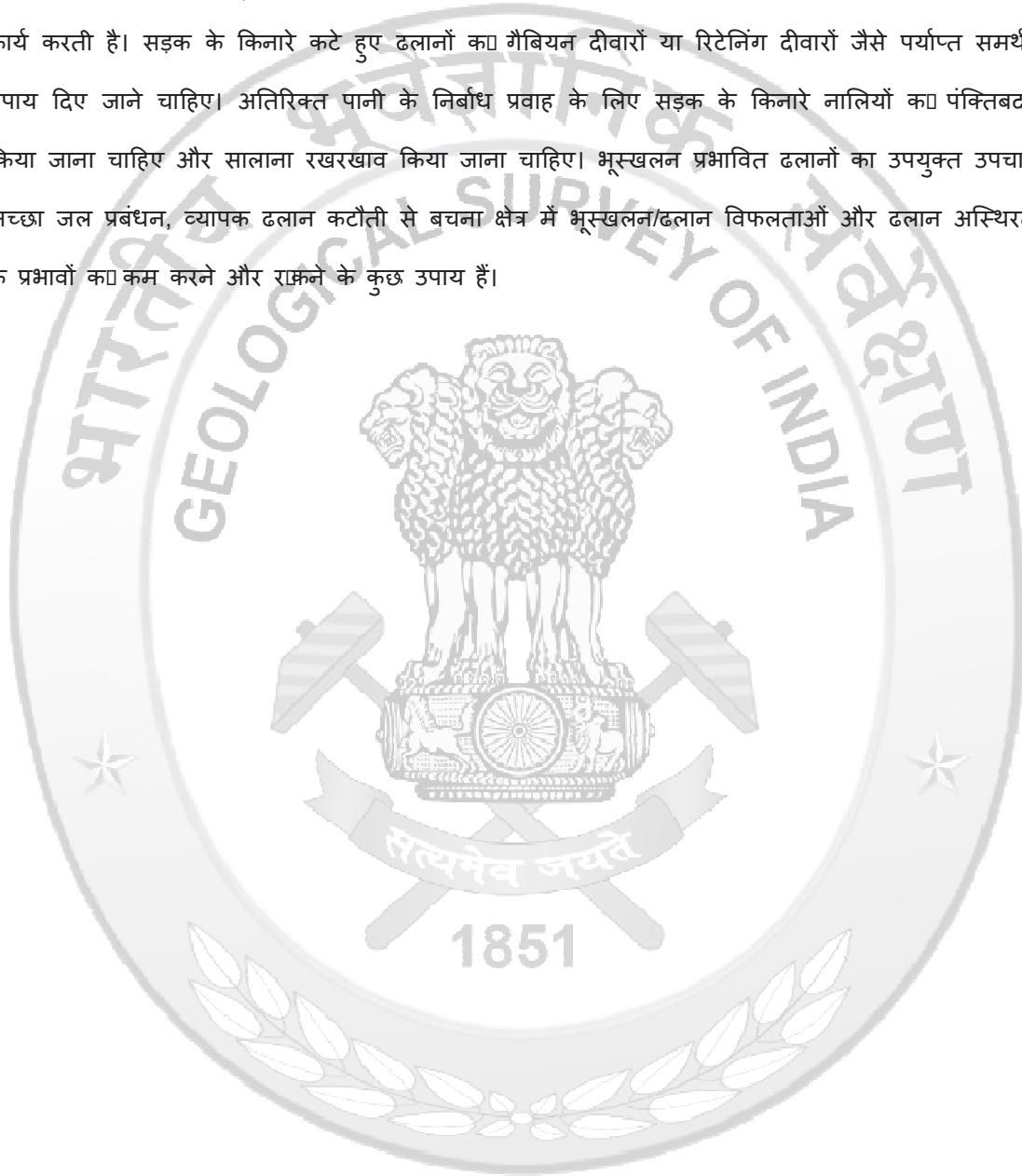
वर्तमान अध्ययन डामेन आधारित भूस्खलन संवेदनशीलता विश्लेषण पर आधारित है, जो चट्टान, मलबे आदि जैसे फिसलन में शामिल सामग्री के संबंध में विभिन्न विफलता डामेन पर जोर देता है। भूस्खलन की संवेदनशीलता अध्ययन क्षेत्र के 26% (2.6 वर्ग किमी) को "उच्च", 22% (2.2 वर्ग किमी) क्षेत्र को "मध्यम" और 52% (5.2 वर्ग किमी) क्षेत्र को "कम" संवेदनशीलता में वर्गीकृत करती है।

अध्ययन क्षेत्र में उच्च संवेदनशीलता वाले पैच अध्ययन क्षेत्र के उत्तर-पश्चिमी भाग में और मुख्य रूप से दक्षिण और दक्षिण-पूर्व की ओर ढलानों में वितरित हैं। भागमंडला-तालाकावेरी सड़क (एसएच-90), जो क्षेत्र में जाखिम का मुख्य तत्व है, में कई उच्च संवेदनशीलता क्षेत्र हैं, जिनमें से सबसे बड़ा तालाकावेरी के दक्षिण पूर्व में हेयरपिन वक्र के पास है। तालाकावेरी मंदिर के पास क्षेत्र के उत्तर-पश्चिमी हिस्से में उच्च संवेदनशीलता क्षेत्र लगभग 350 मीटर की दूरी तक फैला हुआ है और इसकी विशेषता ढीला मलबा है जो भूस्खलन के भाग और निकटवर्ती पहाड़ी ढलानों पर जमा हुआ है, जिसमें कमजोर चट्टानें हैं। द्रव्यमान। उच्च संवेदनशीलता वाले क्षेत्रों के पार्श्व में पूरे अध्ययन क्षेत्र में मध्यम संवेदनशीलता वर्ग देखा जाता है। 52% क्षेत्र निम्न संवेदनशीलता वर्ग के अंतर्गत आता है। अच्छी चट्टानी स्थिति, वनस्पति आवरण और कृत्रिम जल निकासी जल का कम प्रवाह क्षेत्र की कम संवेदनशीलता में योगदान देता है।

भूस्खलन मैनेजमेंट मानचित्र विशिष्ट समस्याग्रस्त स्थानों, सुरक्षित आश्रय स्थानों और प्रत्येक संवेदनशील इलाके के लिए उपचारात्मक उपायों पर हितधारकों को एक तैयार संदर्भ प्रदान करता है। भूस्खलन

प्रबंधन मानचित्र और जाखिम मानचित्र में उल्लिखित विशिष्ट स्थानों का उद्देश्य प्रशासन का समस्याग्रस्त स्थानों के संबंध में आवश्यक जानकारी प्रदान करना है ताकि अध्ययन क्षेत्र में संसाधनों का इष्टतम उपयोग किया जा सके।

क्षेत्र में अधिकांश भूस्खलन मानवजनित गतिविधियों के कारण होते हैं जिनमें वर्षा एक ट्रिगर के रूप में कार्य करती है। सड़क के किनारे कटे हुए ढलानों का गैबियन दीवारों या रिटेंनिंग दीवारों जैसे पर्याप्त समर्थन उपाय दिए जाने चाहिए। अतिरिक्त पानी के निर्बाध प्रवाह के लिए सड़क के किनारे नालियों का पंक्तिबद्ध किया जाना चाहिए और सालाना रखरखाव किया जाना चाहिए। भूस्खलन प्रभावित ढलानों का उपयुक्त उपचार, अच्छा जल प्रबंधन, व्यापक ढलान कटौती से बचना क्षेत्र में भूस्खलन/ढलान विफलताओं और ढलान अस्थिरता के प्रभावों का कम करने और राफ़ने के कुछ उपाय हैं।



MESO-SCALE (1:10,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN
BHAGAMANDLA AND TALAKAVERI HILL TOWNSHIPS, KODAGU DISTRICT,
KARNATAKA.

(Item No: M4LSSM/NC/SR/SU-KG/2022/42401)
(Field Season-2022-23)

By,

Rahul Vadakkedath and Manisha Biswal, Senior Geologists
Geological survey of India

ABSTRACT

Landslides are one of the most frequent natural hazards affecting the hilly terrains of India. Every year, the loss of life and property due to landslides has become a common factor in the country especially in the hilly terrain. In recent years, landslide occurrences in southern India, in the Western Ghats have become frequent phenomena, some of which are devastating in nature. The meso scale (1:10,000) landslide susceptibility mapping of parts of Talakaveri and Bhagamandla is being taken up as per the request from the office of the Deputy Commissioner, Kodagu District.

The study area, spanning 10 sq.km, lies in SOI toposheet no's 48P/07 & 48P/11 and is bounded by latitudes 12.353204N to 12.390325N and longitudes 75.489164E to 75.535502E respectively and is located in Kodagu district. The study area is a part of the Cauvery river basin and the Cauvery River originates within the area. The area forms part of the Coorg Block and is mainly occupied by the Charnockite suite of rocks. The dominant litho unit in the study area is Enderbite. The Enderbite is intruded by white to buff colored granite at places. The granite body is sheared and shows elongated quartz grains. The Enderbite has also undergone alteration which has been classified as "altered Enderbite".

A total of 45 landslides/slope instabilities have been identified in the study area which includes 22 debris slides and 23 rockslides. The majority of the landslides in the study area are along the cut slopes of the road and in the back slopes of a few settlements where the slope has been modified and has their causative factors linked to anthropogenic activities. These landslides are observed to be smaller in dimensions; however, they may reactivate during incessant rainfalls. The most prominent landslide is the Tala Kaveri slide which is a debris slide that occurred in the year 2020. The slide is ~ 60m in length and has a runout distance of >1000m.

Present study aims at landslide susceptibility mapping on 1:10,000 scale. Various thematic maps like Slope, Relative Relief (RR), Geomorphon/Landform, Stream Power Index (SPI), Land Use/ Land Cover (LULC), Slope Forming Material (SFM), Overburden thickness, Geotechnical property (GT), and Kinematic disposition of joints were used for susceptibility analysis. Slope, Relative Relief, Geomorphon/Landform and SPI are DEM derived maps, whereas the other maps are field based and post field derived maps.

The LSER ratings are assigned heuristically based on field observations, landslide inventory data and knowledge about the terrain conditions. Since the rocky slopes, debris covered slopes and cut slopes have different factors governing the initiation of landslides, the susceptibility modelling for both was carried out separately with different sets of thematic maps used for each of the model.

The present study is based on domain based landslide susceptibility analysis, giving emphasis on various failure domains with respect to the material involved in sliding like rock, debris etc. A combined susceptibility map is also prepared by mosaicing different domain based maps, of which 26% (2.6 sq km) of the study area is classified as “High”, 22% (2.2 sq km) of the area as “Moderate” and 52% (5.2 sq km) of the area as “Low” susceptibility classes.

The high susceptibility patches are distributed in the north western part of the study area and predominantly in the south and south-easterly facing slopes. The Bhagmandala-Talakaveri road (SH-90), which is the main element at risk in the area and falls under high susceptibility zones, the largest of which is near the hairpin curve south east of Talakaveri. The high susceptibility zone in the north-western part of the area near Talakaveri temple extends a distance of about 350 m and is characterised by loose debris which has accumulated in the run-out part of the landslide and adjacent hill slopes which is having weak rock mass. The moderate susceptibility class is observed throughout the study area flanking the high susceptibility zones. 52% of the area falls under the low susceptibility class. Good rock mass condition, vegetation cover and a low influx of drainage water contribute to the low susceptibility of the area.

The Landslide Management map provides a ready reference to stakeholders on specific trouble spots, safe shelter locations and remedial measures for each vulnerable locality. The specific locations mentioned in the landslide management map and element at risk map are

aimed to provide necessary information to the administration regarding the trouble spots so that the resources are optimally utilized in the study area.

Majority of the landslides in the area are caused by anthropogenic activities with rainfall acting as a trigger. Cut slopes along the road should be given adequate support measures like gabion walls or retaining walls. Toe drains along the road should be lined and maintained annually for an unhindered flow of excess water. Suitable treatment of the landslide affected slopes, good water management and avoiding extensive slope cuts are some of the measures to curtail and prevent the effects of landslides/slope failures and slope instability in the area.



CHAPTER 1. INTRODUCTION

1.1 Background

Landslides are one of the most frequent natural hazards affecting the hilly terrains of India. Every year, the loss of life and property due to landslides has become a common occurrence in the country especially in the hilly states. In recent years, landslide occurrences in southern India, in the Western Ghats have become a common occurrence, some of which are devastating in nature.

GSI had launched its flagship programme viz. National Landslide Susceptibility Mapping (NLSM) for Macro scale in Karnataka and Goa from the year 2015 to generate a seamless susceptibility map for the entire state. The program has been completed by the year 2020 and has classified an area of 31,316 sq.km into high, moderate and low susceptibility zones on 1:50,000 scale. The macro-scale susceptibility map delineated the major vulnerable landslide zones in the state. The susceptibility map would be an immense help to town planners in chalking out a regional developmental plan by avoiding major susceptible zones or by taking adequate preventive measures for the safety of any project being carried out. However, since the macro scale map provides a regional picture, it has limitations in its utility as a large scale map for use in detailed planning and mitigation. To address this limitation and to provide planners a detailed 1:10,000 landslide susceptibility map, the mesoscale landslide susceptibility mapping has been taken up along major road corridors or townships where the NLSM program has already identified high susceptible zones or along areas where a specific request for such large scale study from stakeholders is received.

The meso scale (1:10,000) landslide susceptibility mapping of parts of Talakaveri and Bhagamandala is being taken up as per the request received from the office of the Deputy Commissioner, Kodagu District (vide letter No. Cal: 07: 2021-22, Dated: 30-04-2021). The proposed study area has witnessed many landslide incidences in the recent past. In August 2020, a major landslide event has resulted in the loss of several human lives. As per the NLSM map, approximately 54% of the proposed area falls in moderate and high susceptible areas. Therefore, a detailed assessment of hill slopes is warranted.

1.2 Study area

The study area, spanning 10 sq.km, lies in SOI toposheet no's 48P/07 & 48P/11 and is bounded by latitudes 12.353204N to 12.390325N and longitudes 75.489164E to 75.535502E respectively. The proposed study area is located in Kodagu district, Karnataka around 36 km away from Madikeri town. The area is well connected by SH-90 (Hunsur-Virajpet-Talakaveri) and several motorable roads. Apart from these, several smaller roads and foot tracks are

available throughout the area. Mysore domestic airport is the nearest from Madikeri located about 121 km away. Kannur International Airport is located about 120 km away from Madikeri. The nearest railway stations to Madikeri (district headquarter) are Mysore Hassan and Mangalore of Karnataka State and Thalassery and Kannur of Kerala state (<https://kodagu.nic.in/>).

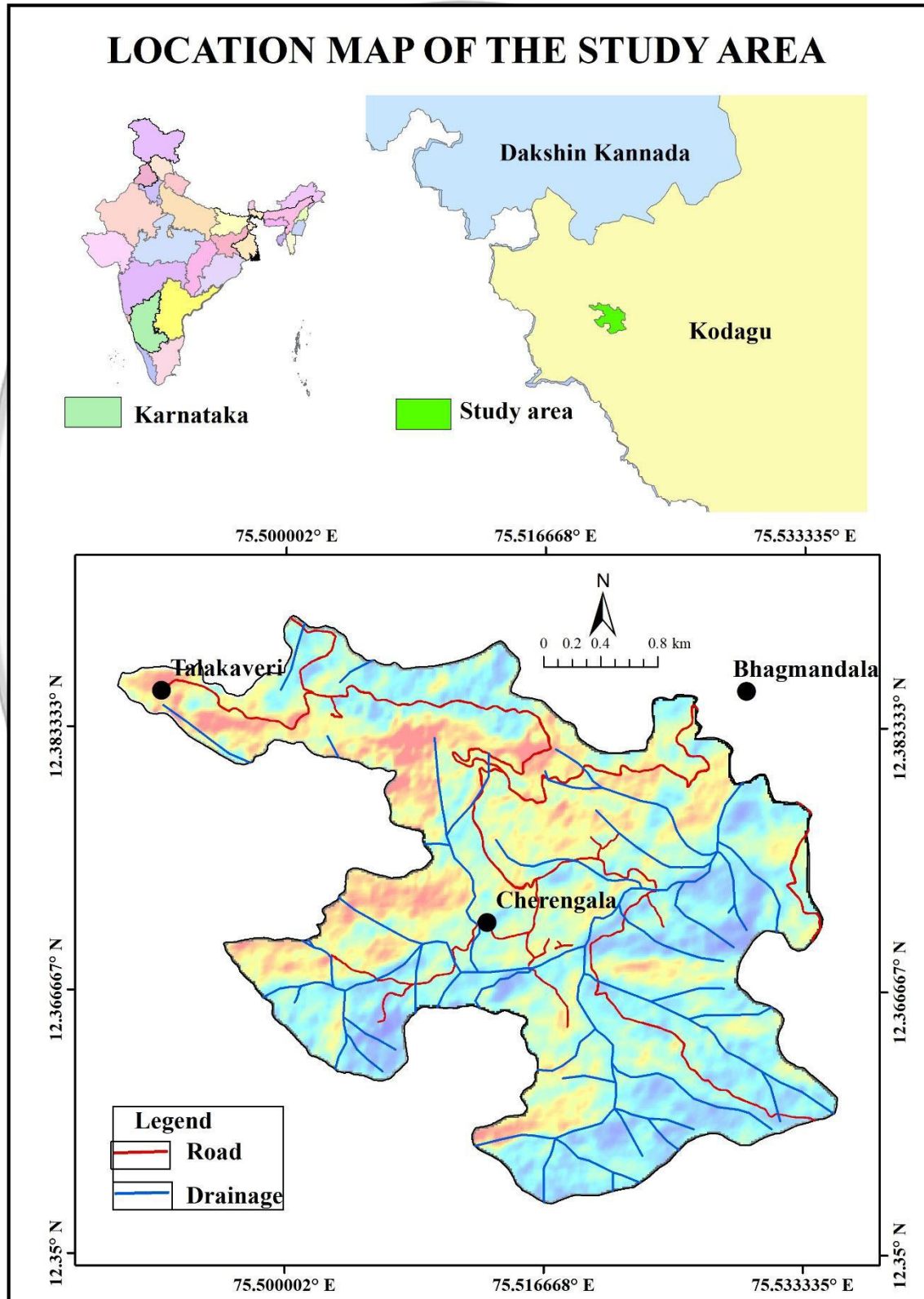


Fig. 1.1: Location map of the study area

The study area is a part of the Cauvery river basin and the Cauvery River originates within the area. The study area experiences inflow of tourists and devotees to visit the Talakaveri Temple and Brahmagiri hills.

1.3 Topography and Drainage

The area is a part of the Western Ghats. The minimum and maximum elevations of the area are 789m (near Bhagamandala) and 1256m (near Talakaveri) respectively. The study area is having mostly low to extremely low relief. Relatively higher relief is observed in the Northern part of the area. The area is drained by Cauvery River and its tributaries. The highest drainage order observed in the area is 5 and the prominent drainage pattern in the area is dendritic.

1.4 Climate and Rainfall

Coorg is known for its pleasant climate. Located in the middle of the Western Ghats, Coorg or Madikkeri is part of the tropical belt. The weather here can be classified as Tropical Monsoon Climate. Summer usually begins in late February and continues till June. In the summer, temperatures can go as high as 35 degrees Celsius. October marks the onset of winter. Winters here can be chilly but they are still very pleasant. The winter temperature goes up to 20 degrees Celsius. The minimum temperatures in this season are around 15 degrees Celsius. The coldest days are usually in December-January. Monsoons in Coorg are also quite cool. They begin in July and continue until September. As the rains cascade over the hills, the weather turns cool, humid and wet. The hills turn a lush green and flowers spot the hillsides. The rains can be quite heavy here (<https://www.karnataka.com/coorg/coorg-climate/>).

Coorg attracts some heavy rainfall that leaves the weather during monsoon season – humid, wet, cool and misty. The average annual rainfall throughout Coorg is between 2,500 and 3,500 millimeters (<https://www.coorg.com/weather/>).

The daily rainfall data from the year 2009 to 2022 (Annexure-VI) for the study area has been collected from Karnataka State Natural Disaster Monitoring Centre (KSNDMC). The analysis of rainfall data from the year 2010 to 2022 has been shown in Fig. 1.2. and Fig. 1.3.

1.5 Nature and scope of present work

This study aims to classify the study area into zones based on their susceptibility to landslides/slope failures. Since the study is on a 1:10,000 scale, it involves extensive field inputs and preparation of field based thematic maps. Apart from the field based maps, high-resolution Digital Elevation Models (DEM) derived maps are also used for select themes. These maps are assigned ratings and weights according to their propensity to landslide initiation to prepare the landslide susceptibility map of the study area.

The landslide susceptibility map (Plate-X) on a 1:10,000 scale allows the user for relatively better decision making for future land-use changes/town planning, disaster preparedness and providing control and corrective measures for existing landslide zones. Apart from the susceptibility map, a landslide management map (Plate-XI) is also prepared which is a ready reference for the user on the general mitigation measures to be given for different zones of the study area.

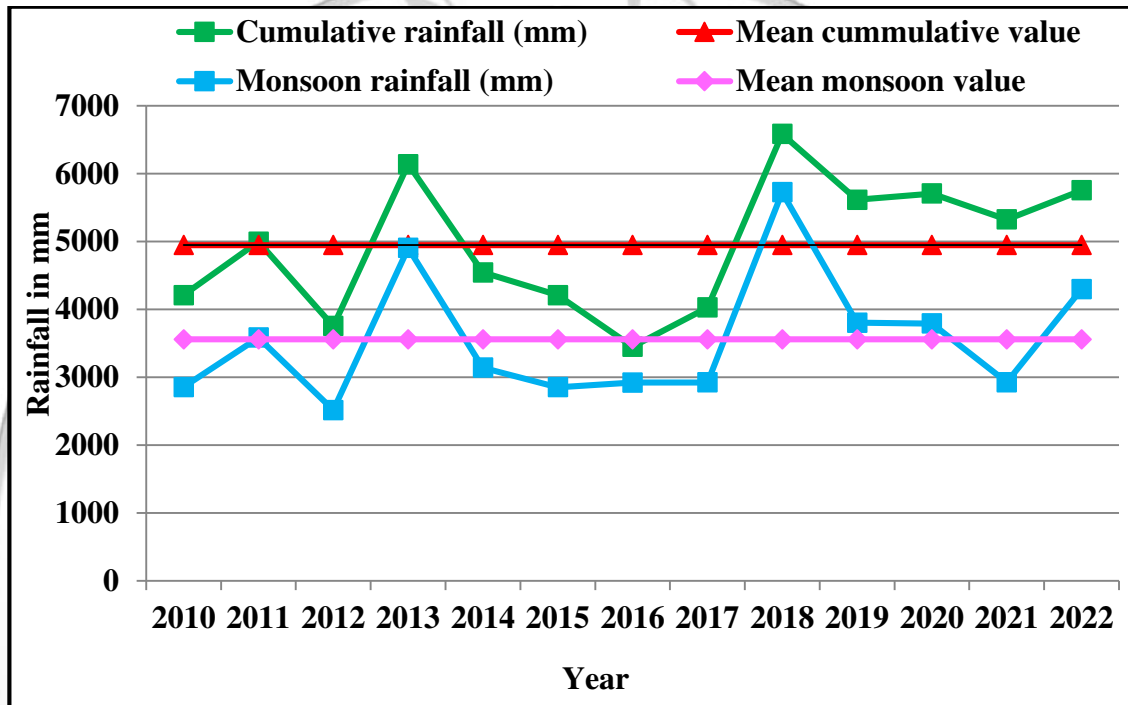


Fig. 1.2: Graph showing average annual rainfall and monsoon rainfall of the study area

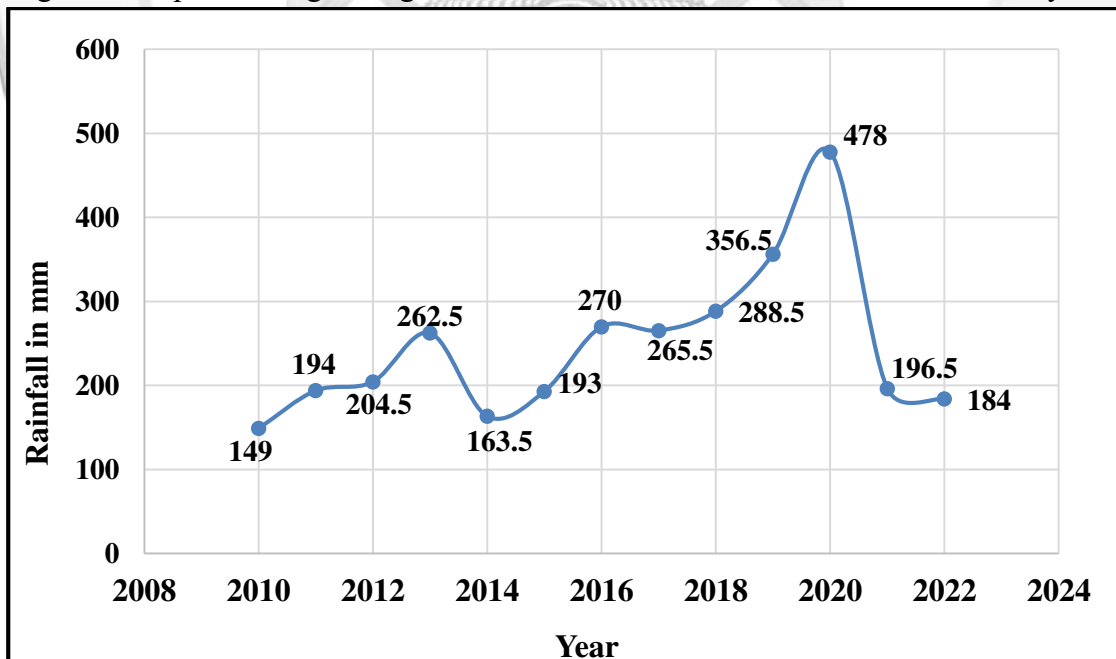
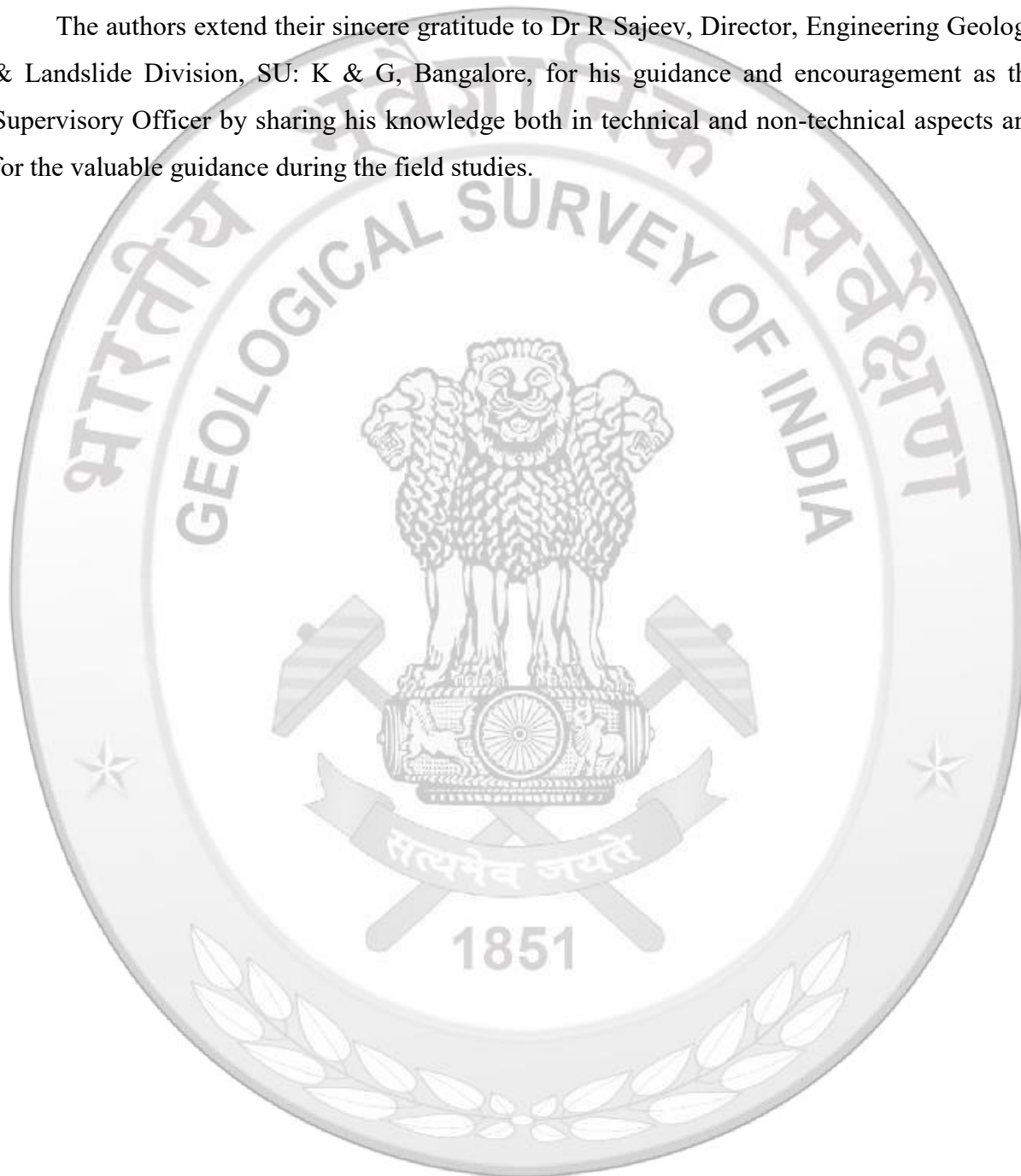


Fig. 1.3: Graph showing annual maximum rainfall of the study area from the year 2010 to 2022

1.6 Acknowledgment

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CHAPTER 2. GEOLOGY AND PREVIOUS WORK

2.1 Regional Geology

The study area is a part of the Coorg Block and is mainly occupied by Charnockite suite of rocks (GSI 1:50,000 map series). The Coorg Block (Fig. 2.1) is a Mesoproterozoic microcontinent bounded by the Mercara shear zone in the north and east, and the Moyar Shear Zone in the south (M. Santosh *et al.* 2015). The Mercara Shear Zone, which is having a width of ~20 km is just north of the study area. The shear zone is characterised by high grade mylonitic rocks and is highly deformed. The shear zone, which has an E-W trend in the western part of the continent takes a sharp bend near Madikeri to a NNW-SSE trending zone which then merges with the Moyar Shear Zone further south.

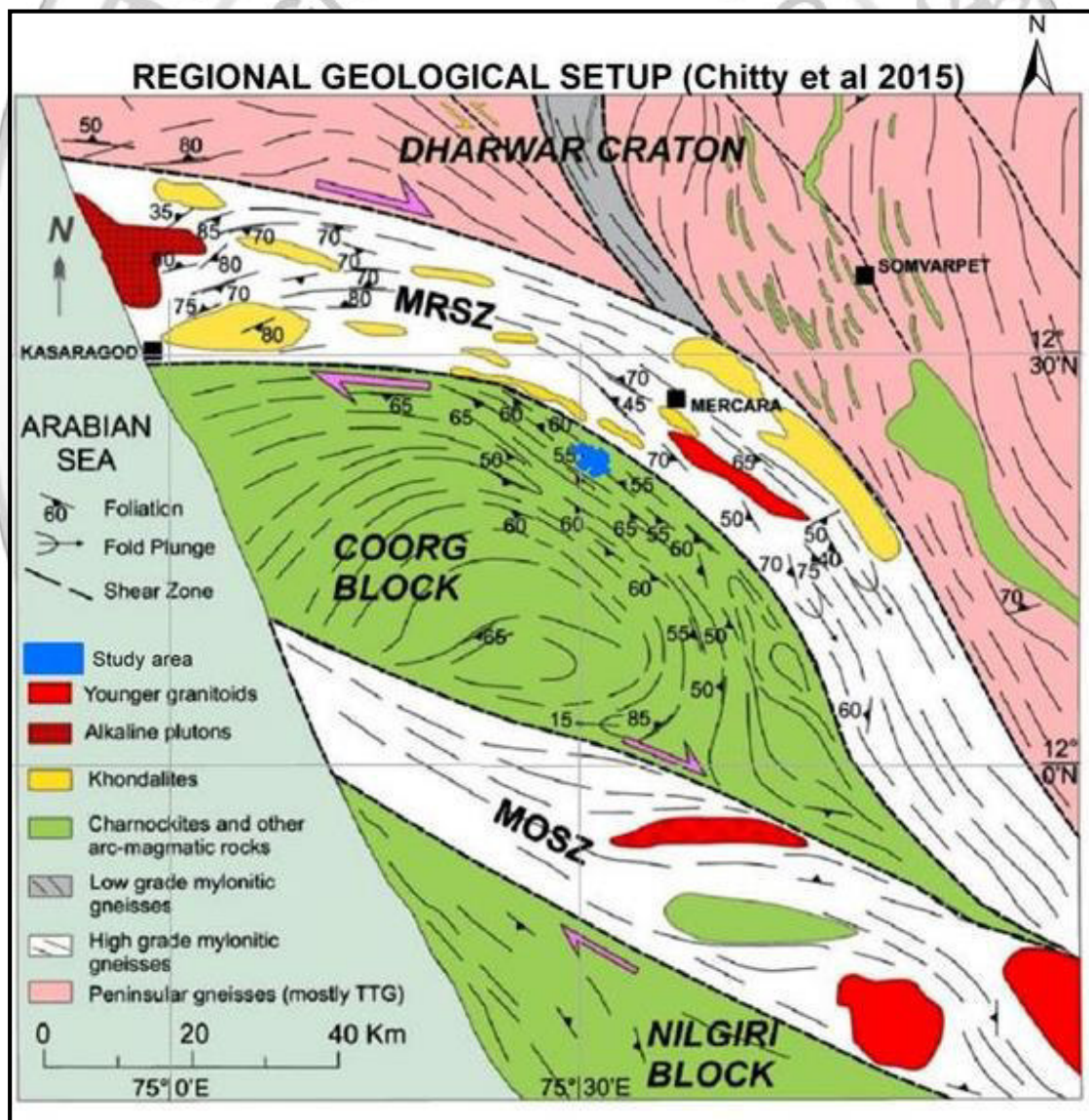


Fig. 2.1: Geological map of the study area (Chitty et al., 2015)

2.2 Geology of the study area

The dominant litho unit in the study area is Enderbite. (Fig. 2.2) The rock is generally massive (Fig. 2.3) in most of the places; however, it shows metamorphic bandings at few localities. The Enderbite is intruded by white to buff colored granite at places. The granite body is sheared and show elongated quartz grains (Fig. 2.5). The Enderbite has also undergone alteration which has been classified as altered enderbite (Fig. 2.4).

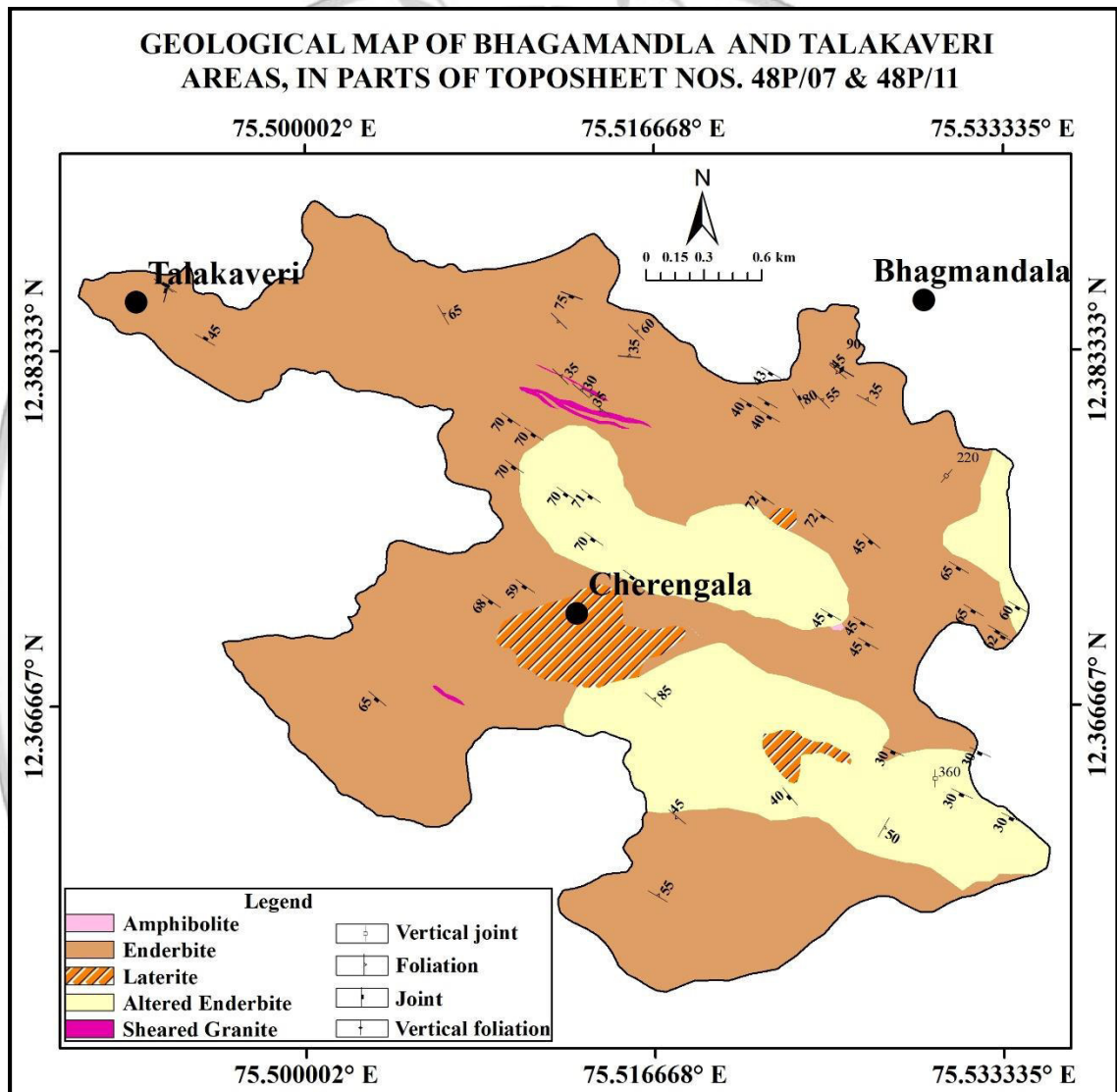


Fig. 2.2: Geological map of the study area

[Source: GSI 1:50,000 map series and 1:25,000 STM map, modified after field work]



Fig. 2.3: Enderbite exposed in road section, near Cherengala



Fig. 2.4: Altered enderbite exposed near Cherengala



Fig. 2.5: Sheared granite showing elongated quartz grain

2.3 Previous Work

K.V. Maruti and A.K. Mishra had carried out landslide inventory studies in Bhagmandala and Talakaveri road sections during 2009-2010 and identified 6 debris slides in the road section. The major causative factor of the slides was reported to be road cuts.

Dey A.K. *et. al.* (1955) carried out Systematic Geological mapping in parts of toposheet numbers 48P/7, 10 and 11 during 1954-55. They have classified the rock units in the area as Charnockites with pyroxene granulite patches. Intrusive granites and basic intrusives were also reported in and around the study area.

Ankur Kumar Srivastava and Neha Kumari carried out Macro scale (1:50,000) landslide susceptibility mapping in the study area. As per the macro scale susceptibility map, 53.6% of the study area falls under moderate to low susceptibility classes

Prantik Santra and Rigzin Norboo carried out Specialized Thematic Mapping of high grade/ultra-high grade supracrustals & granitoids around Madikeri. They have classified the rocks in the study area as Enderbite after detailed petrographic studies. Enderbite mainly contains quartz, feldspar, hornblende, garnet, pyroxene and biotite. The Enderbite mainly has granoblastic texture with bandings observed in few places. Enderbite has more mafic minerals than the Charnockite. The workers have also reported granitic intrusives within the Enderbite which is sheared.

CHAPTER 3. METHODOLOGY

Landslide is the downward movement of material, whether rock or debris, along a hill slope by the action of gravity. Initiation of any landslide can be attributed to two major factors namely triggering factor and conditioning factor. Conditioning factors are those wherein the inherent properties of the material whether rock or debris is conducive for a landslide to occur. These include the inclination of the slope, the slope direction, orientation of discontinuities with respect to the slope direction, extent of weathering, land use/ land cover etc. Triggering factors are those which provide an external stimulus/force by which the slope material becomes unstable. This is mainly due to saturation by rainfall, seismic events or by anthropogenic activities like slope modification.

In a hilly terrain, if the causative factors responsible for landslides are known and can be quantified, the susceptibility of the slope for initiating a landslide can be estimated. Landslide susceptibility is the tendency/propensity of a particular hill slope to be a landslide source in future. The landslide susceptibility mapping in macro-scale (1:50,000) used a bivariate data-driven statistical technique for analysis of susceptibility. The relationship between landslides and various thematic aspects is quantified based on the number of landslides occurring in each class. The meso scale (1:10,000) mapping on the other hand, covers a relatively smaller area and, therefore may not have sufficient landslide data for any data-driven statistical models. Thus the ratings and weights are assigned by extensive field observation for every thematic aspect. These warrants detailed and accurate field based maps along with high-resolution satellite data.

3.1 Selection of mapping unit

Traditionally, landslide susceptibility mapping used slope facets as mapping units. A slope facet may be defined as a part of a particular hill slope having consistent slope direction and inclination. This method was very effective in the mapping of aspects like kinematic stability, geotechnical parameters, etc. where a slope facet can be assigned a single class/value. However, with the use of high-resolution satellite data, much more detailed maps can be produced where a single facet may have hundreds or even thousands of pixels. Therefore, pixels were chosen as the mapping unit as it produces data with higher resolution. Nevertheless, a facet map (Fig. 3.1) was also prepared for the study area. The same can be useful for field work and for stakeholders for having general idea of geographic distribution of various themes and landslide susceptibility and can be helpful for planning. The downside of using pixels is the minor spatial errors in satellite based products.

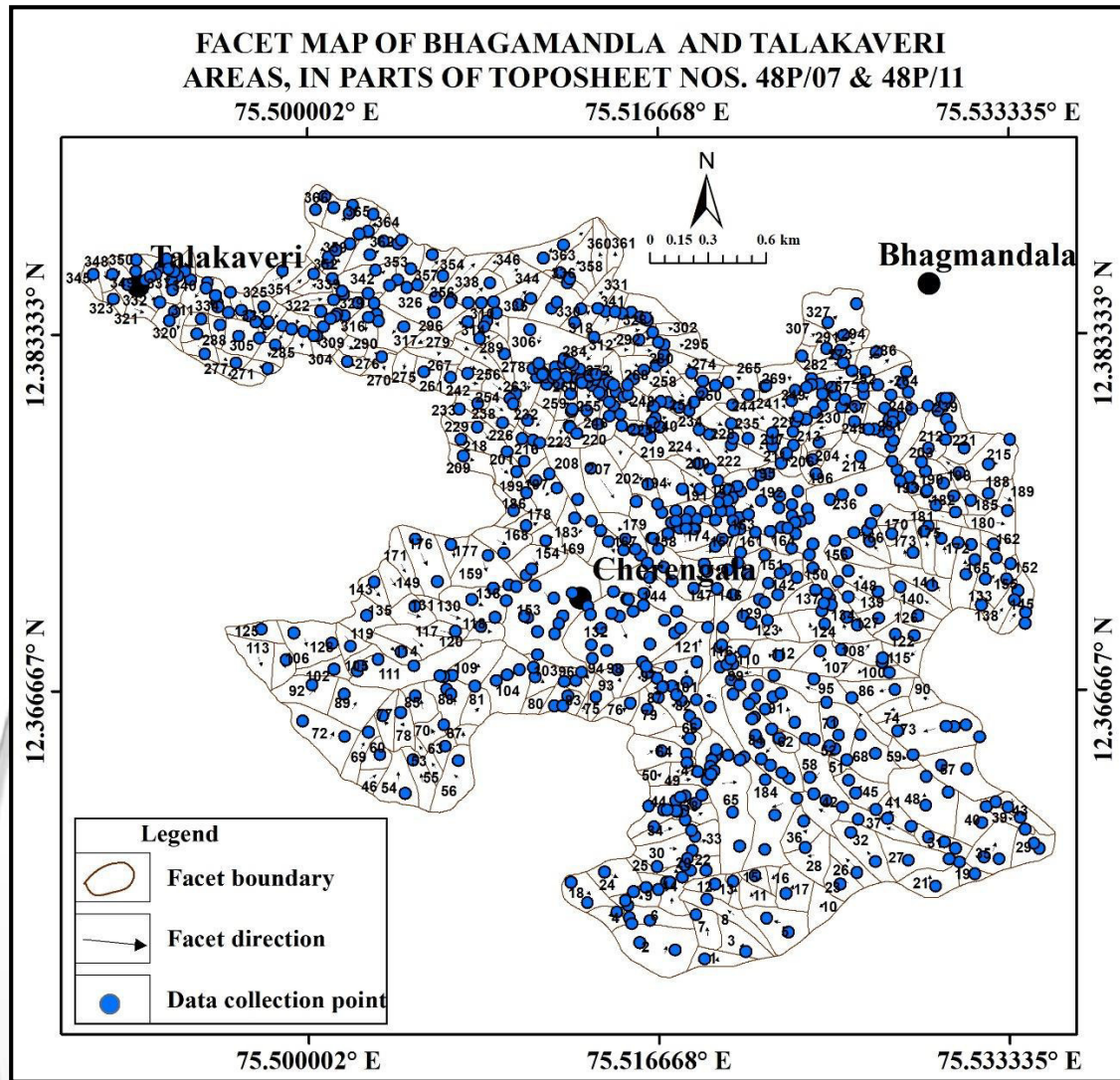


Fig. 3.1: Facet map of the study area

3.2 Methodology used

The methodology is based on approved SOP (GSI, 2020) of GSI on mesoscale landslide susceptibility studies. Susceptibility on the scale of 1:10,000 is carried out by categorizing the area based on failure domains like debris domain, rock domain etc.

The primary requirement of any geological study/investigation is a base map with topographical information on a compatible scale. Physical mapping by theodolite/total station produces accurate data and is ideal for any large scale study but it warrants a lot of time, manpower and professional expertise. With the advent of high-resolution DEM data, semi detailed topographic maps can be prepared in a GIS platform. Even though less accurate than a physical ground survey, the DEM data can be used to prepare contour maps very close to ground conditions. For this study, high resolution Cartosat (10m) and ALOS PALSAR (12.5m) DEMs were available. However, after the comparative study of the DEM derived contours (Fig. 3.2), ALOS DEM was found to be truer to the ground condition in the study area and hence was used to prepare the base map (Fig.3.3). Contours were generated with an interval of 10m

and superimposed with road, drainage and localities to prepare the base map (Fig. 3.3) which was used for field work.

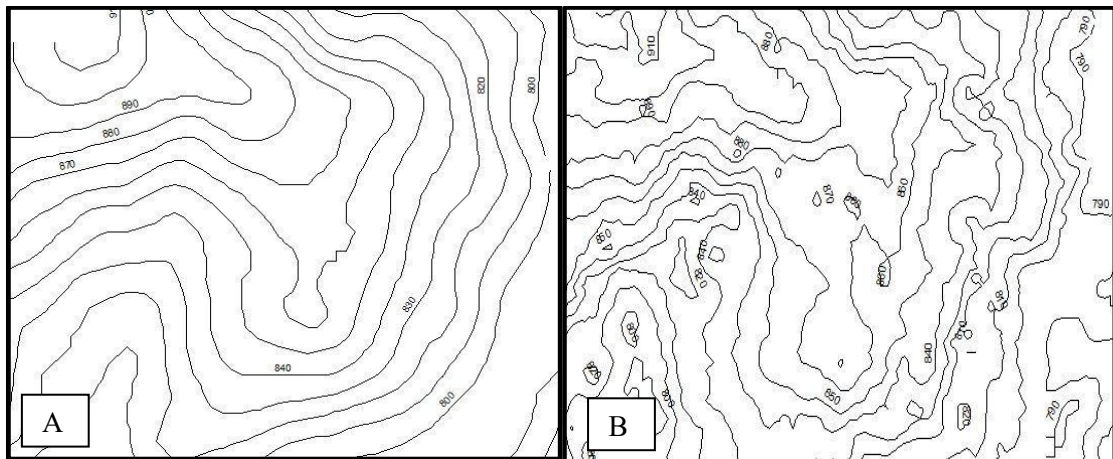


Fig. 3.2: Contour map prepared using ALOS DEM (A) and Carto DEM (B)

The selection of thematic maps/intrinsic variables which contribute to the occurrence of landslides is the next step in susceptibility mapping. For this study, Slope, Relative Relief (RR), Geomorphon/Landform, Stream Power Index (SPI), Land Use Land Cover (LULC), Slope Forming Material (SFM), Geotechnical property (GT), and Kinematic disposition of joints were chosen as the different variables. Apart from Slope, Relative Relief, Landform and SPI, which are DEM derived products, all the other maps are field based thematic maps. The workflow of the study can be divided into the following different parts. A flow diagram for the methodology used is given in Fig. 3.4.

3.2.1 Pre-field components

- Preparation of pre-field landslide inventory map from previous reports and satellite imageries
- Preparation of DEM derivative maps (Slope angle, SPI, Geomorphon/Landform and Relative Relief).
- Preparation of LULC map using satellite imagery.
- Preparation of base map for field work.

3.2.2 Field components

- Collection of Landslide 42-point data for all the landslides/slope failures in the study area.
- Preparation of SFM map, Overburden thickness map and Geological map in 1:10,000 scale and categorization of different overburden types.
- Estimation of *in-situ* Uniaxial Compressive Strength (UCS) of rocks using N-type Schmidt hammer and preparation of the Geotechnical map.
- Collection of bedding and joint data for Kinematic Failure map preparation.

- e) Validation and modification of LULC map through field observations.
- f) Collection of soil and rock samples for estimation of select Geotechnical parameters from GT lab.

3.2.3 Post field components

- a) Finalisation of various thematic maps using data collected by way of extensive field work in the study area.
- b) Preparation of kinematic map from joint data using Markland test.
- c) Assigning ratings to various thematic maps
- d) Preparation of landslide susceptibility map by integrating the thematic maps
- e) Preparation of landslide management map with suggestions for control and corrective measures.

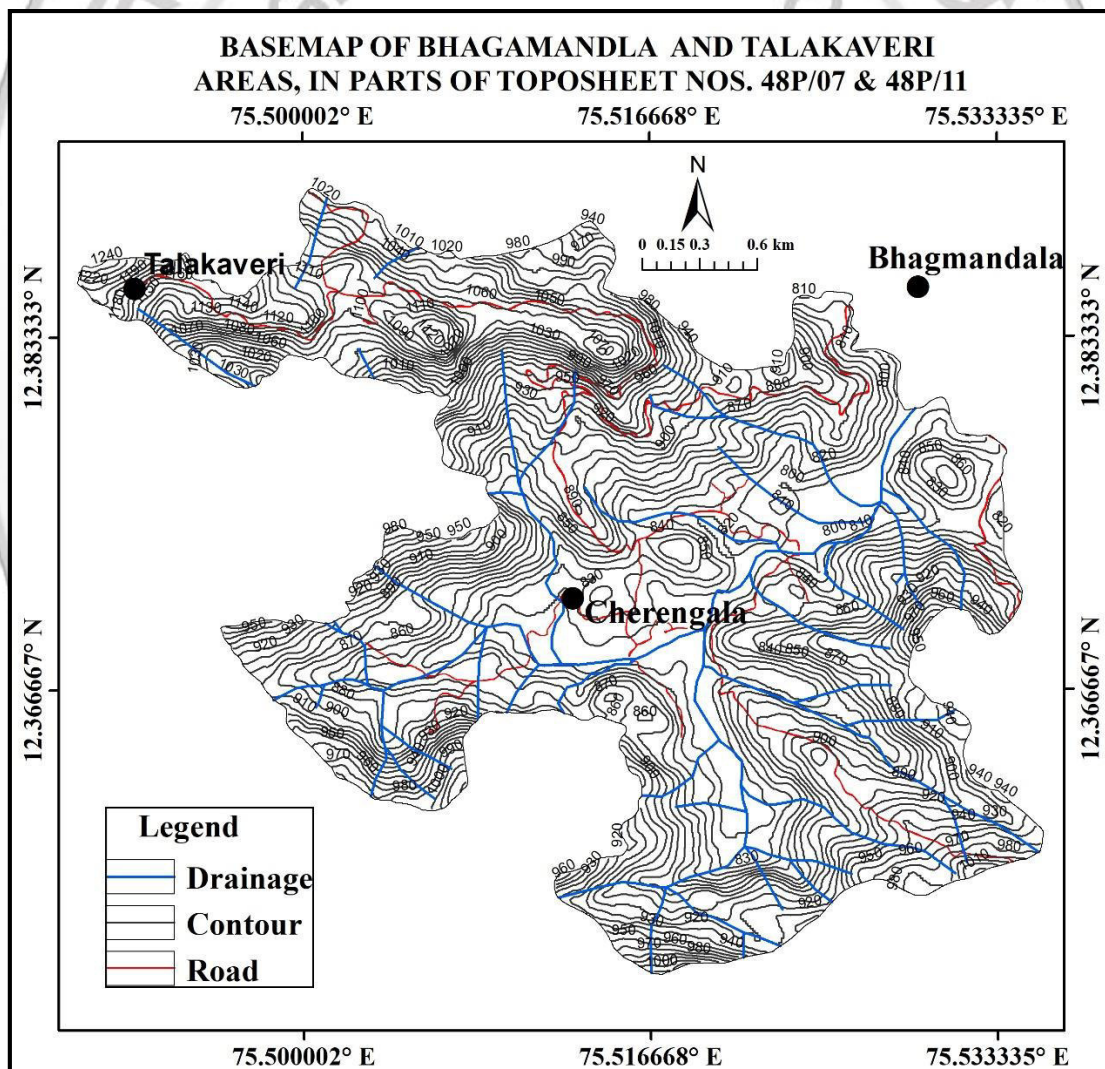


Fig. 3.3: Basemap of the study area

3.3 Contributing factors for slope instability in the study area

Landslides are always a result of interplay of many geofactors which contribute to the instability. It is important in any susceptibility analysis to understand the influence of various

geofactors which are responsible for initiation of landslides. In the study area, rockslides were observed to be occurring due to poor rock mass conditions, unfavourable disposition of discontinuities w.r.t slope face and relief of the slope face where the rock is exposed. Similarly, debris slides were governed by factors like steep slope, type of material, erosion by nala/streams, poor shear strength parameters, land use/land cover changes and relief of the slope.

The contributing factors selected for susceptibility analysis are explained below.

a) Slope inclination

The slope of an area may be defined as the rate of change of elevation. The slope map is prepared using a DEM in an ArcGIS platform. Generally, the greater the slope angle, the higher is the susceptibility for landslides. In the Himalayas however, mostly landslides are observed to occur in slope classes ranging from 35° to 45°.

b) Stream Power Index (SPI)

(SPI) is a measure of the capacity of erosion by a stream. There are many methods for calculation of SPI. In this study, flow accumulation and slope maps were used for the calculation using the equation

$$SPI = (\alpha * \text{cell size}) * \tan(\beta * \pi / 180) \dots\dots\dots (i)$$

Where α = Flow accumulation and β = slope inclination

c) Geomorphon/Landform map

Terrain morphology is an important contributing factor for landslides. Geomorphological features are manually digitised from satellite imagery and field validated in macro scale 1:50,000 landslide susceptibility studies. This method, however, involves greater subjectivity and the interpretations may vary from person to person. To remove this subjectivity, DEM derived landform elements/micro landforms based on the principle of pattern recognition have been used (Jasiewicz J and Stepinski T, 2012). The entire area is classified into 10 geomorphons using GRASS GIS software.

d) Relative Relief (RR)

Relative Relief is the difference between the highest and lowest elevations in a unit area. It represents the steepness of the terrain i.e. the greater the relative relief, the steeper is the slope inclination. The RR map was prepared by classifying the area into equal area grids and calculating the relief values from DEM in ArcGIS platform using zonal statistics tool. The relief values were then interpolated using IDW method.

e) Land use/ Land cover (LULC)

The LULC pattern of an area is an important factor for landslide susceptibility analysis. Human activities like slope modification, agriculture and deforestation can have a significant

impact on the natural stability of a slope. Similarly, thick vegetation cover can also contribute to the stability of a slope due to the binding capacity of roots.

f) Geotechnical properties

The geotechnical condition/ strength of the material is one of the most important factors influencing the initiation of landslides. For the rocky slopes, the Rock Mass Rating (RMR) has been considered whereas for the debris-covered slopes, the cohesion (C) and angle of internal friction (Φ) have been used. The RMR values were incorporated to the whole facet and the C and Φ values were manually assigned to the same debris class which was mapped during the field study.

g) Slope Forming Material (SFM)

The SFM map is one of the most important components in mesoscale landslide susceptibility mapping. The rock and debris-covered areas in the study area were demarcated and further classified based on their physical characteristics during mapping. This demarcation is also important in view of the difference in landslide processes in the rock and debris domains which warrant different sets of thematic maps and ratings for susceptibility analysis.

h) Overburden Thickness

The Overburden thickness map is one of the most important components in mesoscale landslide susceptibility mapping. In debris-covered areas, the depth of the overburden material plays a vital role in slope failures. The overburden thickness classes were observed and classified during field work.

i) Kinematic analysis

For rocky slopes, the major contributing factor for landslide is the disposition of the discontinuities. The failure occurs mostly along discontinuities like joints and bedding planes. Therefore, kinematic analysis of discontinuities (joints and bedding planes) was carried out using Marklands test (Hoek and Bray, 1981) with a view to understand the possible mode of such slope failures (e.g. Planar, wedge etc.)

3.4 Rating system used

There are many methods to assign ratings and weights for the thematic maps like statistical, probabilistic, and machine learning algorithms. The primary requirement for any data-driven statistical analysis is the availability of enough data so that a relationship between landslides and various thematic classes can be reliably ascertained. As the mesoscale landslide susceptibility mapping deals with a significantly smaller area, the ratings are assigned heuristically based on the field observations, landslide inventory data and knowledge of the terrain conditions.

Since the rocky slopes and debris-covered slopes have different factors governing the initiation of landslides, the study area was divided into “Rock”, “Debris” and “Cut slope” domains during mapping. The factors governing landslide processes are very different in the domains and hence the susceptibility modelling for them was carried out separately with a different set of thematic maps and ratings used for each model.

Table 3.1:Thematic variables and maps used in susceptibility modelling

Domain	Thematic variables	Thematic maps
Rock slide	Kinematic analysis	Kinematic failure map
	Rock mass condition	Geotechnical map
	Relief	Relative relief map
	Slope morphometry	Slope map
Debris slide	Slope morphometry	Slope map
	Lithology/material	Slope forming material
	Rill or gully erosion	Stream power index map
	Micro landform	Geomorphon/landform map
	Strength of material	Geotechnical map
	Vegetation cover and land use pattern	LULC map
	Relief	Relative relief map
Cut slope	Relief	Relative relief map
	Slope morphometry	Slope map
	Thickness of overburden	Overburden thickness map
	Rock mass condition	Geotechnical map

The thematic maps were prepared with intensive fieldwork on a 1:10,000 scale to incorporate every scalable variation of the parameters considered. The individual factors of thematic maps were assigned Landslide Susceptibility Evaluation Ratings (LSER) depending on their influence in landslide initiation. The thematic maps were assigned Landslide Hazard Evaluation Factor ratings (LHEF) depending on their relative importance in susceptibility analysis. The rated maps were integrated in ArcGIS to obtain the susceptibility score map which was classified to produce the landslide susceptibility map.

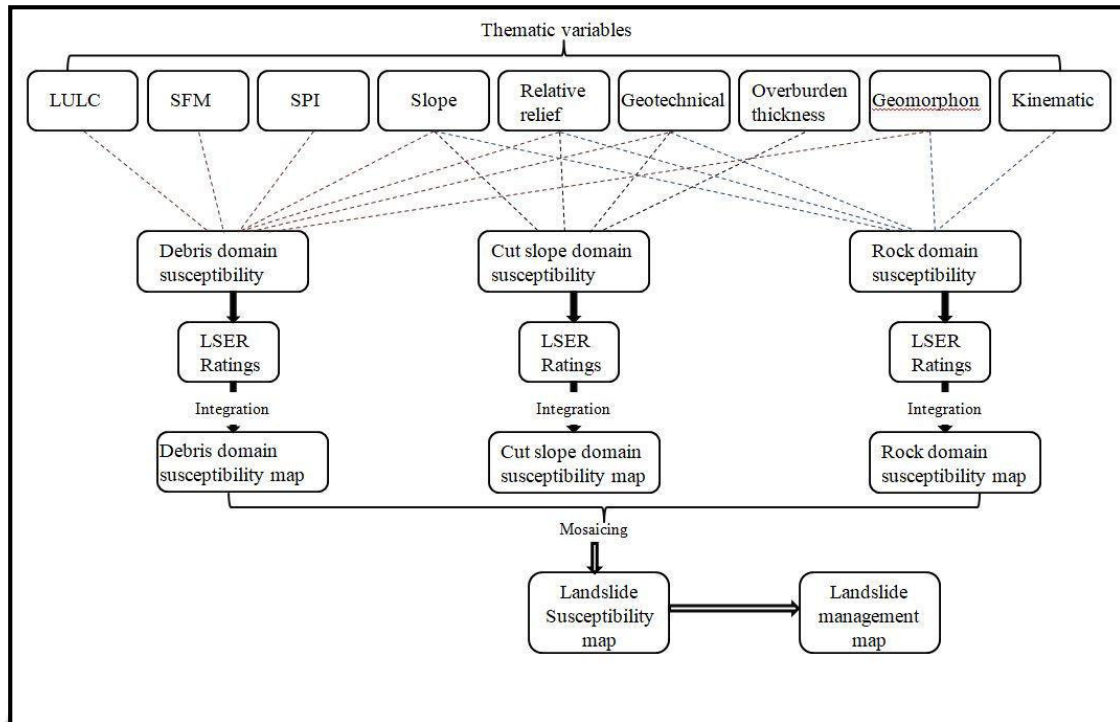
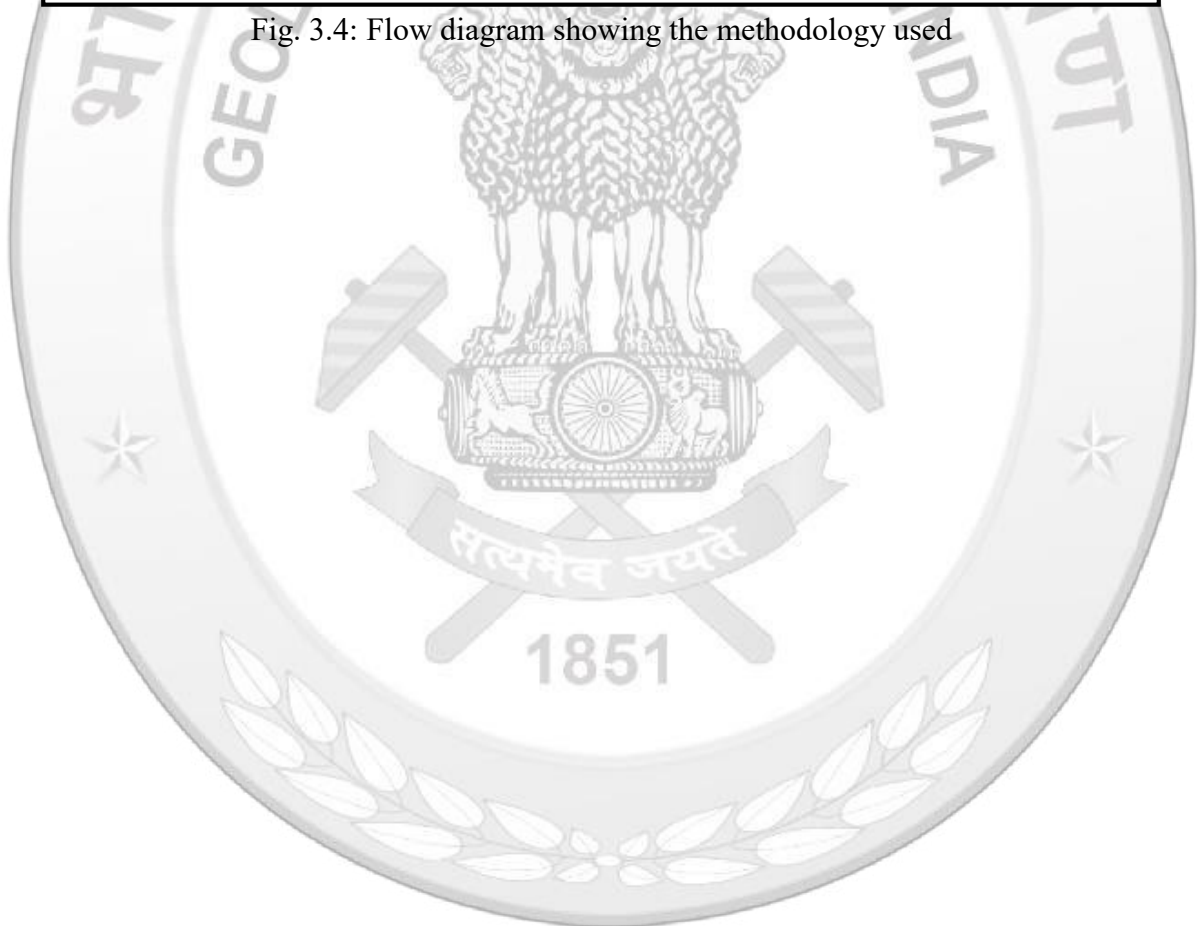


Fig. 3.4: Flow diagram showing the methodology used



CHAPTER 4. LANDSLIDE/SLOPE INSTABILITY SCENARIO

4.1 General landslide scenario

The landslide inventory map (Fig. 4.5) of the study area was prepared using available multi temporal satellite imageries of Google Earth, previous GSI reports and data collected during field work. A total of 45 landslides/slope instabilities have been identified in the study area which includes 22 debris slides and 23 rock slides. The landslides were field validated and the 42 point geoparametric data was collected for each slide. (Annexure- V).

Majority of the landslides in the study area are along the cut slopes of road and in the back slopes of few settlements (Fig. 4.4) where the slope has been modified and have their causative factors linked to anthropogenic activities. These landslides are observed to be smaller in dimensions; however, they may reactivate during incessant rainfalls. The most prominent landslide is the Talakaveri slide (Fig. 4.1) which is a debris slide that occurred in the year 2020. The slide is ~55m in length and has a run out distance of >1000m. There were 5 human casualties due to the Talakaveri landslide.

Altering the natural slopes for plantation without provisions for surface water runoff leads to the oversaturation of debris material and results in slope instabilities in the area. Providing such slopes with proper drainage will reduce water infiltration to the debris materials. Unplanned excavation of hill slopes in few localities without proper retaining structures is another cause of slope failures in the area. Majority of the landslides in the area are active in nature, however a few suspended (Fig. 4.3) and inactive landslides were also recorded during the course of field work.

The landslide incidence map provides necessary information about geofactors to be considered for analysis. Different types of landslides occur in different domains where the governing factors of instabilities are unique to that domain. Therefore, in this study, the area has been divided into “rock”, “debris” and “cut slope” domains. The susceptibility analysis for each domain has been carried out by clubbing the geofactors responsible for slope instabilities in that particular domain.

The Western Ghat ranges receive heavy rainfall and have thick soil cover due to extensive weathering of the rock units. Hence landslides in slopes with thick debris cover can destabilise huge volumes of material and have run outs that reach up to hundreds of meters in length (Fig. 4.2). Two such landslides are observed in the study area where the run out material has travelled to approximately 1km downstream. The slope forming material in such landslide zones was debris and highly weathered rock and had anthropogenic slope modification in the

slide area. This shows the need to control such slope modifications which are being taken up without site specific studies and without any support structures post the slope modification.



Fig. 4.1: A distant view of Talakaveri landslide



Fig. 4.2: Run out path of a landslide near Talakaveri



Fig. 4.3: A suspended landslide on Bhagamandla Talakaveri road



Fig. 4.4: Landslide initiated on a cut slope near a house in Cherengala

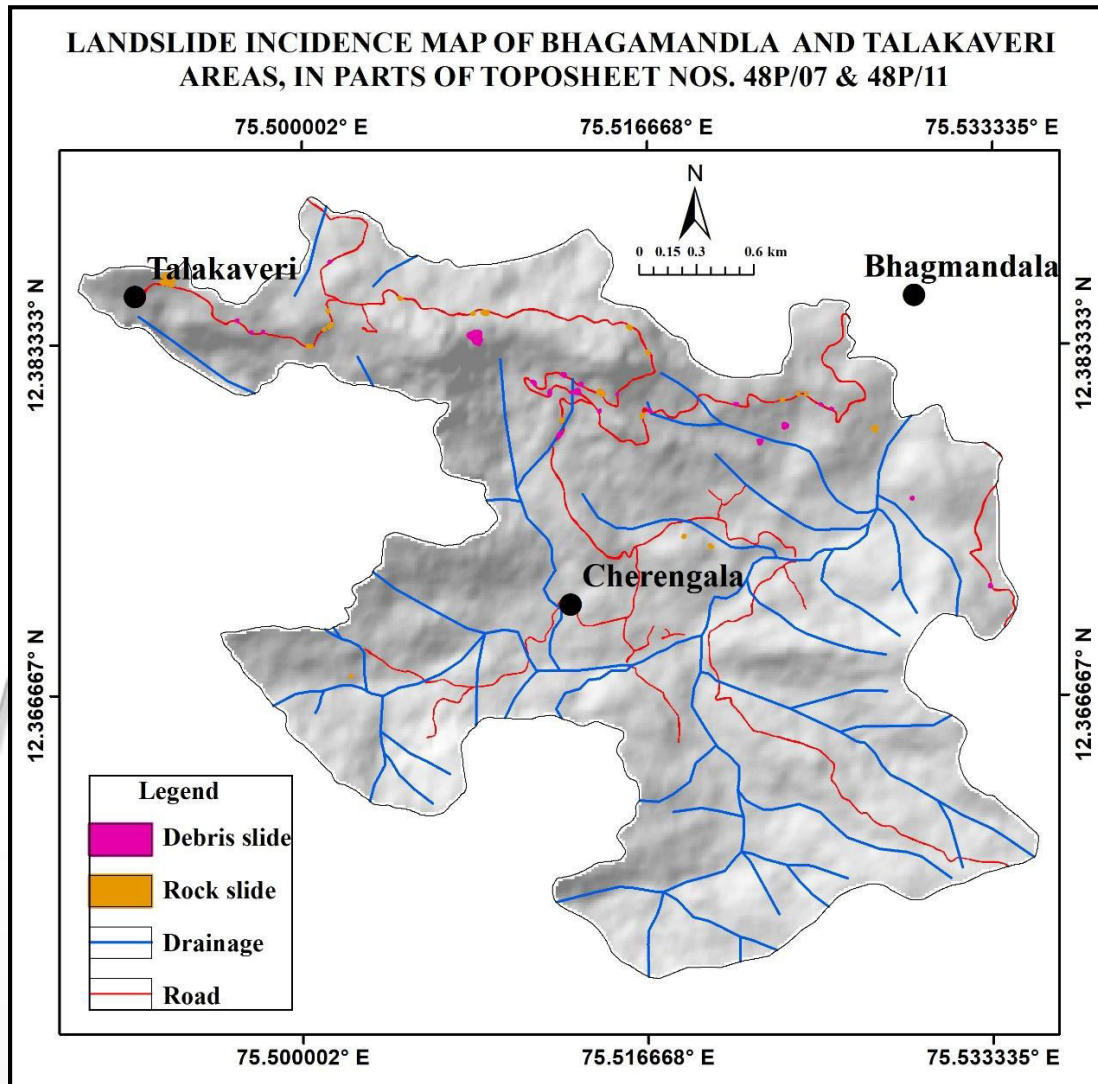


Fig. 4.5: Landslide incidence map of the study area in toposheet nos. 48P/07 & 48P/11

4.2 Talakaveri landslide

The Talakaveri landslide is one of the most prominent landslides in the study area. The landslide is located at a distance of 250m from the Talakaveri temple. The landslide area has slope cuts which are made for road as well as parking zones. The catastrophic landslide was reactivated on the 6th of August, 2020, and claimed 5 lives. The landslide is 55m long and 65m wide with a run-out zone of over 1km.

The landslide was preceded by incessant rains which was much more than the average monsoon rainfall. Fig. 4.6 depicts the rainfall at Talakaveri from 01/08/2020 to 10/08/2020. The area received antecedent rainfall of 172 mm and 185 mm followed by 478 mm rainfall on the date of initiation of the landslide. The extreme rainfall acted as the trigger for the main landslide event in the already destabilized zone.

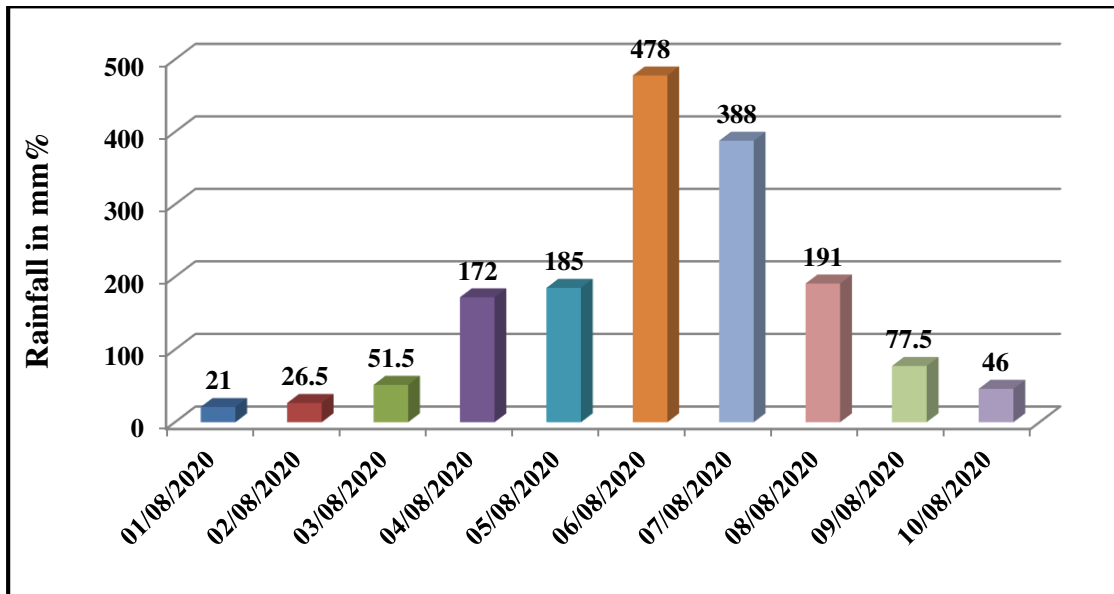


Fig. 4.6: Rainfall at Talakaveri

Previous reports on the landslide:

The Talakaveri landslide was first reported by GSI in 2017 when cracks were identified in the crown area. It was subsequently reported when it reactivated on 09/08/2019 blocking the approach road to the temple (Fig. 4.7). Another minor cut slope failure was reported adjacent to the Talakaveri slide, indicating that the area is prone to slope failures. The Talakaveri landslide which initiated as a cut slope failure retrogressed over the years before reactivating on 06/08/2020 after intense rainfall (Fig.2).



Fig. 4.7: A view of the landslide in 2019
(Source: 2019 GSI post-disaster report)



Fig. 4.8: A view of the landslide in 2020
(Source: 2020 GSI post-disaster report)

The area is occupied by Enderbite which is moderately weathered. The cut slope also exposes a band of sheared rock which is highly deformed and friable. The UCS values of the rocks in the slide area give an average value of 28MPa whereas the UCS value from the shear zone is 16MPa. Previous photographs of the slide zone reveal a considerable amount of debris material in the slope. The antecedent rainfall during 04/08/2020 to 06/08/2020 might have oversaturated the debris material and the rainfall event of 478 mm on 06/08/2020 acted as a trigger. The landslide would have washed out the debris material in the down slope leading to the massive debris flow. Traverses in and around the landslide revealed that there are no tension cracks above the landslide. This means the chances of any large scale retrogression is low. However, the flanks of the landslide still have debris as well as loose rocks exposed. Fig. 4.9.



Fig. 4.9: Latest photograph of Talakaveri landslide

Some remedial measures for Talakaveri landslides are described as follows:

1. The natural drainage channels in the hill slope are discharging the runoff water directly to the approach road to Talakaveri temple. The water may be channelized using lined toe drains and drained away from the area.
2. There are many benches and ditches above the crown of the landslide which are made for afforestation. Rainwater should not be allowed to collect in these areas. Hence, the ditches may be filled with soil and the benches may be given a gradient so that the water is drained off the surface.
3. The loose rocks in the flanks of the slide may be mechanically removed and the exposed rocky area may be provided with shotcrete treatment.
4. The left and right flanks of the landslide have debris material in the slope. These areas are to be protected with RCC breast wall to prevent further retrogradation of the landslide. While designing the walls, adequate weep holes should be given in the wall for draining out the excess water.
5. There should not be any further slope in the zone without providing support measures.
6. The police outpost near the Talakaveri temple is also constructed after a steep slope cut without any support measures. A breast wall may be provided in this location for the stability of the slope
7. The design parameters of the walls should be finalized after detailed site-specific studies.

CHAPTER 5. GEOFACTOR MAPS AND RATINGS

5.1. Preparation of thematic maps

For susceptibility mapping, the selection of preparatory factors for landslides depend on the scale of analysis, the characteristics of the study area, the landslide type, the failure mechanisms and the prior knowledge of the main causes of landslides (Guzzetti *et al.*, 1999; Glade and Crozier, 2005). Prior knowledge of the main causes of landslides in the area of interest is essential in selecting the most relevant factors out of the many known preparatory factors that can “theoretically” cause landslides (Ghosh and Carranza, 2010).

Slope stability, irrespective of the scale at which it is viewed and analysed is known to be influenced by causative factors such as slope morphometry, nature of slope-forming material, the thickness of overburden, degree of weathering of the rockmass, relationships between the slope inclination and attitude of discontinuities in the rockmass, land cover, land use, hydrological conditions, vicinity of the slope to the faults/ thrusts/ fracture zones, etc. Also, rainfall and seismic events play an important role in triggering the failures (Ghosal .T.B. *et al.*, 2013).

The different thematic geofactor maps used for the landslide susceptibility analysis are as follows:

- i. Slope
- ii. Relative relief
- iii. Geomorphon
- iv. Stream power index (SPI)
- v. Land Use/ Land Cover (LULC)
- vi. Slope Forming Material (SFM)
- vii. Overburden thickness
- viii. Kinematic Failure
- ix. Geotechnical (GT)

Out of the nine maps, four maps i.e. slope; relative relief, geomorphon and SPI have been prepared using 12.5mX12.5m ALOS DEM resampled to 10mx10m. LULC, SFM and Overburden thickness maps were prepared during pre-field exercise and were extensively modified during fieldwork. GT and kinematic failure maps were prepared during post fieldwork.

Apart from the above mentioned maps, a landslide incidence map was also prepared to study the instability scenario of the area.

5.2 DEM derivative maps

12.5mx12.5m ALOS DEM resampled to 10mx10m was used for all the DEM derivative maps since it gave a better representation of the study area as compared to those derived from 10mx10m CARTOSAT DEM. The description of the DEM derived map is as listed below:

5.2.1 Slope map

Slope inclination has a significant contribution to the occurrence of a landslide. The slope map (Fig.5.1 and Plate-I) of the study area classifies the study area into 5 different slope classes ranging from 0° - 48° . The classes have been divided with an interval of 10° . As per Fig. 5.2, 80% of the area is occupied by slope angles varying from 0° - 20° and only 0.1% of the area has slope angles $>40^{\circ}$. 48% of the total landslide area falls in slope class 10° - 20° followed by 31% in slope class 20° - 30° , 18% in 0° - 10° slopes and 3% in 30° - 40° slopes (Fig. 5.2).

The steeper slopes are mostly observed in the northern part of the study area in and around Talakaveri whereas the gentler slopes are mostly observed in the central and southern part near Cherengala.

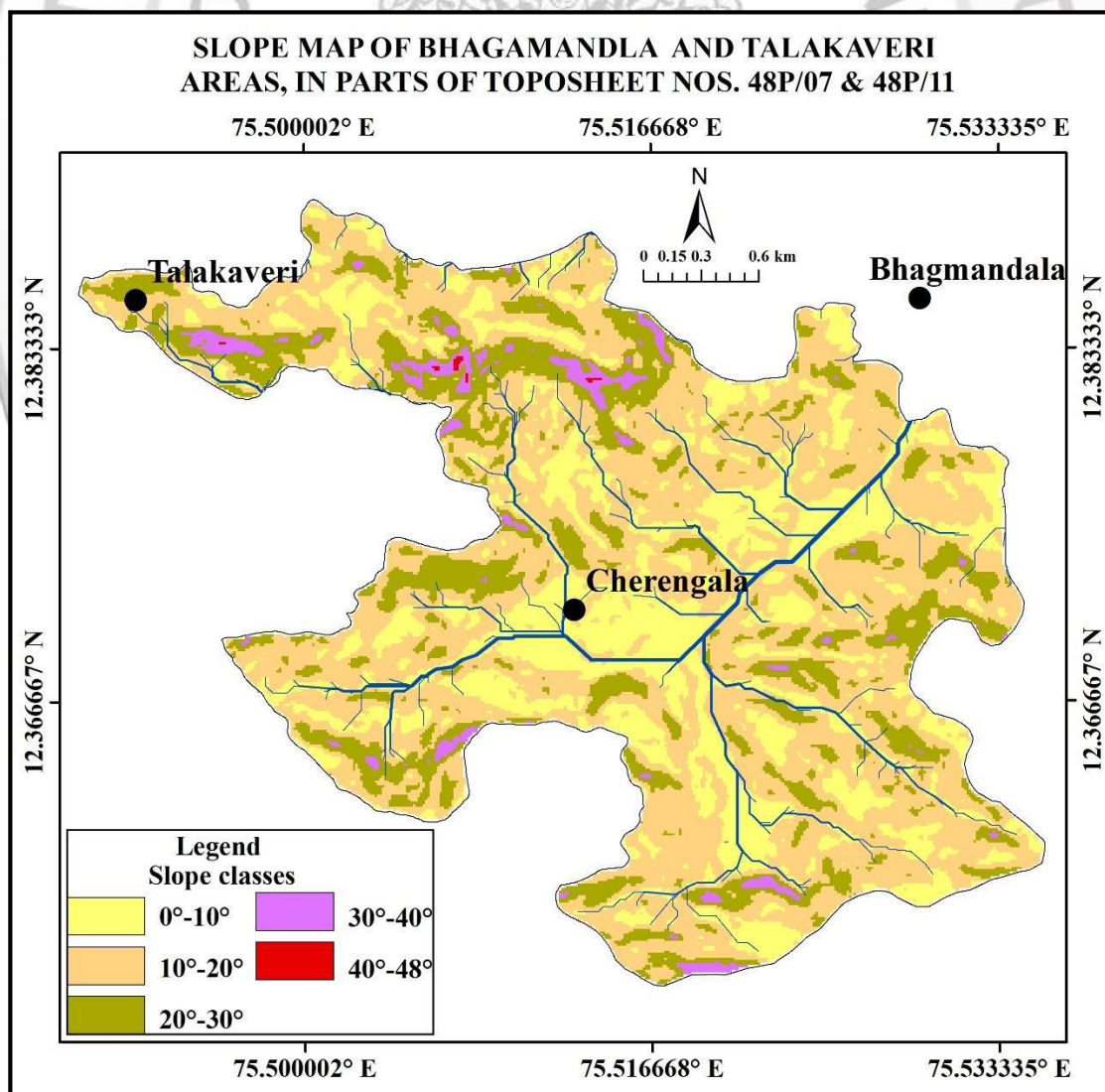


Fig. 5.1: Slope map of the study area

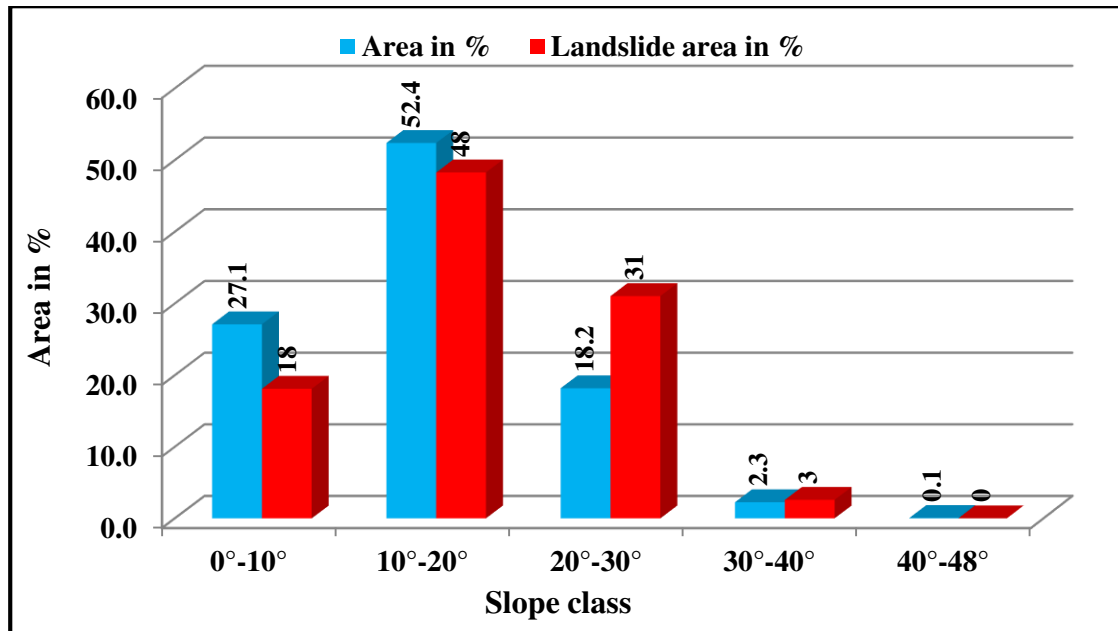


Fig. 5.2: Bar diagram showing the distribution of slope classes and landslide in the study area

The Landslide Susceptibility Evaluation rating (LSER) for different slope classes for overburden and rock covered areas are described in Table 5.1 and 5.2.

Table 5.1:LSER for Slope Classes for overburden covered areas

Sl. No.	Slope Classes	LSER
1	0°-10°	0.1
2	11°-20°	0.5
3	21°-30°	0.6
4	31°-40°	0.6

Table 5.2: LSER for Slope Classes for rock covered areas

1	0°-10°	0.3
2	11°-20°	0.4
3	21°-30°	0.4
4	31°-40°	0.4
5	40°-48°	0.4

5.2.2 Relative relief map

The Relative relief (RR) may be defined as the difference between the maximum and minimum elevation within a unit area. The RR is a significant parameter in a hilly terrain since it is associated with the geomorphological process and landform, which further can be linked with the landslide occurrences. The RR map was prepared using DEM in ArcGIS platform by dividing the area into equal area grids. The relative relief values of each grid were calculated using zonal statistics tool and the derived values were interpolated using IDW method.

In the study area, extremely low relief, moderately low relief and low relief classes covers 99.4% of the area which makes it a low relief terrain. A mere 0.6% of the area has moderate relief (Fig.5.4). 71% of the total landslide area falls in the low relief class and 26% of the landslide area falls in the moderately low relief class (Fig. 5.4). Extremely low relief areas are mostly confined to the central part of the area where the slopes are very gentle (Fig.5.3). Moderate relief areas are observed in the northern part of the study area near Talakaveri (Fig.5.3).

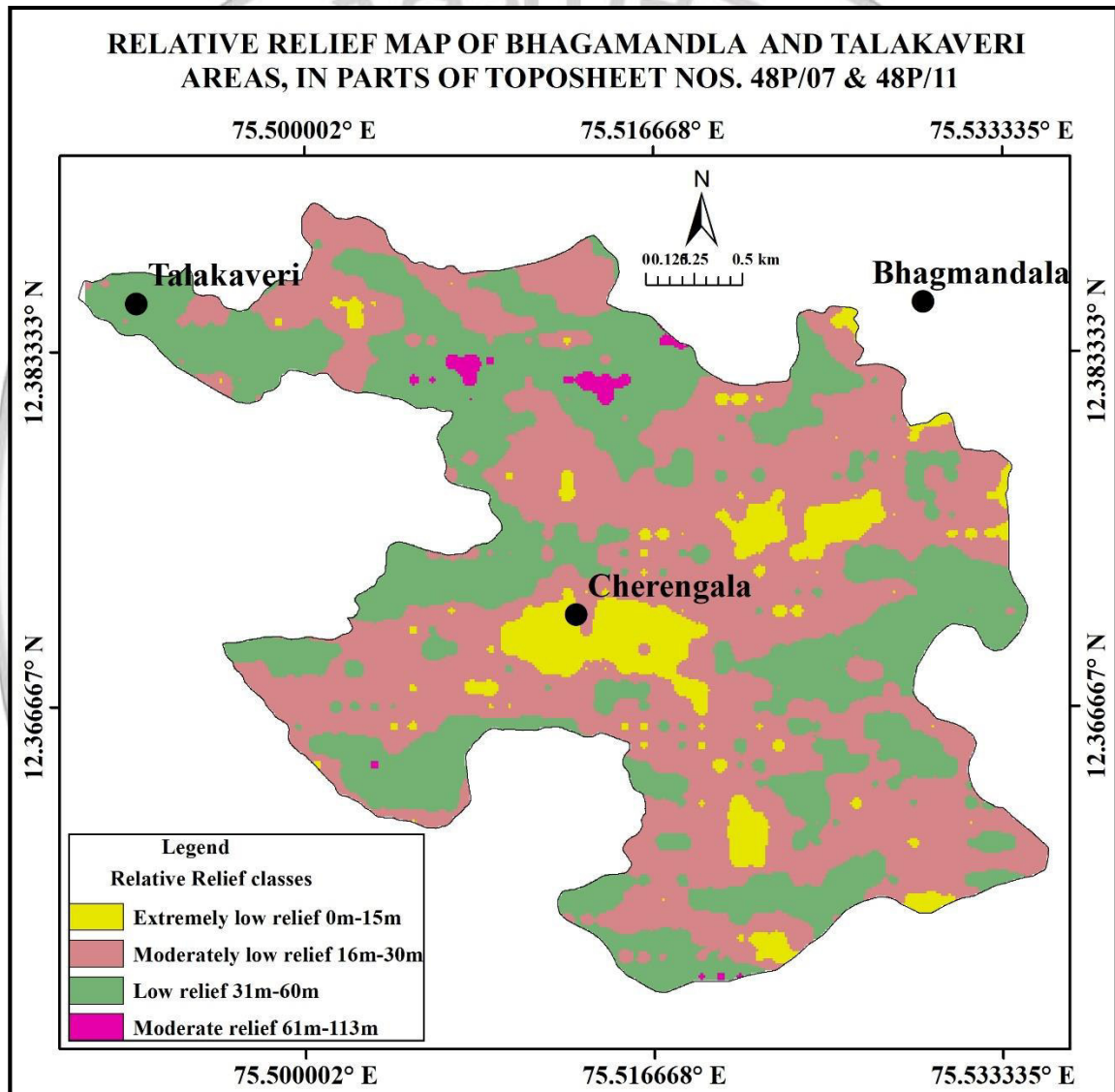


Fig. 5.3: Relative relief map of the study area

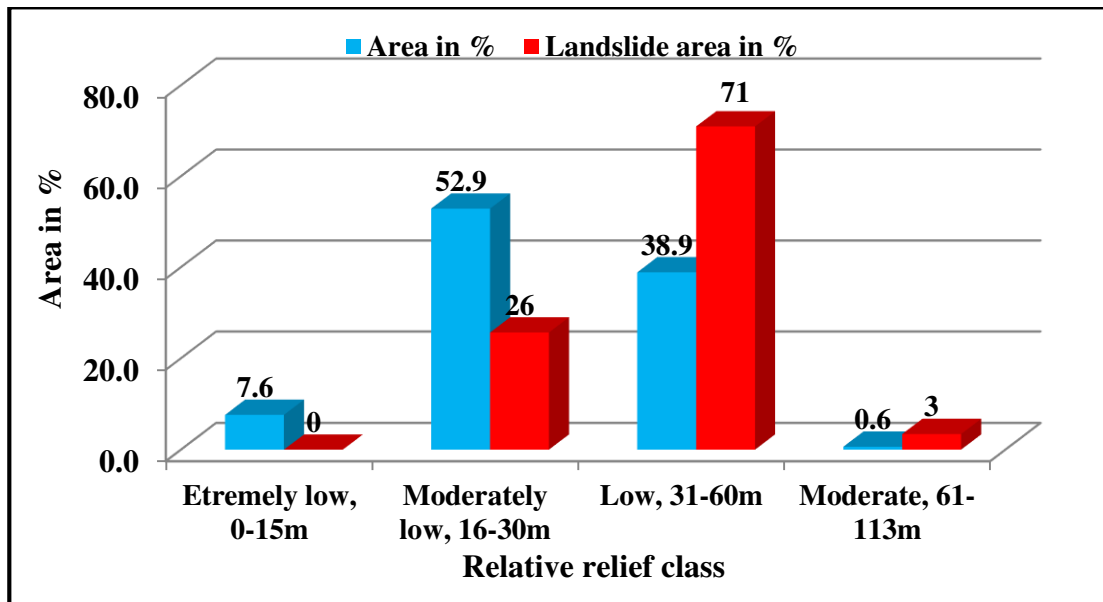


Fig. 5.4: Bar diagram showing the distribution of relative relief classes and landslide in the study area

The Landslide Susceptibility Evaluation rating (LSER) for different relative relief classes for rock and overburden covered areas and cut slope areas are described in Table 5.3., 5.4 and 5.5.

Table 5.3: LSER for Relative Relief Classes for overburden covered area

Sl. No.	RR Classes	LSER
1	0m-15m	0
2	16m-30m	0.6
3	31m-60m	0.4
4	61m-113m	0.4

Table 5.4: LSER for Relative Relief Classes for rock covered area

Sl. No.	RR Classes	LSER
1	0m-15m	0
2	16m-30m	0.2
3	31m-60m	0.8
4	61m-113m	0.2

Table 5.5: LSER for Relative Relief Classes for cut slope

Sl. No.	RR Classes	LSER
1	0m-15m	0
2	16m-30m	0.6
3	31m-60m	0.4
4	61m-113m	1

5.2.3 Geomorphon/Landform map

Geomorphon/Landform is a concept of presentation and analysis of terrain forms. Geomorphon map of an area is based on the quantitative terrain analysis using a DEM. The geomorphon map was prepared using GRASS GIS platform. It classifies the study area into 8 different classes viz. Summit, ridge, spur, slope, depression, valley, footslope and hollow

(Fig.5.5). Nearly 49% of the area is covered by the class “slope” followed by 19.67% by “spur” and 16.35% by the class “hollow” and 14.7% of the area is covered by the rest of the geomorphon classes (Fig.5.6). Slope class has 56% of the total landslide area, followed by 28% in spur and 13% in hollow (Fig. 5.6).

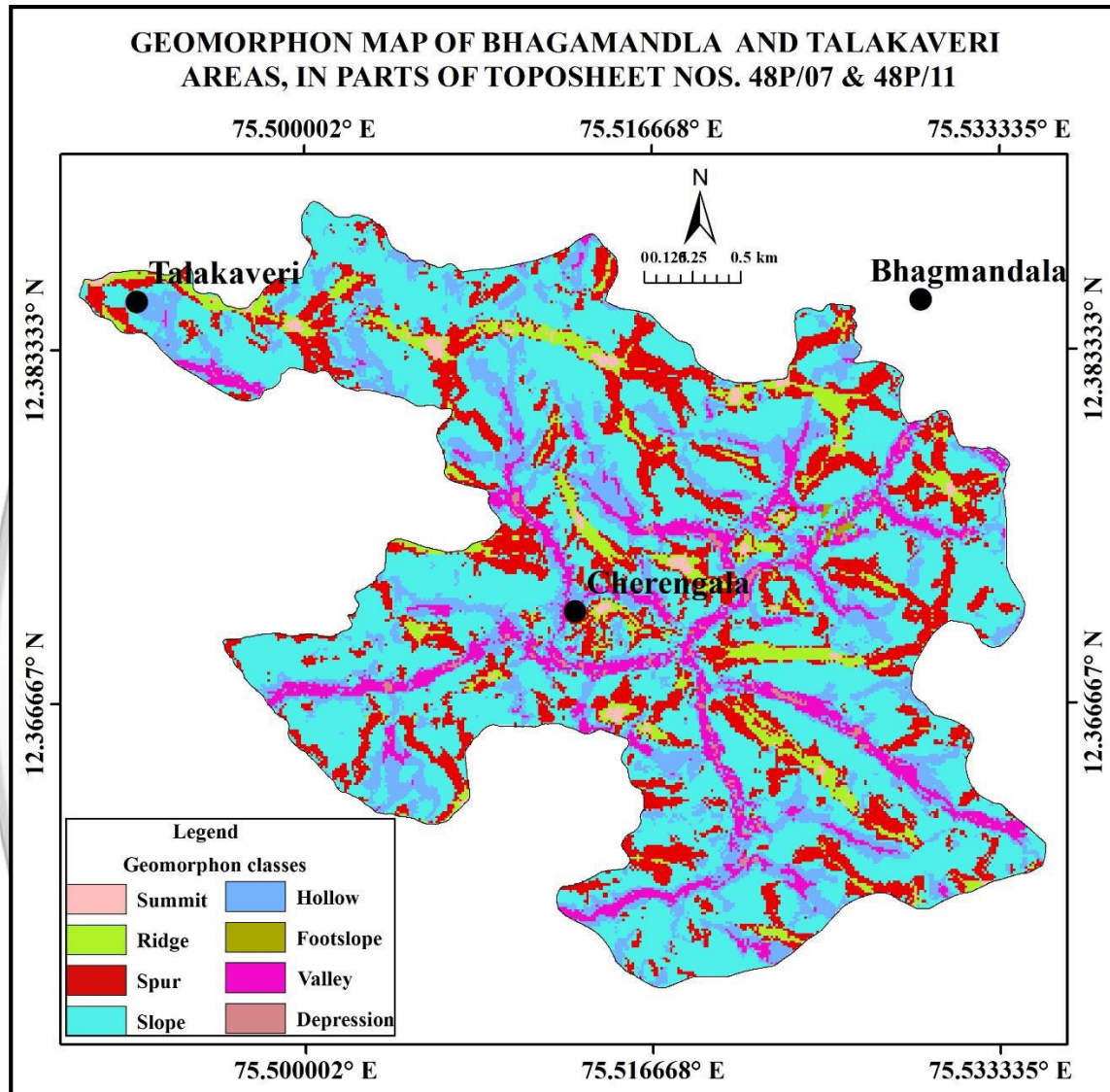


Fig. 5.5: Geomorphon map of the study area

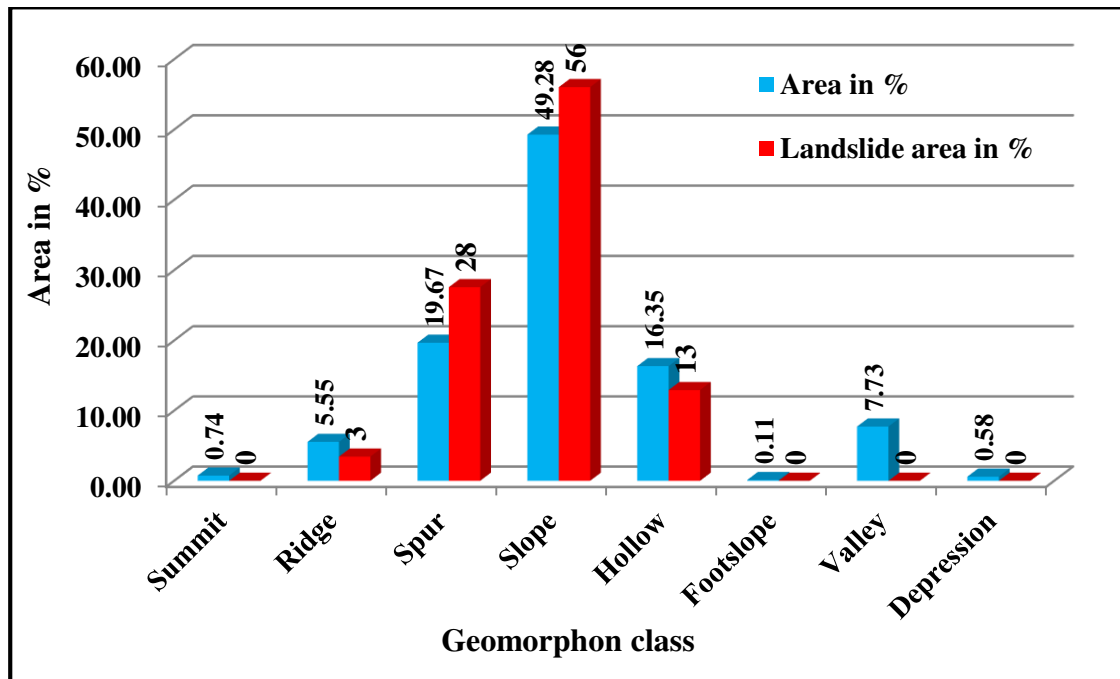


Fig. 5.6: Bar diagram showing the distribution of geomorphon classes and landslide in the study area

The Landslide Susceptibility Evaluation rating (LSER) for various geomorphon classes for overburden covered areas are described in Table 5.6.

Table 5.6: LSER for Geomorphon Classes for overburden covered area

Sl. No.	Geomorphon Classes	LSER
1	Summit	0
2	Ridge	0
3	Spur	0.5
4	Slope	0.2
5	Hollow	0.6
6	Footslope	0
7	Valley	0
8	Depression	0

5.2.4 Stream power index (SPI) map

The SPI map is prepared using DEM which considers the flow accumulation and slope angle at a given pixel and determines the erosive power of flowing water (Eq. i). 93.7% of the area has low values of stream power and only 6.3% area has moderate to high values (Fig.5.8). The higher SPI values are mostly confined to the higher order drainages (Fig.5.7). Lower SPI classes has maximum landslide area % in the study area (Fig. 5.8).

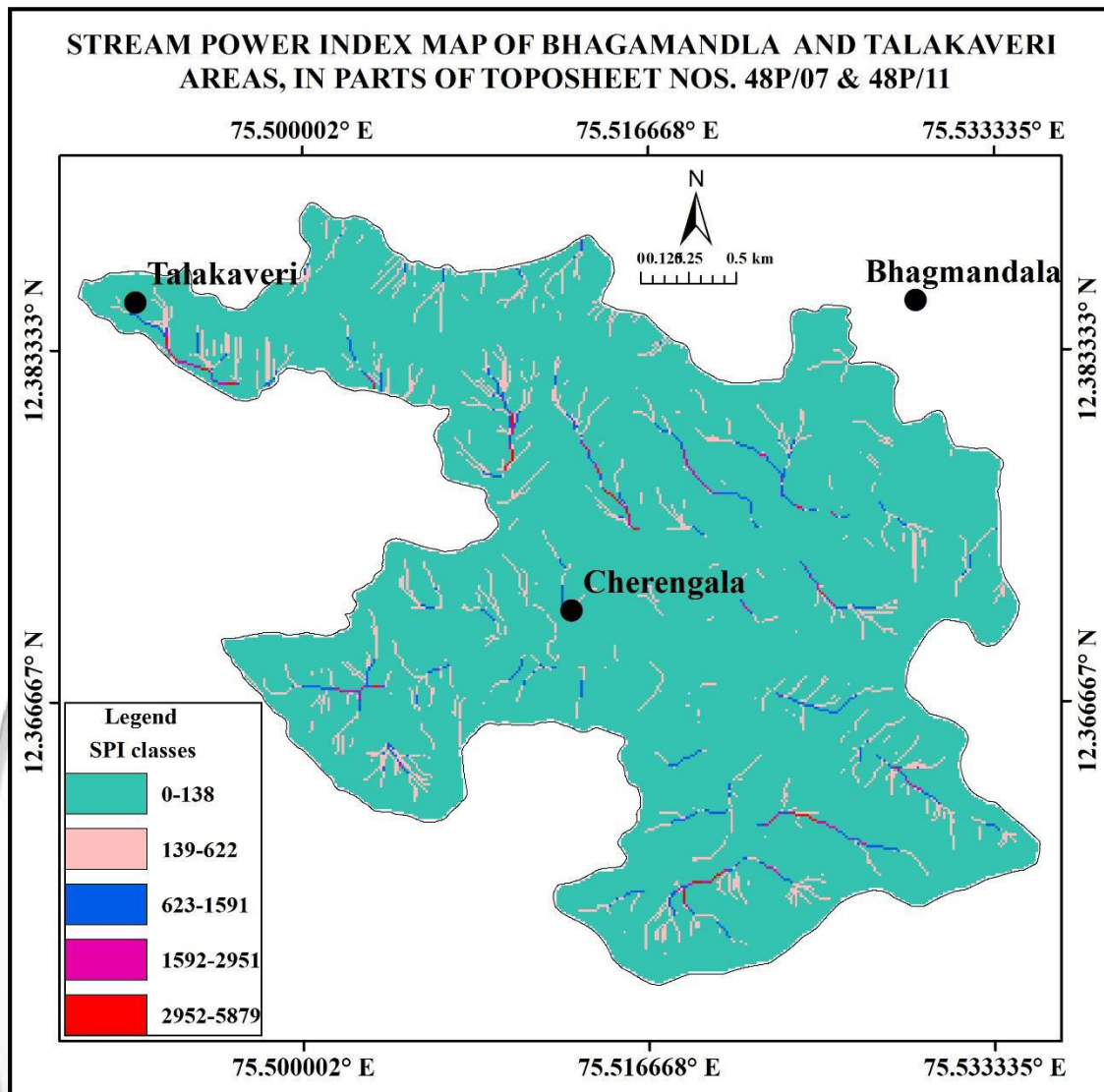


Fig. 5.7: Stream power index map of the study area

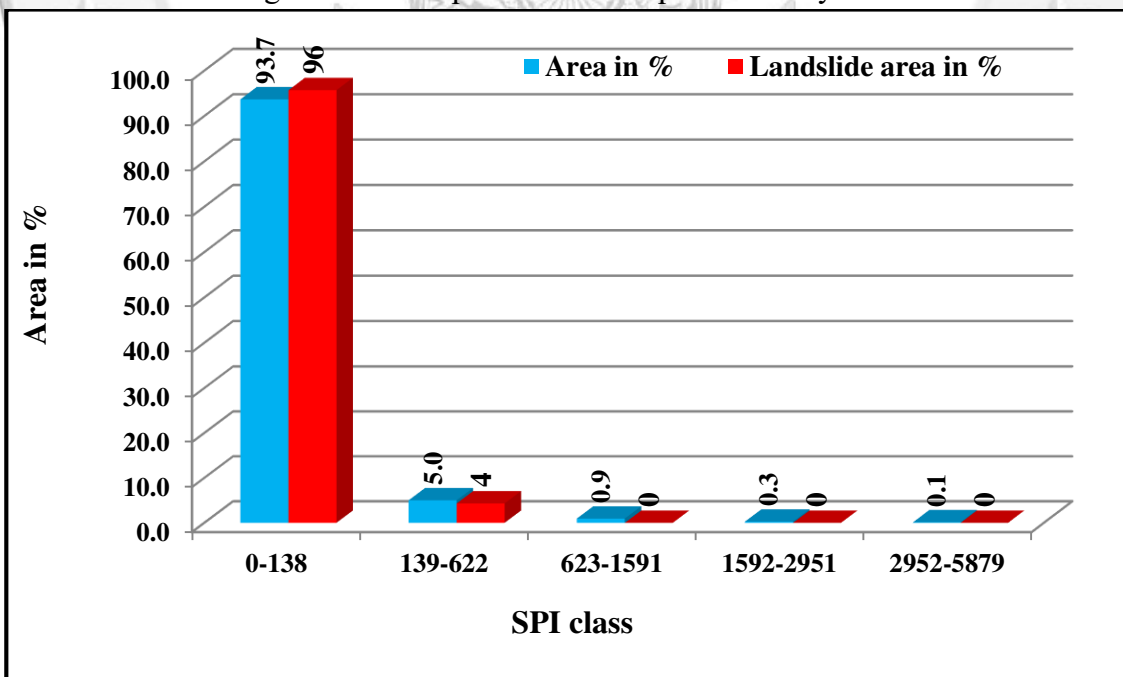


Fig. 5.8: Bar diagram showing the distribution of SPI classes and landslide in the study area

The Landslide Susceptibility Evaluation rating (LSER) for different SPI classes for overburden covered areas are described in Table 5.7.

Table 5.7: LSER for SPI Classes for overburden covered area

Sl. No.	SPI Classes	LSER
1	0-786	0.2
2	787-3144	0.4
3	3145-8123	0.6
4	8124-17556	0.8
5	17557-66817	1

5.3 Field based maps

Among the five field based maps, LULC, SFM and Overburden thickness maps were prepared before field studies and were extensively modified during fieldwork whereas kinematic failure and geotechnical maps were prepared post fieldwork by using the data collected from the field.

5.3.1 Land Use / Land Cover (LULC) map

Land cover is the observed (bio) physical cover on the earth's surface (Gregorio and Jansen 1998). Land use is commonly defined as a series of operations on land, carried out by humans, with the intention to obtain products and/or benefits through using land resources (Coffey, 2013). The different land use classes observed in the study area are cut slope, agriculture, coffee plantation, cardamom plantation, plantation with vegetation, settlement, and road whereas the different land cover classes are sparse vegetation, moderate vegetation, dense vegetation, water body, river, grassland and barren land (Fig 5.13). Nearly 70% of the study area comes under land cover classes and 30% area has been utilized for different land use (Fig.5.14). 50% of the total landslide area falls in the barren land followed by 32% in the cut slopes and 9% in the dense vegetation (Fig. 5.14).

Nearly 55% area is covered by dense vegetation followed by 10% as moderate vegetation and 10% as coffee plantation. The vegetation type in the area is mostly mixed vegetation. The agricultural activities cover 9.5% of the area and are predominantly observed in the central part of the area with comparatively gentler slopes. The dominant plantation type is coffee and cardamom and black pepper plantation is observed at places. Settlements are observed to be scattered throughout the study area. Field photographs of various LULC features have been shown in Fig. 5.9, 5.10, 5.11 and 5.12.

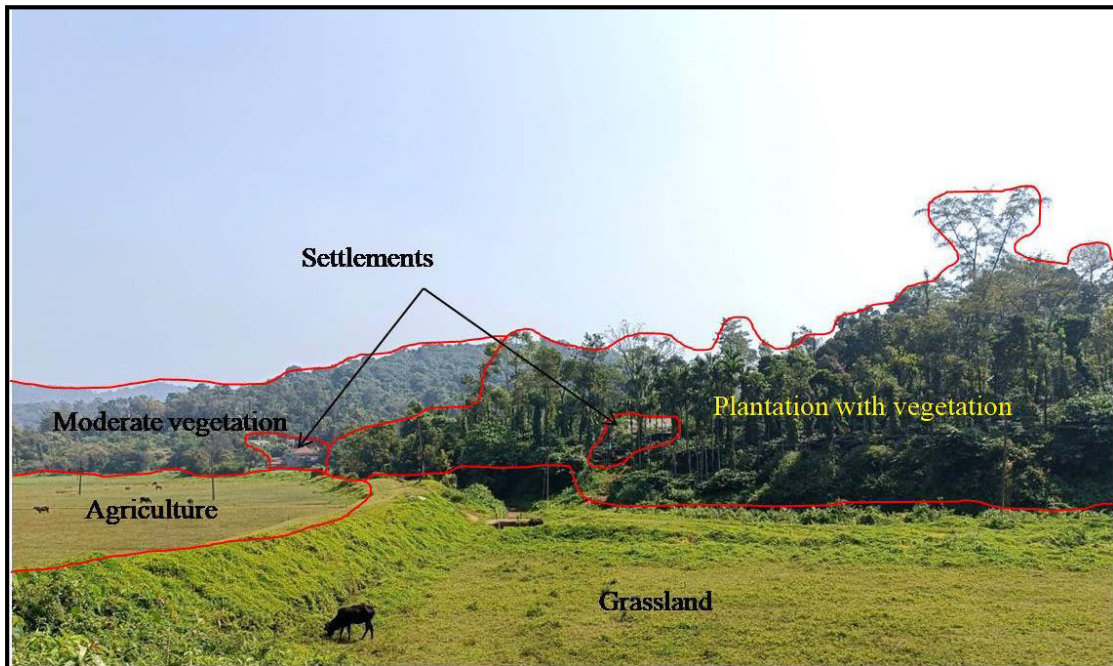


Fig. 5.9: Various LULC classes observed near Bhagamandla

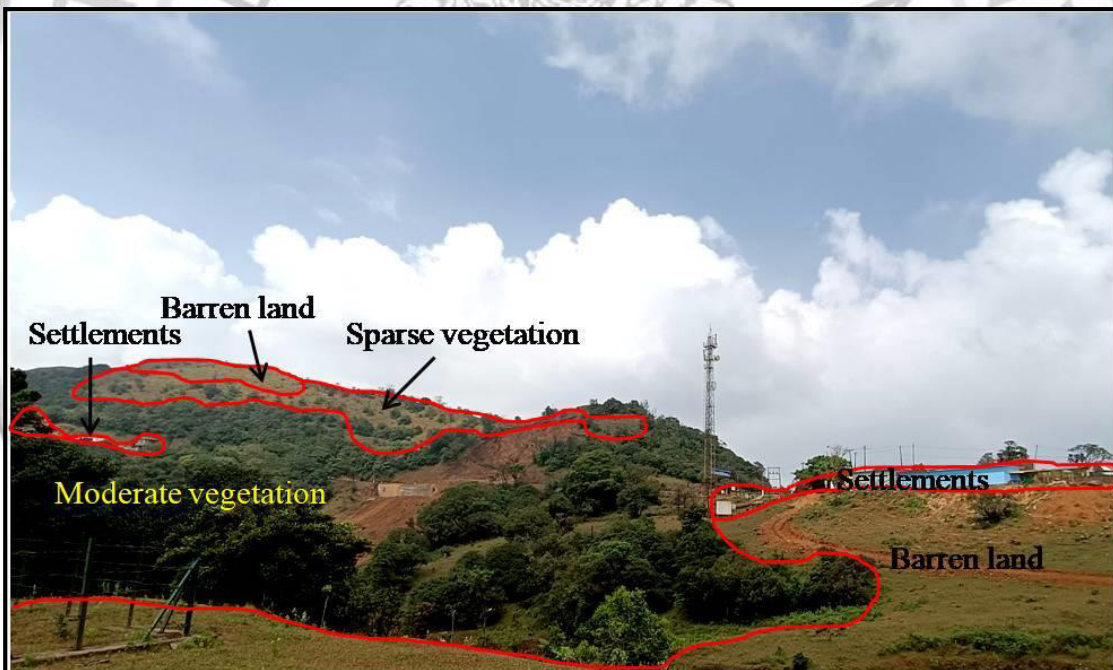


Fig. 5.10: Various LULC classes observed near Talakaveri



Fig. 5.11: Coffee and black pepper plantation mixed with vegetation near Cherengala



Fig. 5.12: A cut slope along Bhagamandla Talakaveri road near Cherengala

The Landslide Susceptibility Evaluation rating (LSER) for different LULC classes for overburden covered areas are described in Table 5.8.

Table 5.8: LSER for LULC Classes for overburden covered area

Sl. No.	LULC Classes	LSER
1	Agriculture	0
2	Barren Land	0.2
3	Plantation with vegetation	0.3
4	Water Body	0
5	River	0
6	Moderate Vegetation	0.2
7	Plantation	0.4
8	Grassland	0
9	Cardamom	0.2
10	Dense Vegetation	0.4
11	Sparse Vegetation	0.6
12	Road	0
13	Settlement	0.2

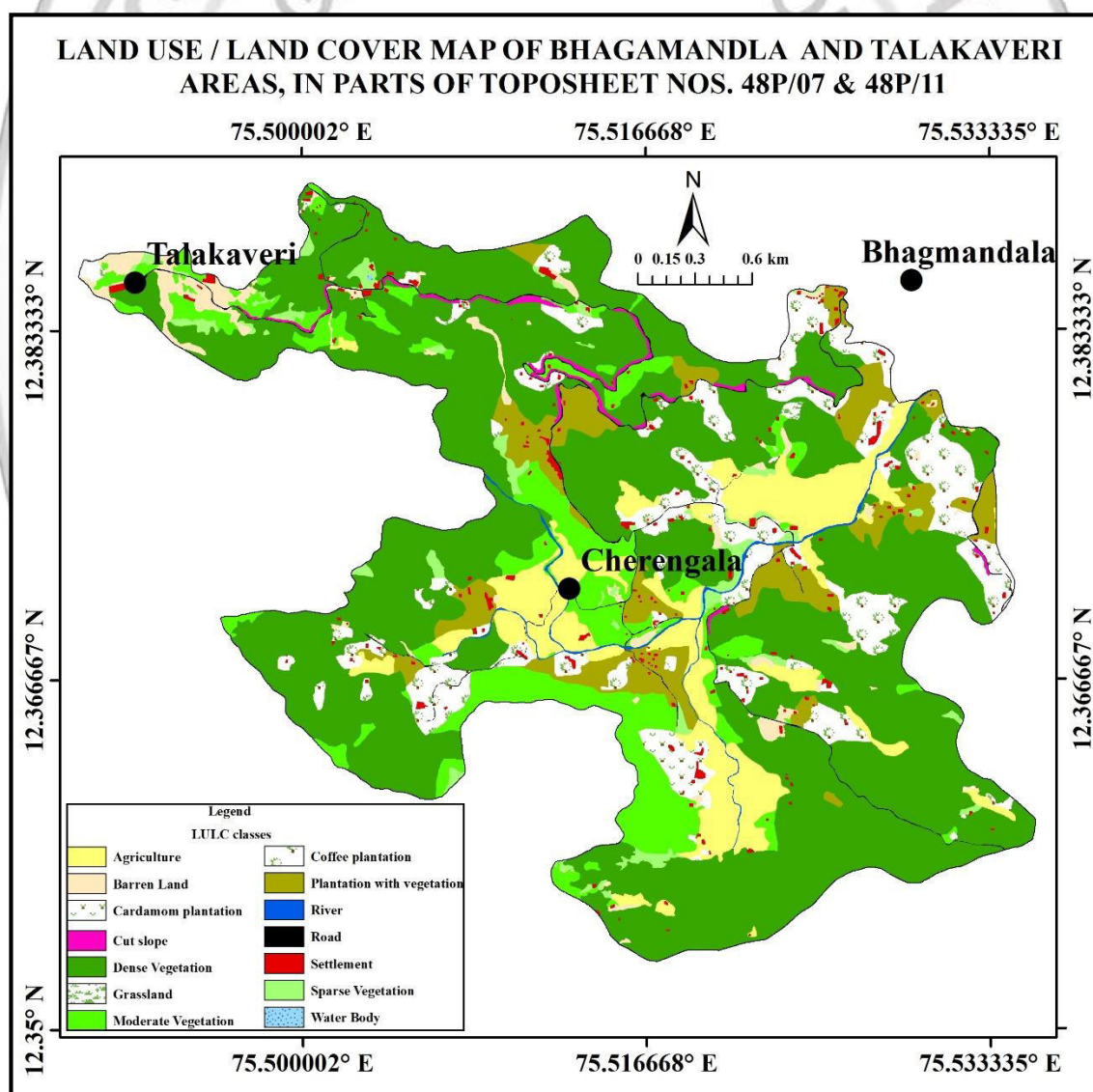


Fig. 5.13: Land use / Land cover map of the study area

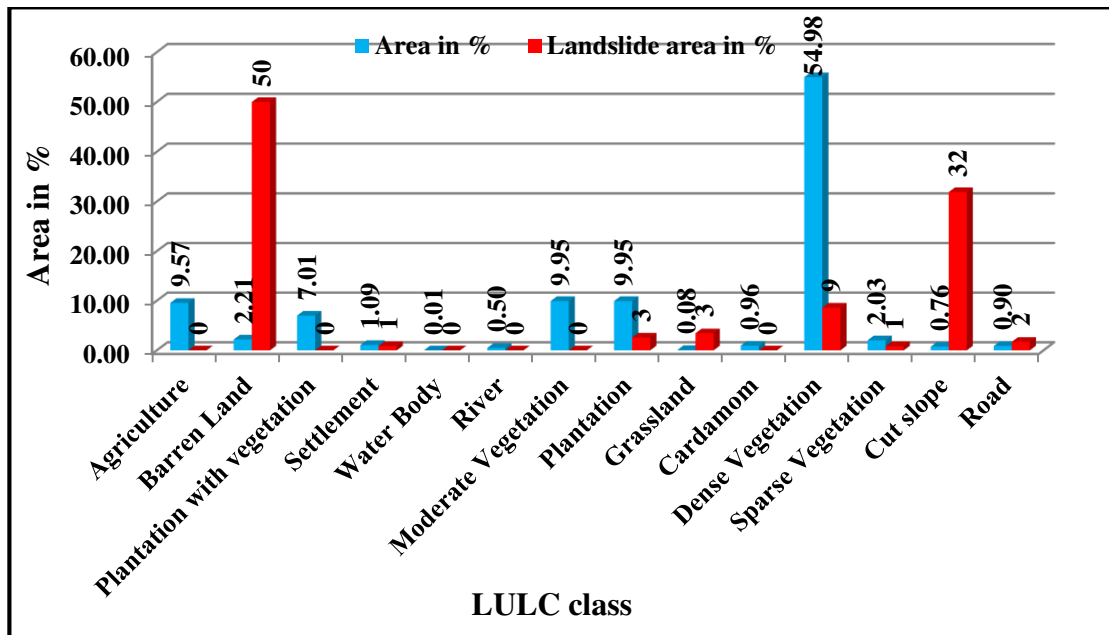


Fig. 5.14: Bar diagram showing the distribution of LULC classes and landslide in the study area

5.3.2 Slope forming material (SFM) map

The SFM map classifies the area into rock and various types of overburden materials. The rocky slopes without any overlying debris have been considered as rock exposure and the rest of the area as overburden covered classes. The various types of overburden material observed in the area are thin soil cover, older well compacted debris, younger loose debris, alluvium, colluvium and in-situ soil (Fig.5.15). 58% of the landslide area falls under the class exposed rock, followed by 28% in the thin soil cover and 9% in the younger loose debris (Fig. 5.16). Areas with thin soil cover occupy 63% of the study area and are observed throughout the area (Fig.5.16). Rock exposure covers 14% area, a larger patch of which can be observed in the northern part of the area near Talakaveri. Alluvium and colluviums are observed mostly in the southern and central part of the area with gentler slopes. Field photographs of some SFM classes have been shown in Fig. 5.17, 5.18, 5.19 and 5.20.

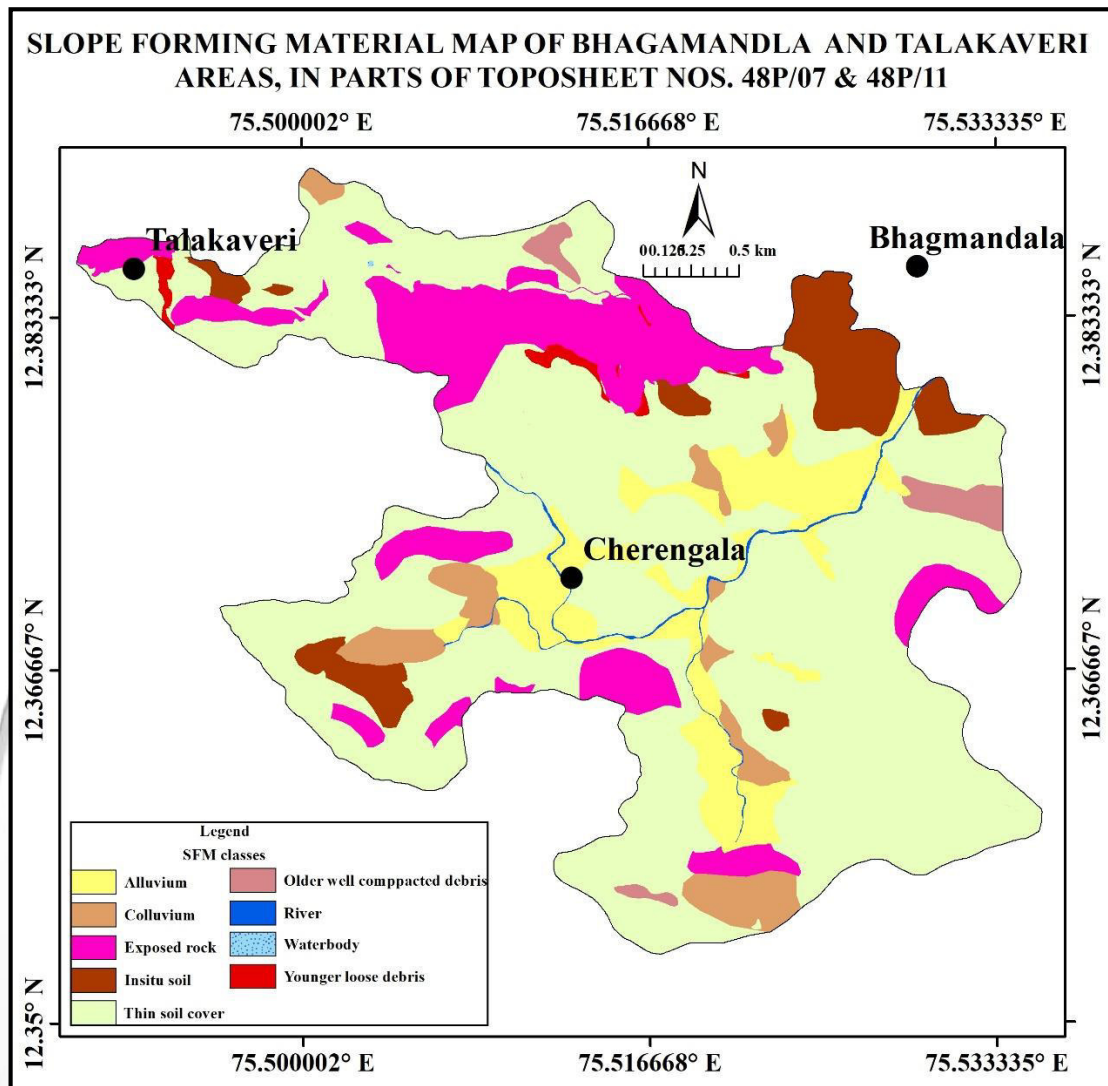


Fig. 5.15: SFM map of the study area

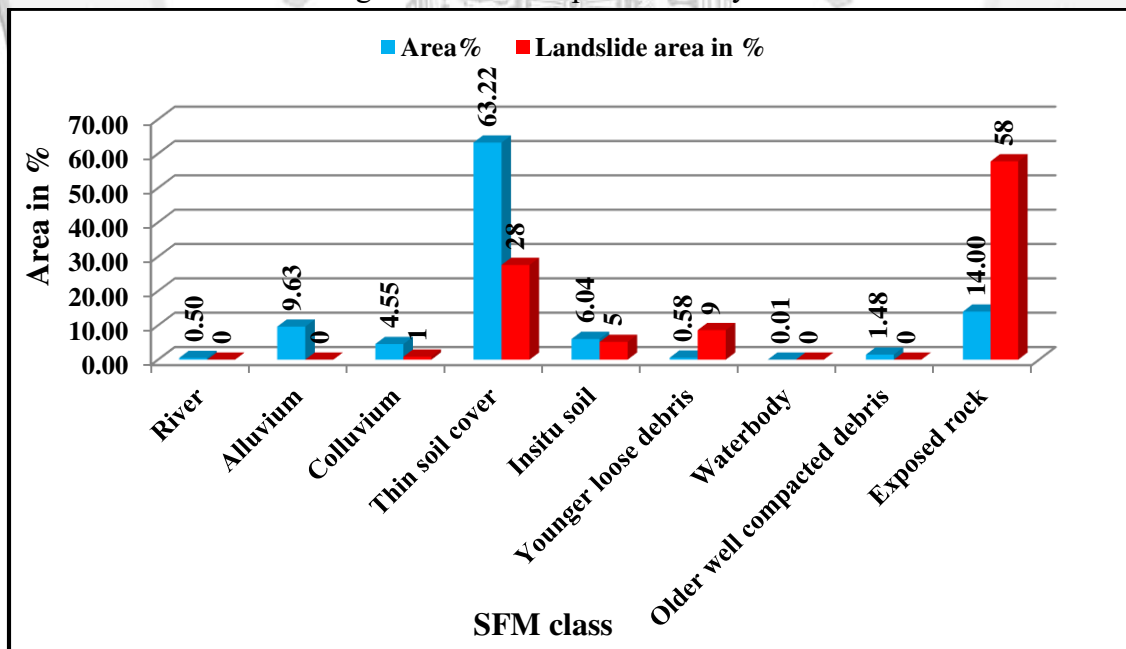


Fig. 5.16: Bar diagram showing the distribution of SFM classes and landslide in the study area

The Landslide Susceptibility Evaluation rating (LSER) for different SFM classes for overburden covered areas are described in Table 5.9.

Table 5.9: LSER for SFM Classes for overburden covered area

Sl. No.	SFM Classes	LSER
1	River	0
2	Alluvium	0
3	Colluvium	0.1
4	Thin soil cover	0.4
5	Insitu soil	0.2
6	Younger loose debris	1
7	Waterbody	0
8	Older well compacted debris	0.1
9	Laterite	0



Fig. 5.17: Exposed rock along Bhagamandla Talakaveri road



Fig. 5.18: Alluvium material near Bhagamandla



Fig. 5.19: Younger loose debris exposed in Talakaveri landslide runout zone



Fig. 5.20: Thin soil cover exposed near Cherengala

5.3.3 Overburden thickness map

The Overburden thickness map has values ranging from 0 m to >5m and is classified into 6 classes viz. 0m, 0-0.5m, 0.5m-1m, 1-2m, 2-5m and >5m (Fig. 5.21). Thicker overburden is mostly observed in the central and southern part of the area where alluvium and colluviums are exposed. Exposed rocks are given thickness 0 m and rocky slopes with thin soil cover have given thickness of 0-0.5m, which covers nearly 57% of the study area (Fig. 5.22). 58% of the total landslide area fall in the thickness class of 0m i.e., areas with exposed rock, followed by 26% in the 0-0.5 m class and 9% in 1-2m class (Fig. 5.22). Field photographs of some overburden thickness classes have been shown in Fig. 5.23, 5.24 and 5.25.

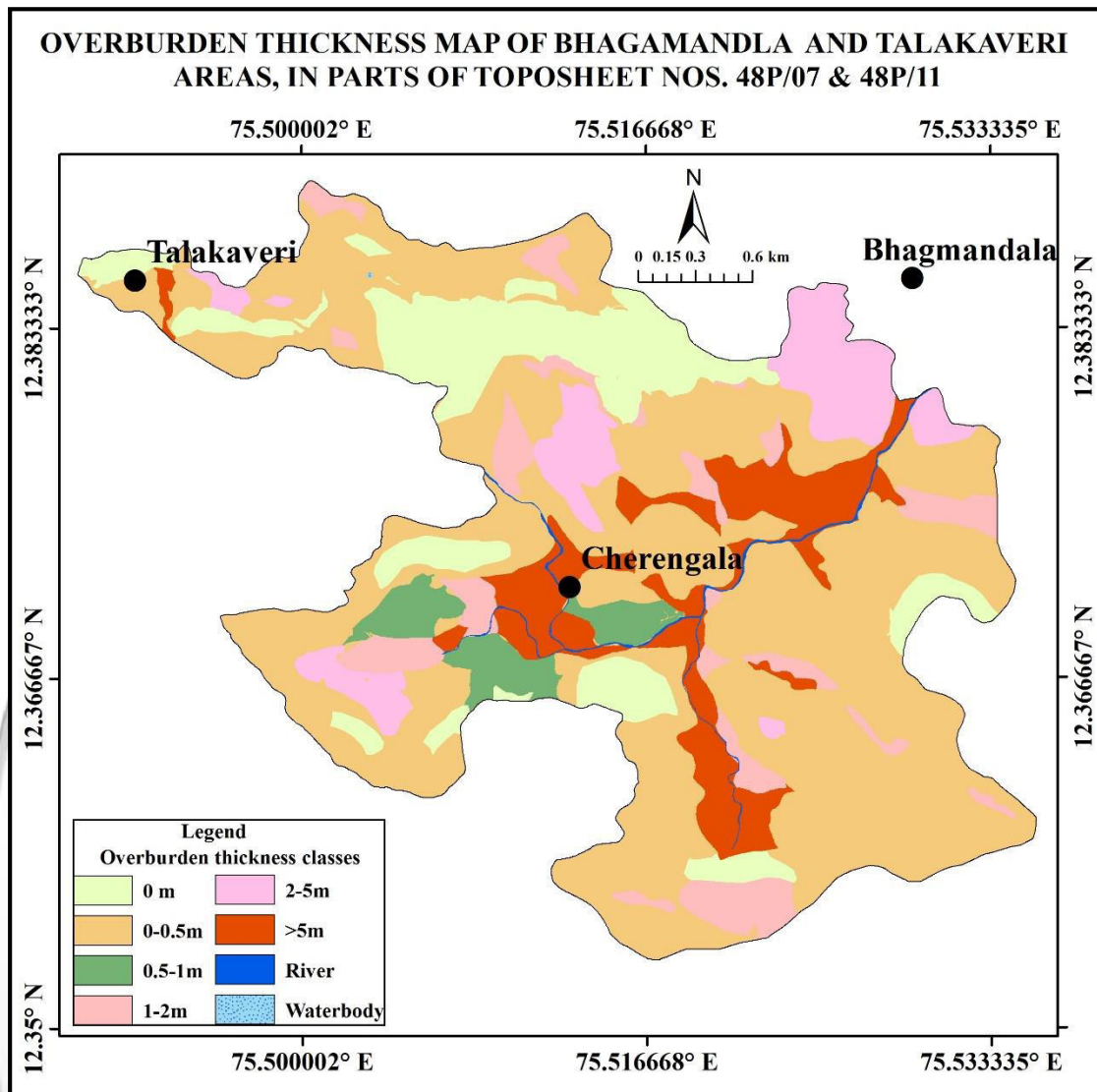


Fig. 5.21: Overburden thickness map of the study area

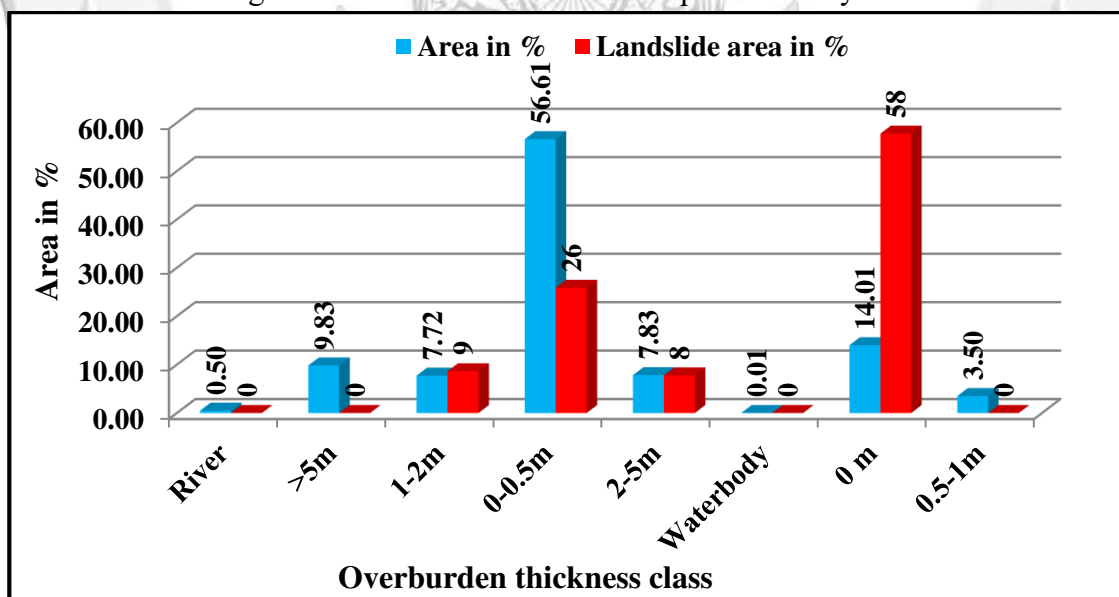


Fig. 5.22: Bar diagram showing the distribution of Overburden thickness classes and landslide in the study area

The Landslide Susceptibility Evaluation rating (LSER) for different Overburden thickness classes for cut slope areas are described in Table 5.10.

Table 5.10: LSER for Overburden thickness Classes for overburden covered area

Sl. No.	Overburden thickness Classes	LSER
1	2-5m	0.8
2	0-0.5m	0.1
3	1-2m	0.6
4	0 m	0.1



Fig. 5.23: 0 m thickness and 0-0.5m thickness classes along Bhagamandla Talakaveri road



Fig. 5.24: Older well compacted debris with 1-2m thickness exposed near Cherengala



Fig. 5.25: Younger loose debris with >5m thickness exposed near Talakaveri

5.3.4 Kinematic failure map

The stability of rocky slopes is mainly governed by the strength of the rock and the disposition of structural discontinuities with respect to the slope. Generally, there are three common types of failures observed in rocky slopes which are planar, wedge and toppling failures. Such type of failure criteria can be derived by using kinematic analysis. Kinematic analysis for the rock covered areas was carried out by using Markland's tests (Hoek and Bray, 1981). A total of 27 nos. of rock slopes were analysed with a view to assess the possible modes of failures in the area. The analysis reveals the presence of few planar and wedge failures in the area. No toppling failure condition was observed in the study area.

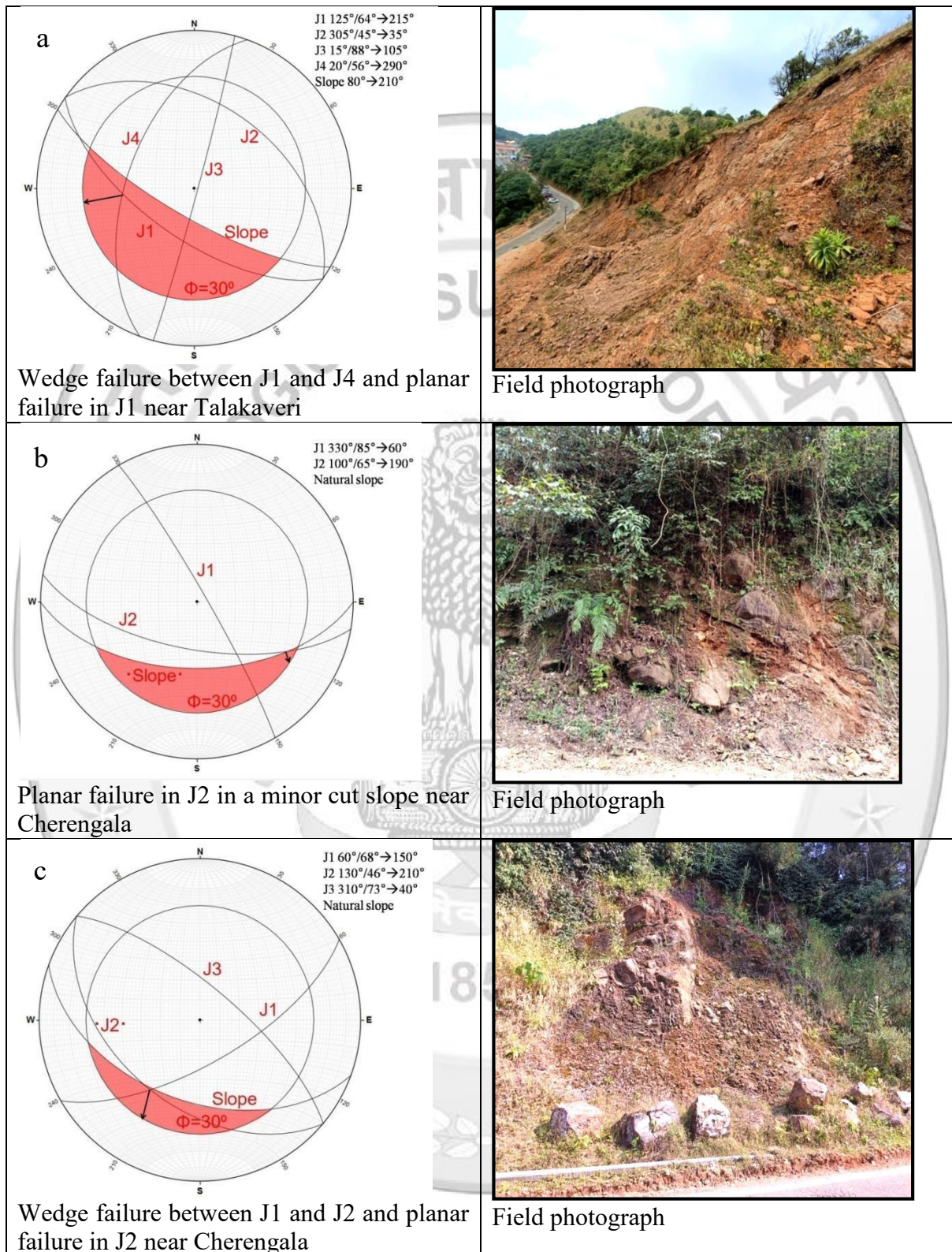
As per the kinematic analysis, planar failure occurs when the following criterion is met:

- i. The strike of the slope face and the favourable discontinuity plane are parallel ($\pm 20^\circ$)
- ii. The discontinuity plane should be gentler than the slope.
- iii. The discontinuity plane should be steeper than the angle of internal friction of the rock mass.

The failure criterion for wedge failure is as follows:

- i. The plunge line of the intersection of two discontinuities should be gentler than the slope and dipping in the same direction to be "day lighted".
- ii. The plunge line of the intersection of two discontinuities should be steeper than the angle of internal friction of the rock mass.

Kinematic analysis of select rocky slope areas along with their field photographs are shown in Fig. 5.26 (a) to 5.26 (f).



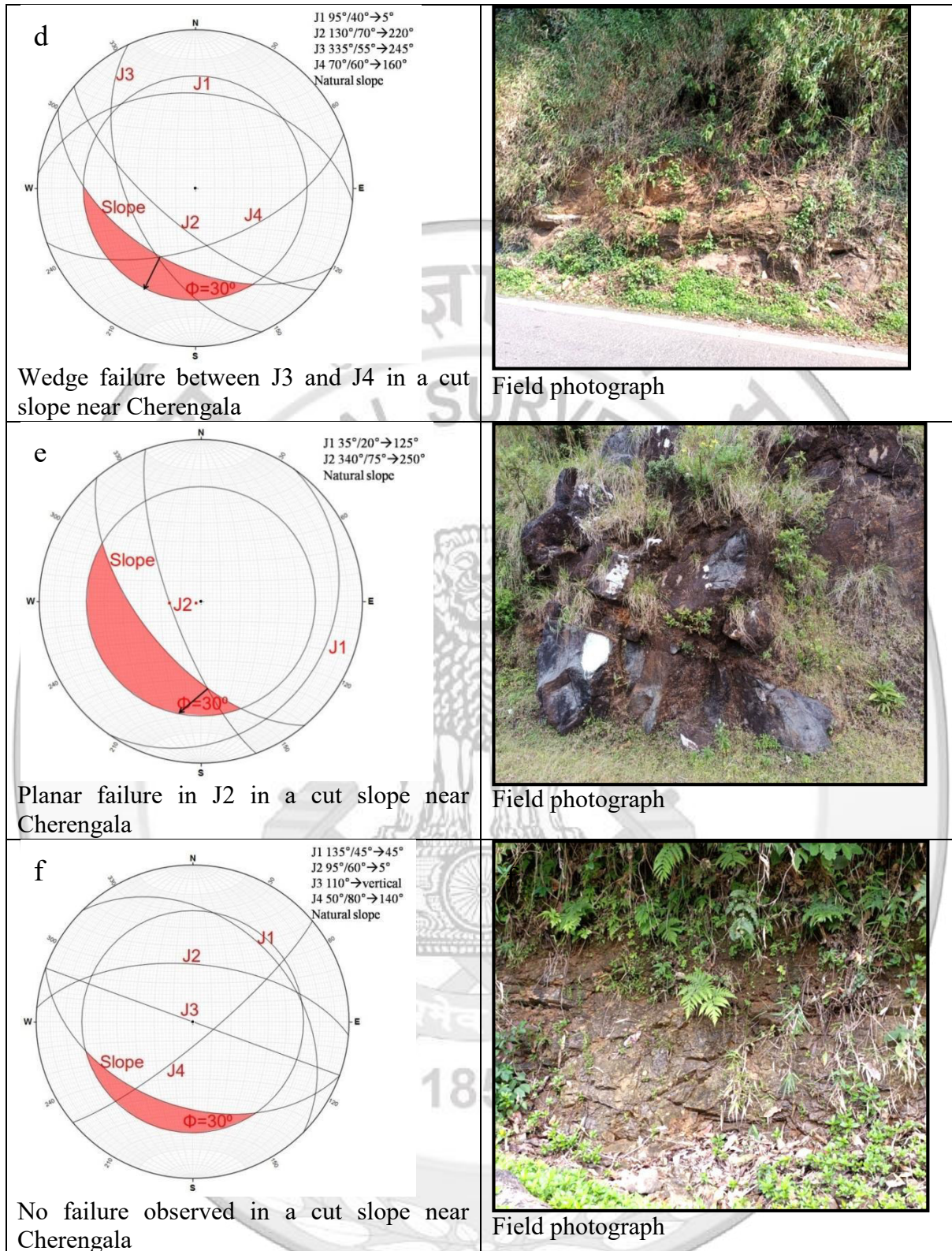


Fig. 5.26: Kinematic analysis of some rocky slopes along with their field photographs
 Angle of internal friction $\Phi=30^\circ$,  = Sliding envelope

The kinematic failure map of the area reveals five different classes viz. An area with no failure, an area with 1 planar failure, an area with 1 planar failure and 1 wedge failure, and an area with 2 planar failures and 1 wedge failure and area with 2 wedge failures and 1 planar failure (Fig. 5.27). Nearly 93% of the rock covered area has no kinematic failure condition

(Fig. 5.28). 51% of the landslide area falls in the areas with 1 planar failure and 1 wedge failure and 49% of the landslides fall in the area with 1 planar failure and 2 wedge failures (Fig. 5.28).

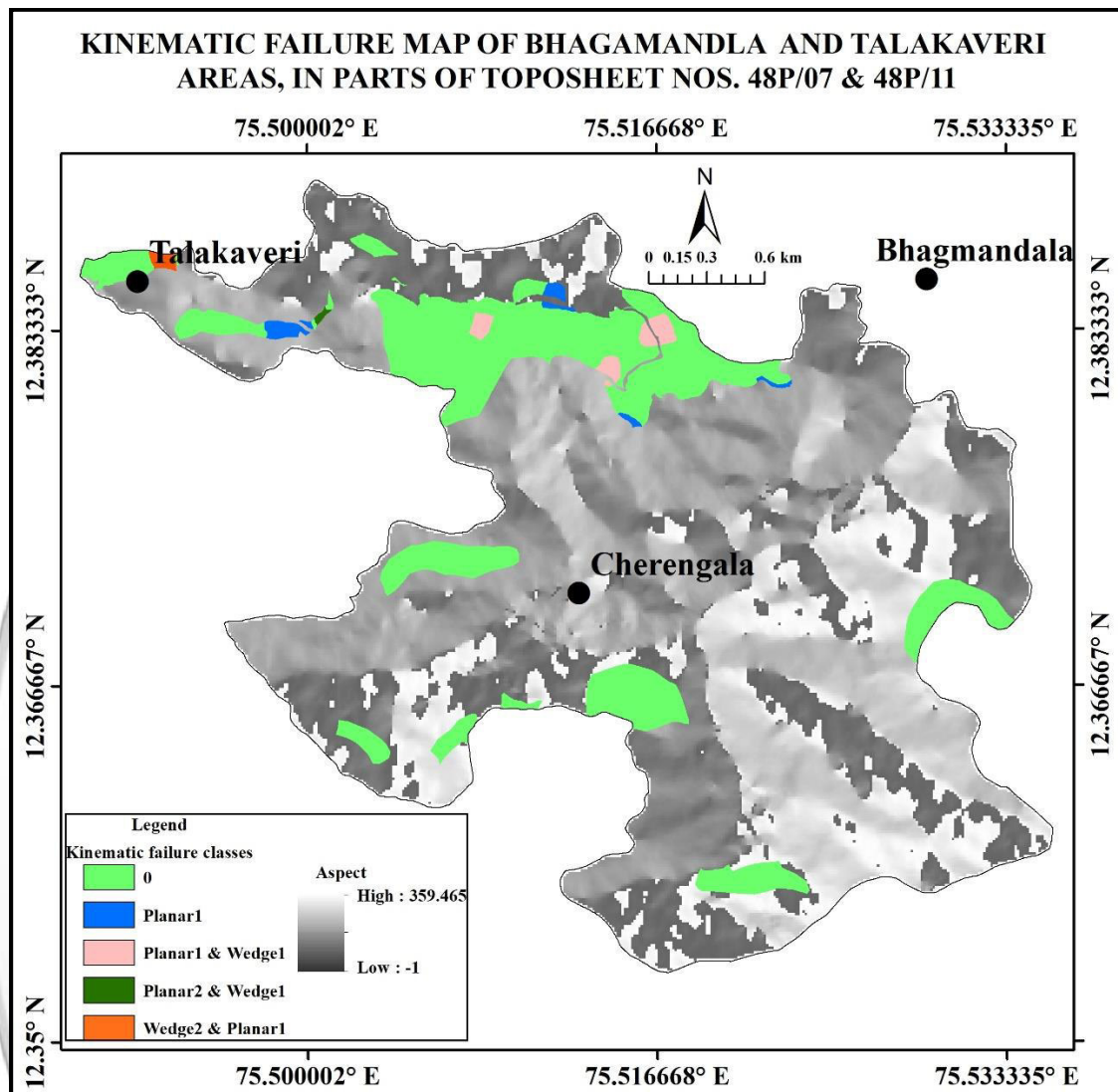


Fig. 5.27: Kinematic failure map of the study area

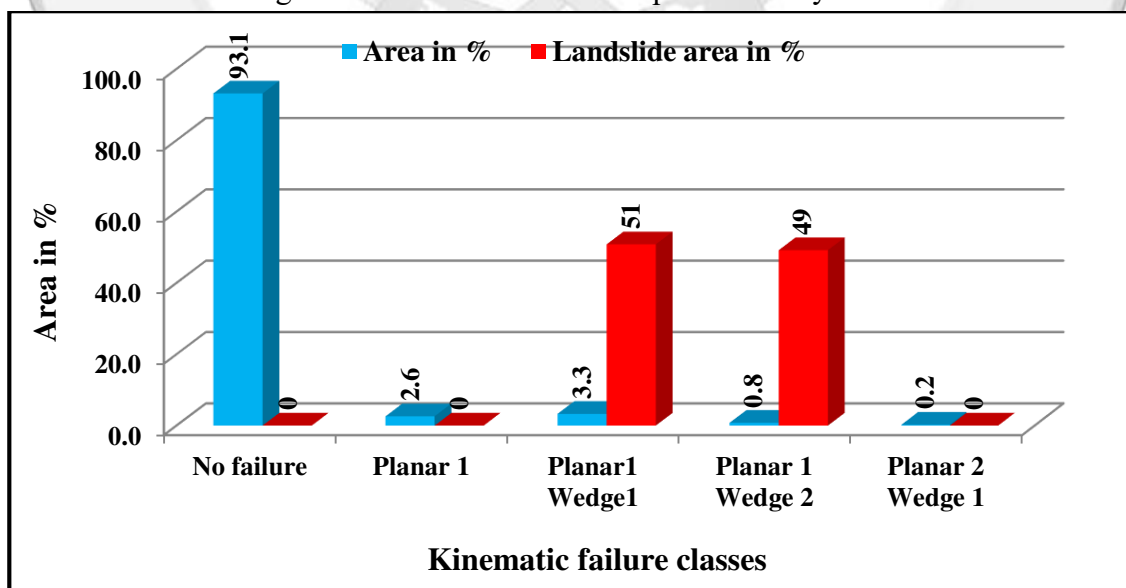


Fig. 5.28: Bar diagram showing the distribution of kinematic failure classes and landslide in the study area

The Landslide Susceptibility Evaluation rating (LSER) for different kinematic failure classes for rock covered areas are described in Table 5.11.

Table 5.11: LSER for Kinematic Failure Classes for rock covered area

Sl. No.	GT Classes	LSER
1	No failure	0
2	Planar 1	0.5
3	Planar1 Wedge1	1
4	Planar 1 Wedge 2	1
5	Planar 2 Wedge 1	1

5.3.5 Geotechnical (GT) map

The GT map for rock covered areas was prepared using the RMR values (Table 5.13) calculated as per Bieniawski, 1989 (Fig. 5.29). The locations from where data has been collected for RMR calculation are shown in Fig. 5.35. The different parameters considered for RMR calculation are (1) Uniaxial Compressive Strength (UCS), (2) Rock Quality Designation (RQD), (3) Spacing of discontinuities, (4) Condition of discontinuities and (5) Groundwater conditions. RMR values were calculated for a total of 27 nos. of rocky slopes, an example of which is shown in Table 5.12, in a location near Talakaveri. Based on the RMR values calculated, the study area is divided into good, fair, bad and very bad rock classes (Fig. 5.34). The rock mass condition is observed to be very bad in a hill slope in the southern part of the area and bad rock mass condition is observed near Talakaveri and some scattered patches in the northern part. Fair rock was also observed in the northern and southern part of the area. The rest of the rocky areas, exhibit good rock mass condition.

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS										
PARAMETER			Range of values // ratings							
1	Strength of intact rock material	Point-load strength index	> 10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range uniaxial compr. strength is preferred			
		Uniaxial compressive strength	> 250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa	
		RATING	15	12	7	4	2	1	0	
2	Drill core quality RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	< 25%			
	RATING		20	17	13	8	5			
3	Spacing of discontinuities		> 2 m	0.6 - 2 m	200 - 600 mm	60 - 200 mm	< 60 mm			
	RATING		20	15	10	8	5			
4	Condition of discontinuities	Length, persistence	< 1 m	1 - 3 m	3 - 10 m	10 - 20 m	> 20 m			
		Rating	6	4	2	1	0			
		Separation	none	< 0.1 mm	0.1 - 1 mm	1 - 5 mm	> 5 mm			
		Rating	6	5	4	1	0			
		Roughness	very rough	rough	slightly rough	smooth	slickensided			
		Rating	6	5	3	1	0			
		Infilling (gouge)	none	Hard filling		Soft filling				
			-	< 5 mm	> 5 mm	< 5 mm	> 5 mm			
5	Ground water	Inflow per 10 m tunnel length	none	< 10 litres/min	10 - 25 litres/min	25 - 125 litres/min	> 125 litres /min			
		p_w / σ_1	0	0 - 0.1	0.1 - 0.2	0.2 - 0.5	> 0.5			
		General conditions	completely dry	damp	wet	dripping	flowing			
		RATING	15	10	7	4	0			
		p_w = joint water pressure; σ_1 = major principal stress								
B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS										
		Very favourable	Favourable	Fair	Unfavourable	Very unfavourable				
RATINGS	Tunnels	0	-2	-5	-10	-12				
	Foundations	0	-2	-7	-15	-25				
	Slopes	0	-5	-25	-50	-60				
C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS										
Rating		100 - 81	80 - 61	60 - 41	40 - 21	< 20				
Class No.		I	II	III	IV	V				
Description		VERY GOOD	GOOD	FAIR	POOR	VERY POOR				

Fig. 5.29: RMR classification of rock masses (Bieniawski, 1989)

Table 5.12: A sample RMR calculation sheet for a rocky slope near Talakaveri

Location Name	Near Talakaveri	Rating
Facet No.	347	--
Lat	12.386495	--
Long	75.493472	--
Elevation	1188m	--
Lithology	Enderbite and granite	--
UCS values (MPa)	25, 16, 16, 18, 22	--
Mean UCS (MPa)	24	2
Slope amount	80°	--
Slope direction	200°	--
Volumetric Joint (Jv)	20	--
RQD=115 – 3.3Jv	49	8
Spacing of	J ₁ 150, J ₂ 100, J ₃ 1000, J ₄ 5000	8

discontinuities (mm)		
Persistence (m)	J ₁ 20, J ₂ 20, J ₃ 1, J ₄ 5	0
Separation (mm)	J ₁ >5, J ₂ 1-5, J ₃ 1-2, J ₄ 1	1
Roughness	J ₁ rough, J ₂ Slightly rough J ₃ Slightly rough, J ₄ Rough	3
Infilling	J ₁ None, J ₂ None J ₃ Soft filling <5mm, J ₄ None	2
Weathering	J ₁ Moderately weathered, J ₂ Slightly weathered, J ₃ Slightly weathered, J ₄ Slightly weathered	3
Groundwater condition	J ₁ Completely dry, J ₂ Damp J ₃ Damp, J ₄ Completely dry	10
RMR_{basic}	2+8+8+1+3+2+3+10=37, (Bad rock)	
Photograph of the location		

Using the RMR_{basic} values, the Slope Mass Rating (SMR) was calculated for rocky slopes with planar and wedge failure conditions. SMR is an empirical rock mass classification system developed by Manuel Romana in 1985 to describe the strength of an individual rock outcrop or slope. The SMR is obtained using four correction factors of basic RMR. These factors depend on the existing relationship between discontinuities affecting the rock mass and the slope and the slope excavation method (Romana et al 2015). It is obtained using the following Eq.

$$\text{SMR} = \text{RMR}_{\text{basic}} + (F_1 \times F_2 \times F_3) + F_4 \dots\dots\dots (ii)$$

Where RMR_{basic} is the basic RMR index resulting from Bieniawski's rock mass classification.

F1 depends on the parallelism between discontinuity dip direction, α_j , and slope dip, α_s .

F2 is related to the probability of discontinuity shear strength (Romana, 1993) and depends on the discontinuity dip, $B=\beta_j$, in the case of planar failure. For toppling failure, this parameter adopts the value 1.0.

F3 depends on the relationship between slope, β_s , and discontinuity, β_j , dips.

F4 is a correction factor that depends on the excavation method

For the present study, SMR studies were carried out for 11 locations where planar and wedge failures were observed after carrying out kinematic analysis. The SMR values reveal

that the study area has mostly good and normal SMR values. The SMR values were used to suggest preliminary remedial measures for the landslides/ slope failures present in the study area.

For overburden covered areas, the GT map was prepared after assessing the shear parameters of the soil samples. The amount of shear stress that a soil can withstand is denoted by shear strength. The shear strength depends upon the shear strength parameters i.e. the angle of internal friction (Φ) and cohesion (C). A total of 20 nos. of geotechnical samples were collected for different overburden types (Fig. 5.36) for the estimation of C and Φ values. Based on the lab derived C and Φ values (Annexure-VII), the GT class for overburden was assigned (Table 5.14). The GT map for overburden covered areas depicts a good overburden class for the entire study area (Fig. 5.34 and 5.37).

The GT map for rock and overburden were prepared separately and finally combined to form the final geotechnical map. The map classifies nearly 85.6% of the area as good overburden and 11.5% area as good rock mass and 2.2% area as fair rock, 0.5% area as bad rock and 0.1% area as very bad rock (Fig. 5.37). 61% of the total landslide area falls in the bad rock class and 16% of the landslide area fall under the good overburden class, followed by 16% in the fair rock (Fig. 5.37).

Table 5.13: GT Class based on RMR basic values for rock covered area

Category	RMR _{basic} value
Good	61-80
Fair	41-60
Bad	21-40
Very bad	≤ 20

Table 5.14: GT Class based on C and Φ values for overburden covered area

Cohesion (C)	Angle of internal friction (Φ)	
	$>30^\circ$	$21^\circ-30^\circ$
16-30 Kn/m ²	Good	Good

The Landslide Susceptibility Evaluation rating (LSER) for different GT classes for rock and overburden covered areas and cut slopes are described in Table 5.15, 5.16 and 5.17.

Table 5.15: LSER for GT Classes for overburden covered area

Sl. No.	GT Classes	LSER
1	Good	0.2

Table 5.16: LSER for GT Classes for rock covered area

Sl No.	GT Classes	LSER
1	Good	0.2
2	Fair	0.4
3	Bad	0.6
4	Very bad	0.8

Table 5.17: LSER for GT Classes for cut slope

Sl No.	GT Classes	LSER
1	Good overburden	0.2
2	Fair rock	0.4
3	Bad rock	0.8

The Natural Moisture Content (NMC) of the soil samples collected from the study area varies from 11.15 % to 46.95% (Annexure-VII). The average NMC value in the study area is 24.14%. NMC values greater than the average values were found in 8 locations (Fig. 5.32). The NMC values in these areas are expected to be higher as most of the area is northerly facing slopes where the amount of sunlight received is comparatively less. Soil having higher NMC also indicates poor compaction of the soil which results in a higher void ratio and vice versa. The shear parameters of the soil also reduce with the increase in the NMC. Fig 5.30 shows the relationship between NMC and the angle of internal friction. The higher friction angles are observed for NMC values ranging from 10° to 20°. Higher NMC values result in a reduction of the internal friction angle.

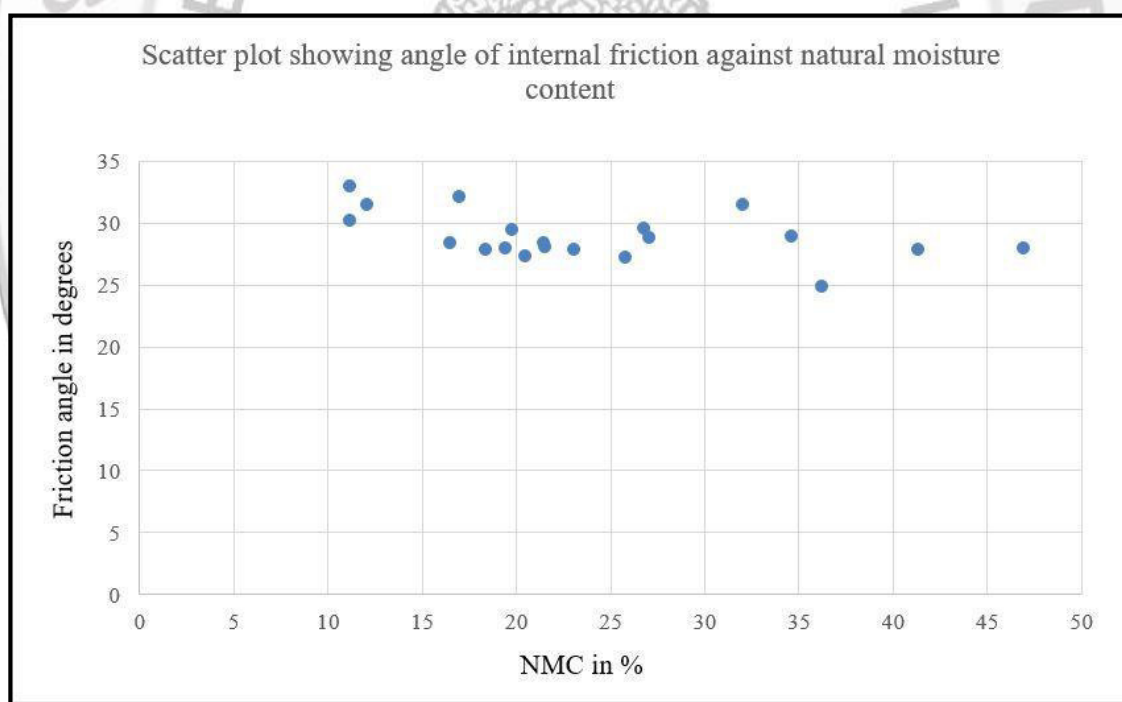


Fig. 5.30: Scattered plot showing internal friction angle with NMC in the study area

The porosity of the soil is a function of grain size distribution and compaction of the soil. The porosity values in the area were found to be uniform with values ranging from 0.41 to 0.59 (Annexure-VII). The soil samples in the study area have higher coarse fragments and very little clay. This along with the poor compaction results in the marginally higher porosity of the topsoil in the area. Fig 5.31 shows the relationship between porosity and NMC. There is a clear positive correlation between porosity and NMC in the study area.

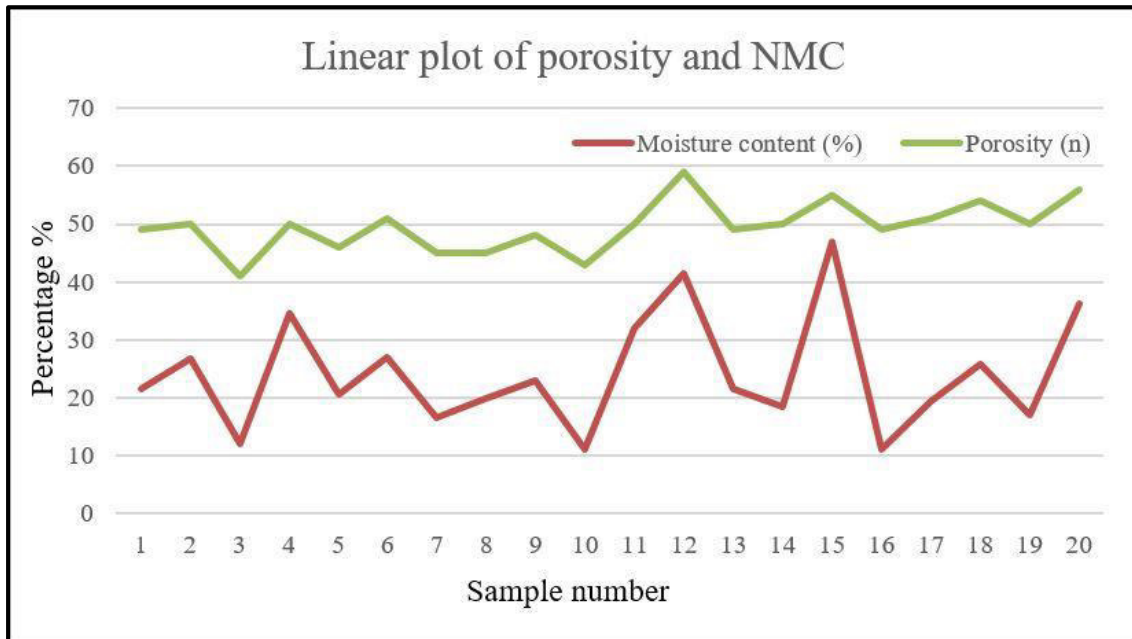


Fig. 5.31: Linear plot of porosity and natural moisture content

The void ratio values range from 0.7 to 1.41. The dry and wet densities in the area are also found to be uniform and range from 1.09 to 1.49 and 1.51 to 1.69 respectively (Annexure-VII). The Liquid Limit (LL) is conceptually defined as the water content at which the behaviour of clayey soil changes from plastic to liquid. The transition from plastic to liquid behaviour is gradual over a range of water contents and the shear strength of the soil is not actually zero at the liquid limit. The Plastic Limit (PL) is defined as the moisture content where the soil changes from plastic to non-plastic. The Plasticity Index (PI) is a measure of the plasticity of soil. The plasticity index is the range of water contents where the soil exhibits plastic properties. The PI is the difference between the liquid limit and plastic limit ($PI = LL - PL$). Soils with a high PI tend to be clay, those with a lower PI tend to be silt, and those with a PI of 0 (non-plastic) tend to have little or no silt or clay. In the Casagrande plasticity chart (Casagrande, 1948), high plastic soils are those that have LL higher than 50 and tend to swell with water content. Low plastic soils are those that have LL less than 50 and do not swell with water addition (Amadi et al., 2015).

The plasticity index and liquid limit of the soil samples were plotted in the Casagrande plasticity chart (Fig. 5.33) after calculating the A and U lines. It is observed that the samples are falling below the A-line and below the 50% liquid limit in the plasticity chart. In view of this, the samples were classified as ML (silt of medium plastic) and indicate that the type of the material is inorganic/organic silt or silty clay whose plasticity is low.

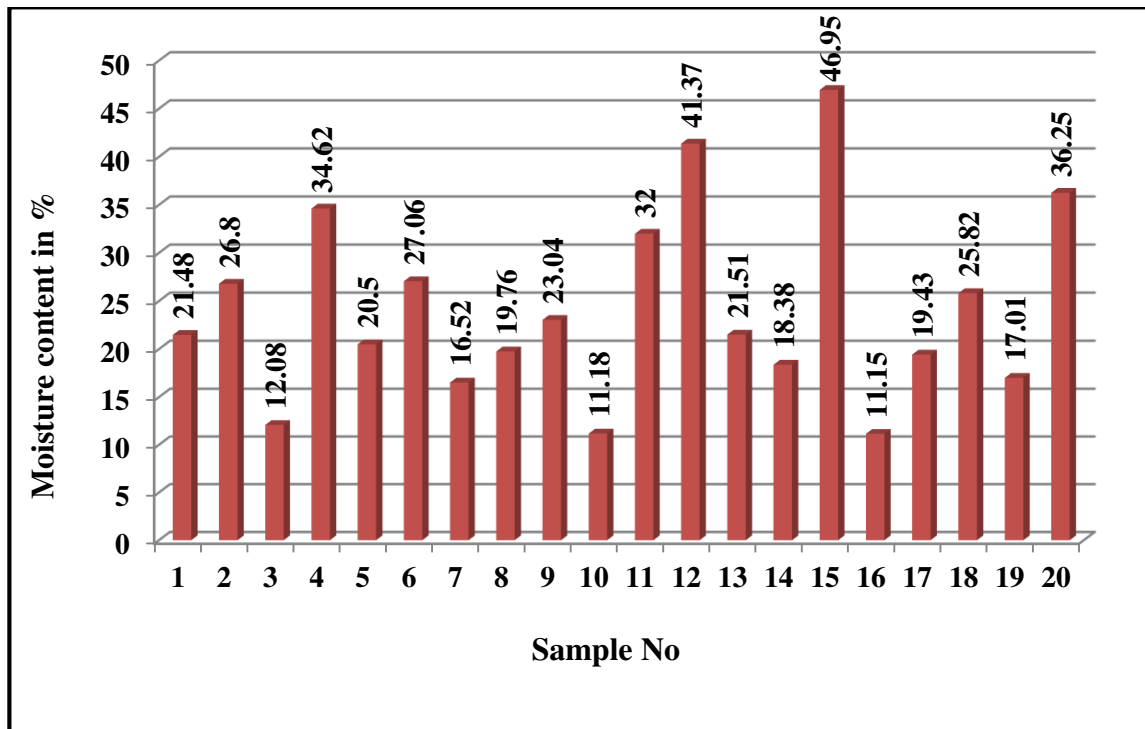


Fig. 5.32: Bar diagram showing the distribution of NMC in the study area

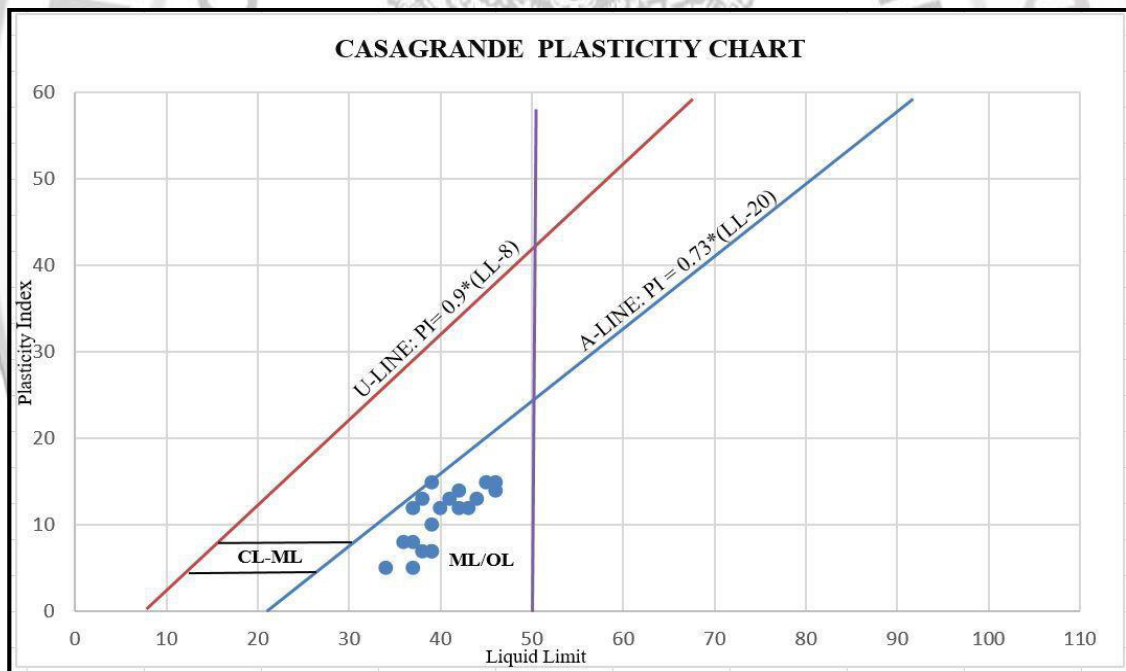


Fig. 5.33: Casagrande plasticity chart

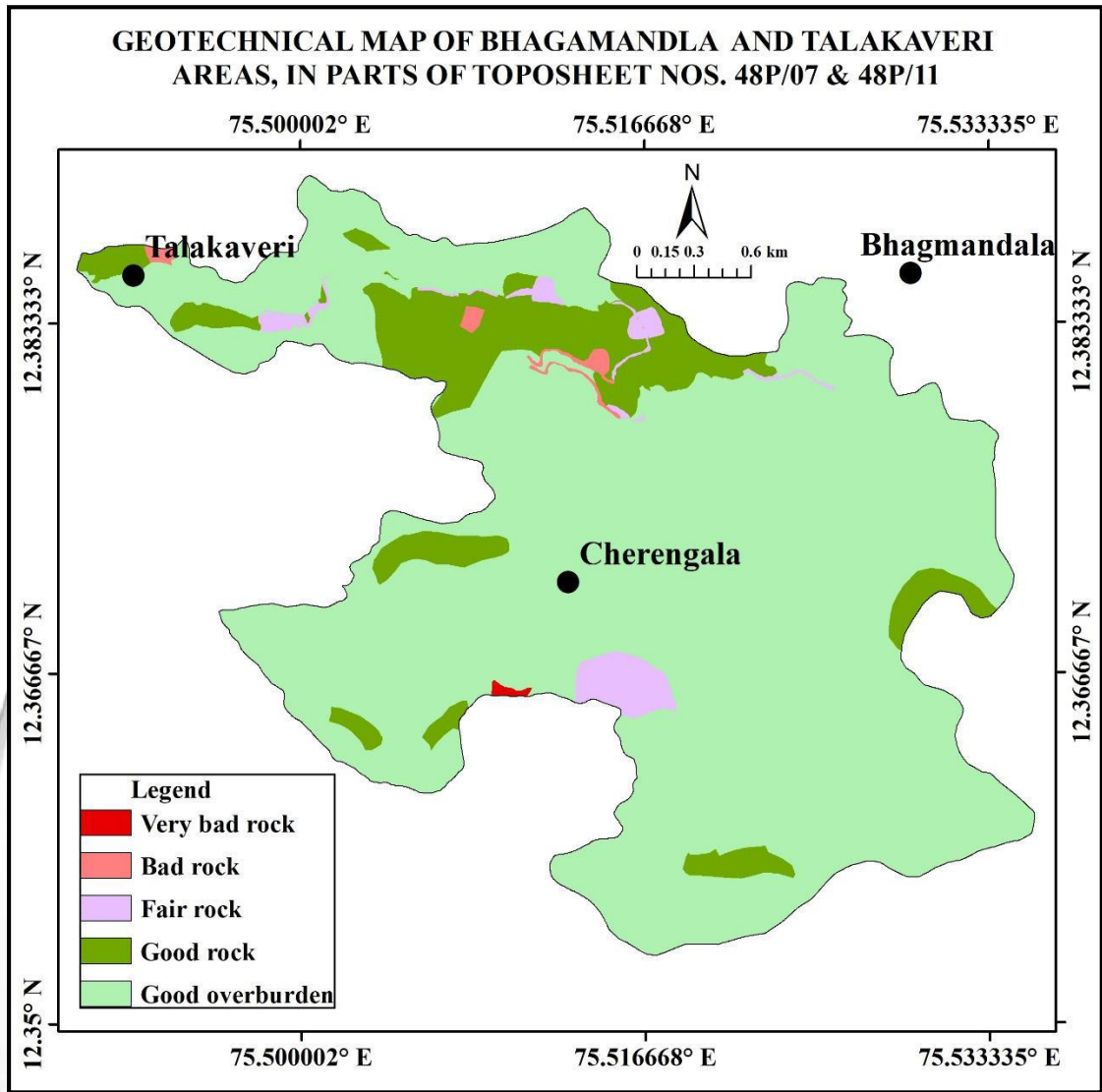


Fig. 5.34: Geotechnical map of the study area

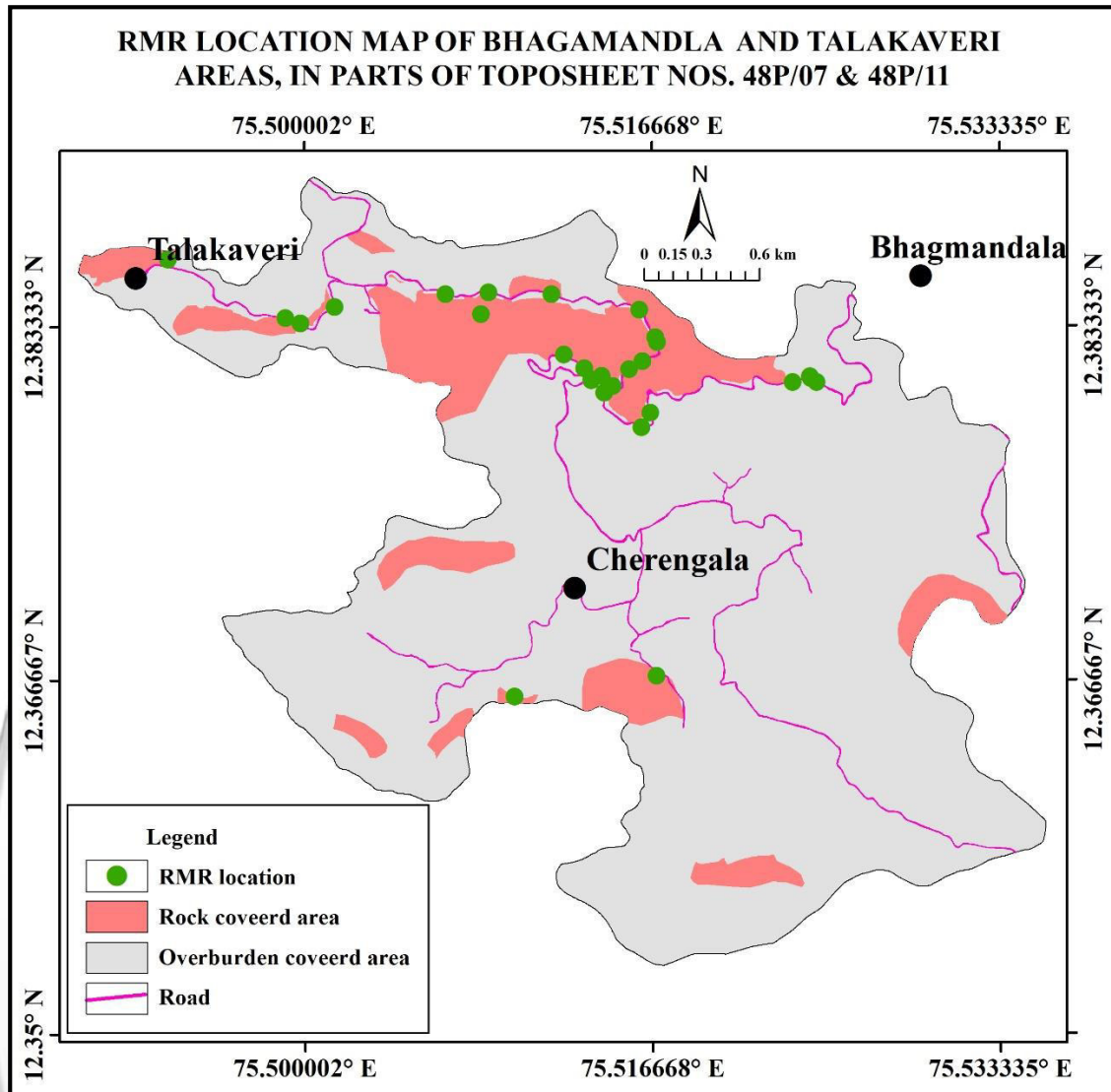


Fig. 5.35: Map showing locations considered for RMR calculation

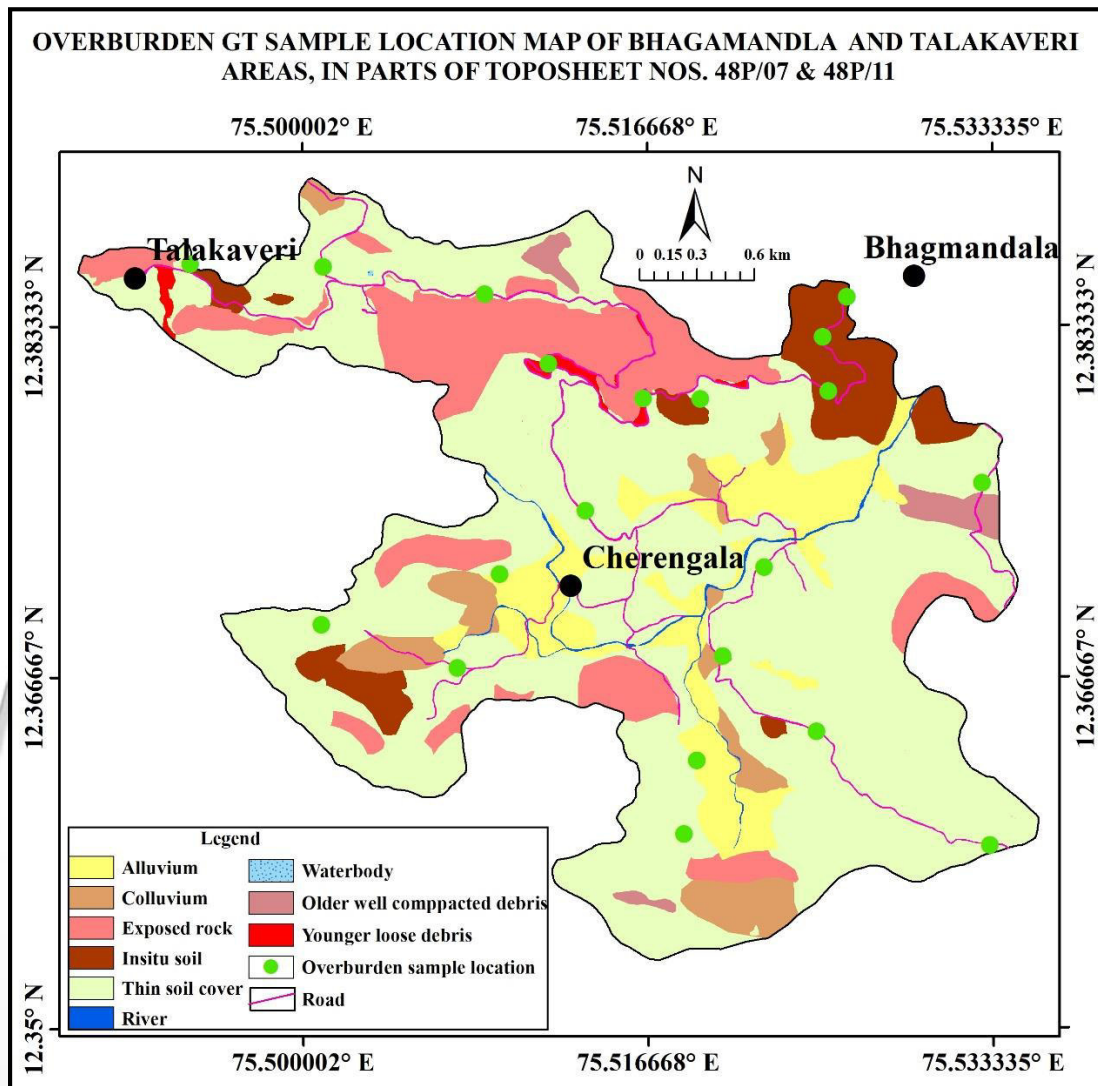


Fig. 5.36: Map showing locations considered for overburden sample collection

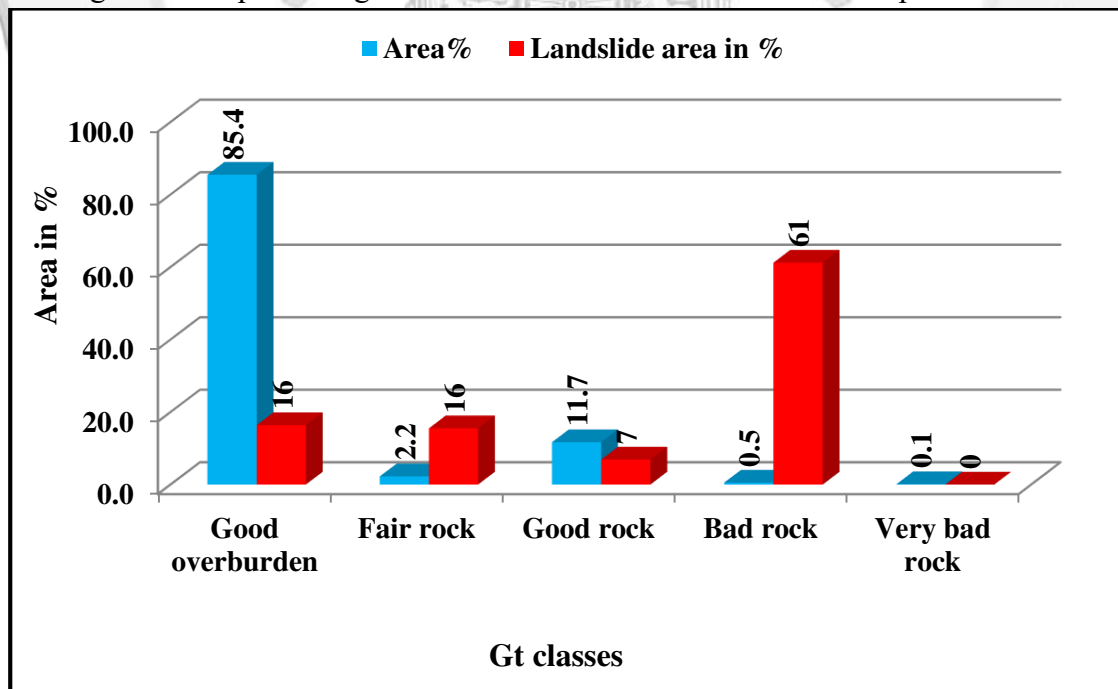


Fig. 5.37: Bar diagram showing the distribution of GT classes and landslide in the study area

CHAPTER 6. LANDSLIDE SUSCEPTIBILITY ANALYSIS

6.1 Susceptibility Modelling

Landslide susceptibility may be defined as the degree to which a slope is prone to the initiation of a landslide. The landslide susceptibility map predicts the locations that are prone to be future landslide source areas and does not predict the run-out path of the slide. Therefore, any susceptibility map should be studied by considering the possible run-out path of a landslide. The susceptibility map classifies the area into different classes based on how the various thematic factors present in the area contribute to landslide initiation. Since the factors contributing to rock slides and debris slides are different, the study area was divided into rocky slopes, overburden covered slopes and cut slopes. Various thematic maps for these areas were prepared and the susceptibility analysis was carried out separately. The thematic factors considered for the rocky slopes are the Geomorphon map, Kinematic Failure map, Slope map, Geotechnical map and Relative Relief map whereas the factors considered for debris slides are Slope map, Slope Forming Material map, Stream Power Index map, Geomorphon map, LULC map, Geotechnical map and Relative Relief map. The factors considered for cut slope areas are Relative Relief map, Slope map and Overburden Thickness map and Geotechnical map.

All the thematic maps were given terrain specific ratings for their sub classes (LSER ratings for each thematic class given in Chapter 5) and weights for each map. The ratings and weights were based on the landslide data and field observations. The ratings of thematic sub classes were given on a scale of 0-1, where 0 represents the lowest contribution to landslide initiation and vice versa. The weights of the thematic maps were assigned values based on how important the thematic map is in classifying the low and high landslide susceptibility areas.

The final rated thematic maps were rasterized and integrated in ArcGIS 10.3 using the raster calculator function to obtain the susceptibility score map. The score map was then classified into “High”, “Moderate” and “Low” susceptibility classes to obtain the landslide susceptibility map for the rock covered areas (Fig. 6.1), for overburden covered areas (Fig. 6.2) and for cut slopes (Fig. 6.3). The combined susceptibility map (Fig. 6.4) was prepared by mosaicking these three maps.

Table 6.1: Weightages of different thematic maps

Thematic map	Landslide domain	Weightage
LULC	Debris	2
Slope forming material		2
Slope		3
Stream power index		1
Geomorphon		3
Relative relief		1
Geotechnical	Rock	1
Kinematic failure		2
Geomorphon		3
Relative relief		2
Slope		2
Geotechnical		2
Relative Relief	Cut slope	2
Slope		2
Overburden Thickness		3
Geotechnical		2

LANDSLIDE SUSCEPTIBILITY MAP OF ROCKY SLOPES OF BHAGAMANDLA AND TALAKAVERI AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11

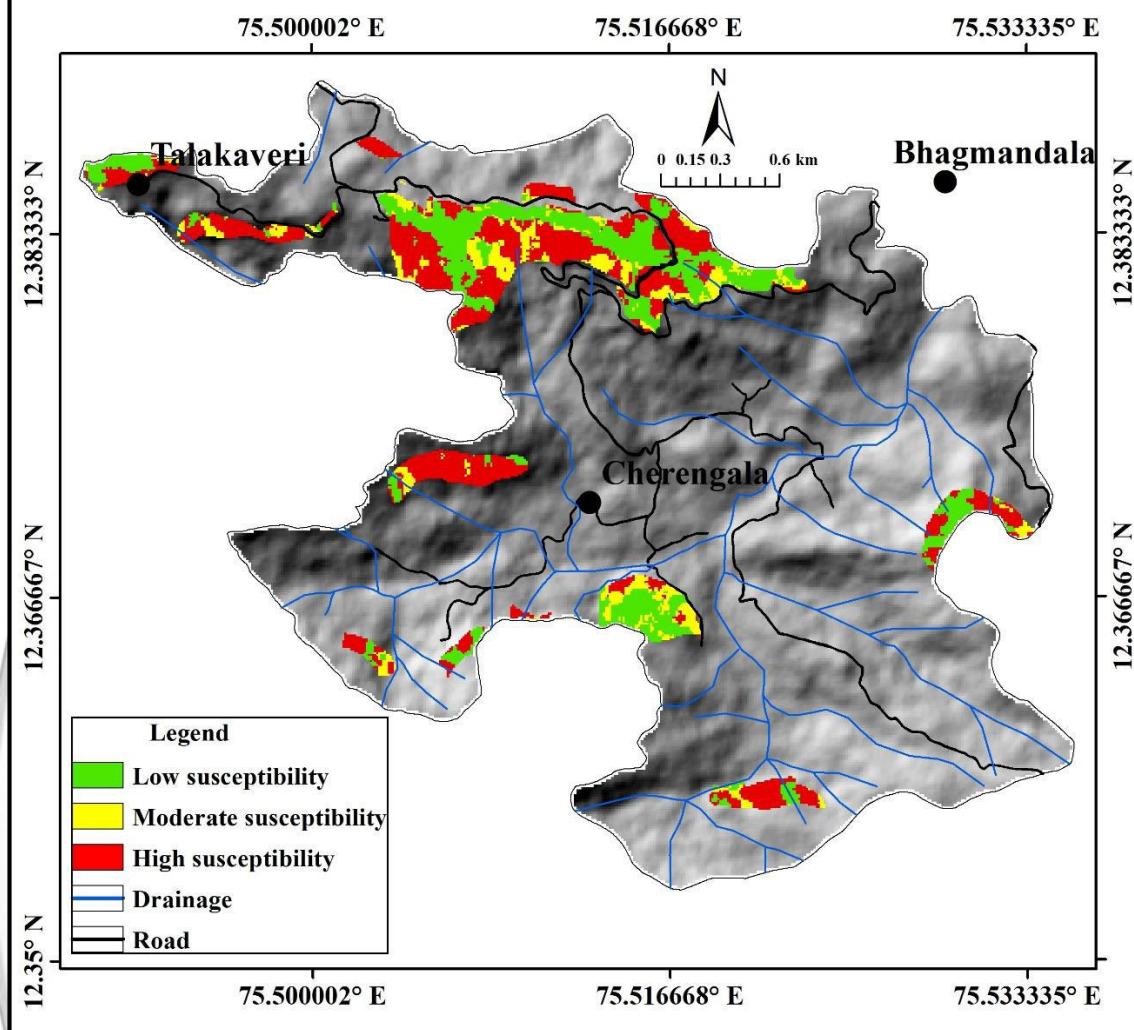


Fig. 6.1: Landslide susceptibility map for rock covered areas

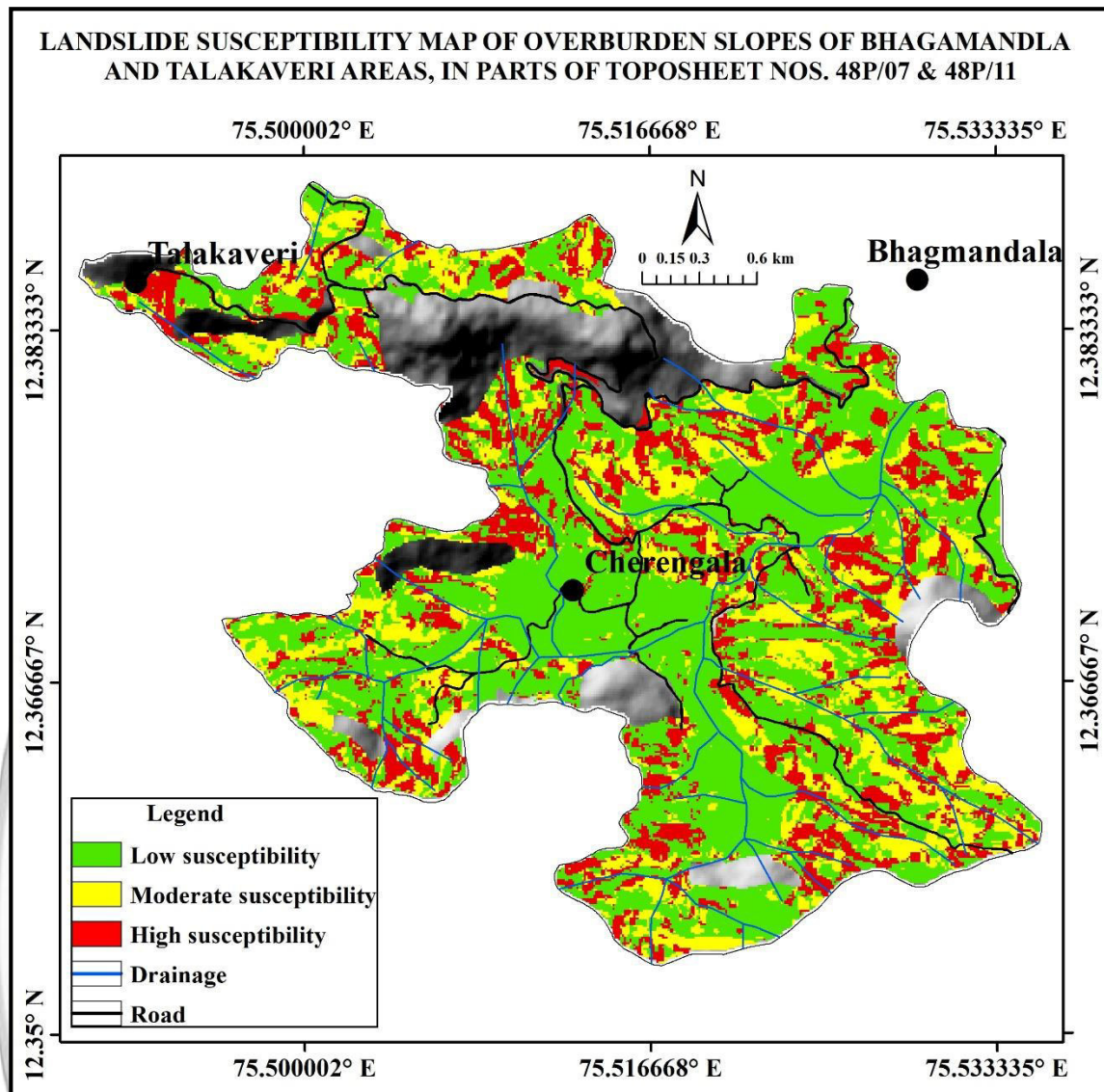


Fig. 6.2: Landslide susceptibility map for overburden covered areas

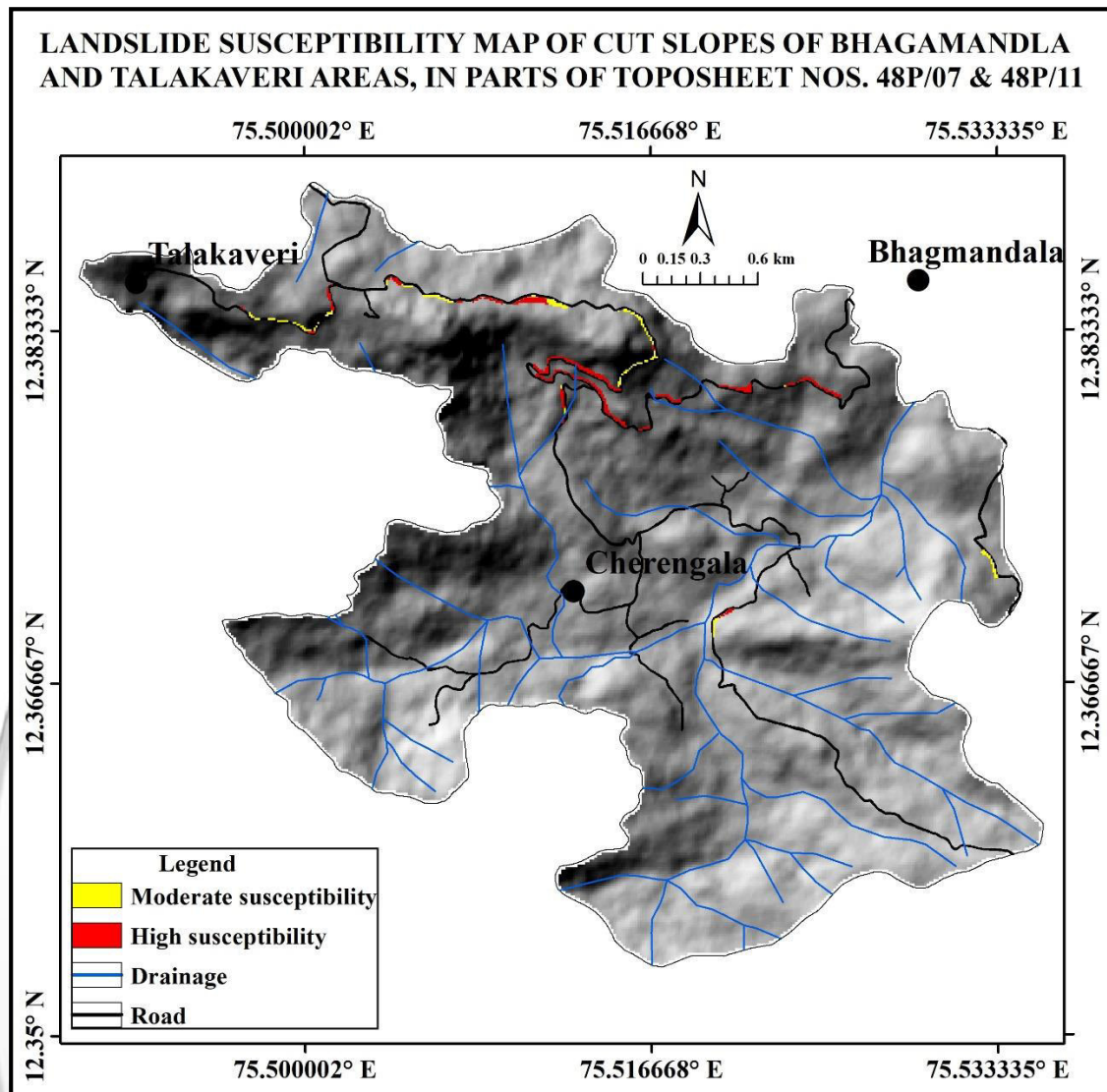


Fig. 6.3: Landslide susceptibility map for cut slope areas

6.2 Combined Landslide Susceptibility Map

The combined landslide susceptibility map (Fig. 6.4) was prepared using the mosaic tool in ArcGIS by combining all three landslide susceptibility maps. The combined landslide susceptibility map (Fig. 6.4) classifies 26% (2.6 sq km) of the study area into “High”, 22% (2.2 sq km) of the area into “Moderate” and 52% (5.2 sq km) of the area into “Low” susceptibility classes.

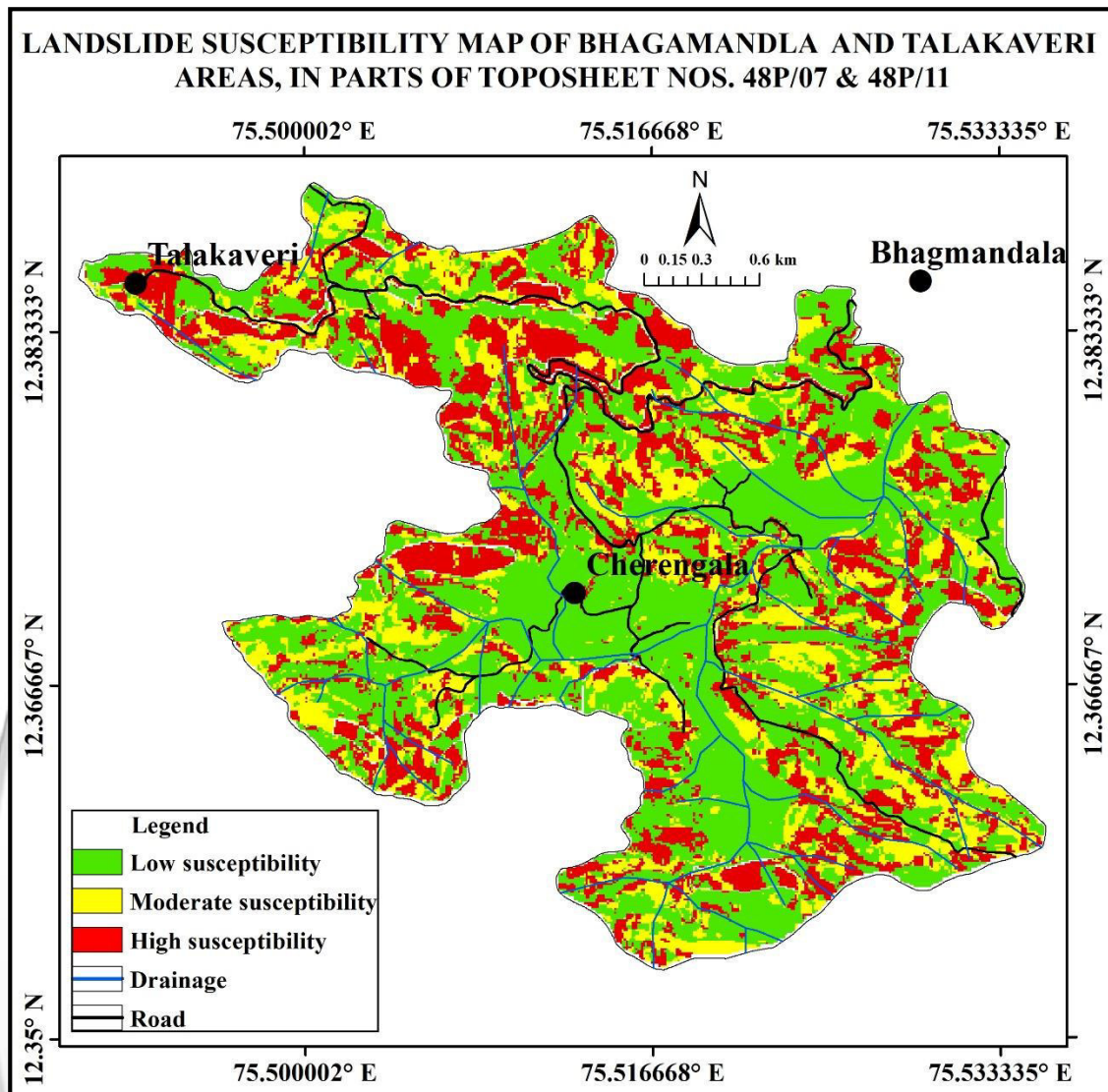


Fig. 6.4: Combined landslide susceptibility map of the study area

6.2.1 High Susceptible Zones

A total of 26% of the study area falls under high landslide susceptibility zones. The high susceptibility patches in the study area are distributed in the north western part of the study area and predominantly in the south and south-easterly facing slopes. The Bhagamandla-Talakaveri road (SH-90), which is the main element at risk in the area has many high susceptibility zones, the largest of which is near the hairpin curve (Fig. 6.5) south east of Talakaveri, this zone is extended up to a distance of approximately 2 kilometres and is characterised by weak and structurally disturbed rock mass. Many landslide incidences have also been recorded in this zone which is mainly along the cut slope of the road.

The high susceptibility zone in the north-western part of the area near Talakaveri temple (Fig. 6.6) extends a distance of about 350 m and is characterised by loose debris which has accumulated in the run-out part of the landslide and adjacent hill slopes which is having weak rock mass. This area is having a previous record of having few debris slides and is still

vulnerable due to cut slopes and poor rock condition. The high susceptibility zone, south-east of the Talakaveri slide, below the road is of minimal risk as the down slope areas do not have any human settlement.



Fig. 6.5: A high susceptibility zone on SH-90



Fig. 6.6: Talakaveri landslide in the high susceptibility zone

There are many smaller high susceptible patches throughout the southern part of the study area. These areas have the propensity to generate landslides, however, owing to less interference to the natural slope and drainages, low relief and good vegetation cover, these areas have been unaffected by landslides.

6.2.2 Moderate Susceptible Zones

The moderate susceptibility class is observed throughout the study area flanking the high susceptibility zones. 22% of the study area falls under moderate susceptibility zone. Majority of the moderate susceptibility zone is observed in the debris slide domain. The moderate susceptibility patches are observed in the south-east part of the study area. This area is characterised by dense and moderate vegetation and thin soil cover. The landslides observed in the moderate susceptibility zones are shallow landslides with less run out areas (Fig. 6.7). However, in case of extreme or incessant rainfall, the slide run out material may be more.



Fig. 6.7: A moderately susceptible cut slope on SH-90

6.2.3 Low Susceptible Zones

Nearly 52% of the area falls under the low susceptibility class. Good rock mass condition, vegetation cover and low influx of artificial drainage water contribute to the low susceptibility of the area. The area is also characterised by gentle slopes (Fig. 6.8) which also contribute to the lesser landslide incidences. The high percentage of vegetation cover (67% of the area) also helps in the stability of the slopes due to root cohesion. Good land use

management with scientific modification of slopes for any construction activities would help in sustainable development in the area by keeping the risks related to landslide at a minimum.



Fig. 6.8: Gently sloping low susceptibility zone near Bhagamandla

6.3 Validation of Susceptibility Map

The landslide susceptibility map was validated by calculating the landslide pixels falling in each susceptibility class. To validate the susceptibility map, the landslide incidence map was crossed with the final landslide susceptibility map in ArcGIS. The analysis calculates the area of the landslide polygons falling in the different susceptibility classes. It shows that 84% of landslide area falls in high susceptibility zone, 14% landslide area in moderate susceptibility and 2% in low susceptibility zones (Fig. 6.9). The high and moderate zones together classify 98% of the landslide incidences.

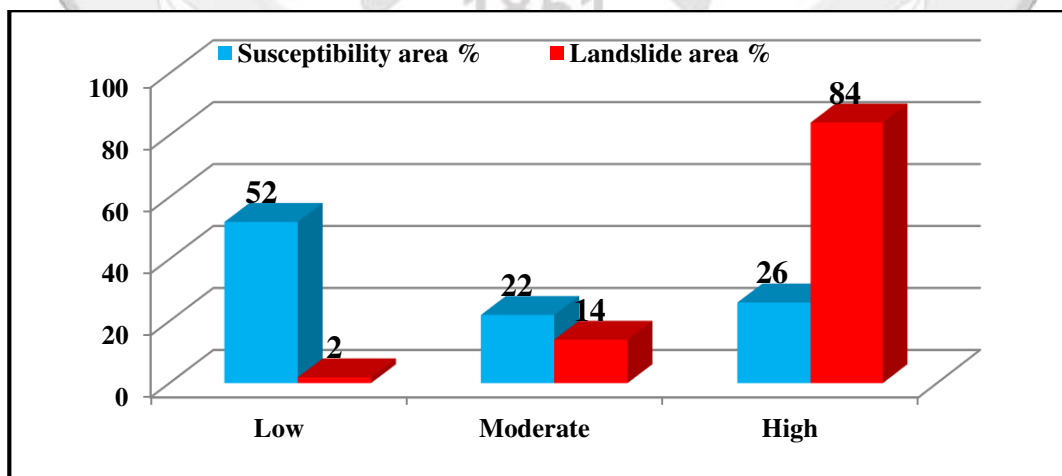


Fig. 6.9: Bar diagram showing landslide area % in various susceptibility classes

CHAPTER 7: ELEMENTS AT RISK AND LANDSLIDE MANAGEMENT MAP

7.1 Elements at risk

Landslide management map serves as a reference for the stakeholders on the mitigation measures to be taken up in the area of study. A total of four houses have been observed to be affected by landslides in the study area. All the houses have steep cut slopes and minor landslides on these slopes (Fig. 7.4). Apart from this, the road stretch from Bhagmandala to Talakaveri has many vulnerable zones which are marked in the Element at risk map (Fig. 7.1). Out of these, the important stretches are a 1.1 km zone along the hairpin bend (Fig.7.2) and a 250m zone near the Talakaveri temple (Fig. 7.3).

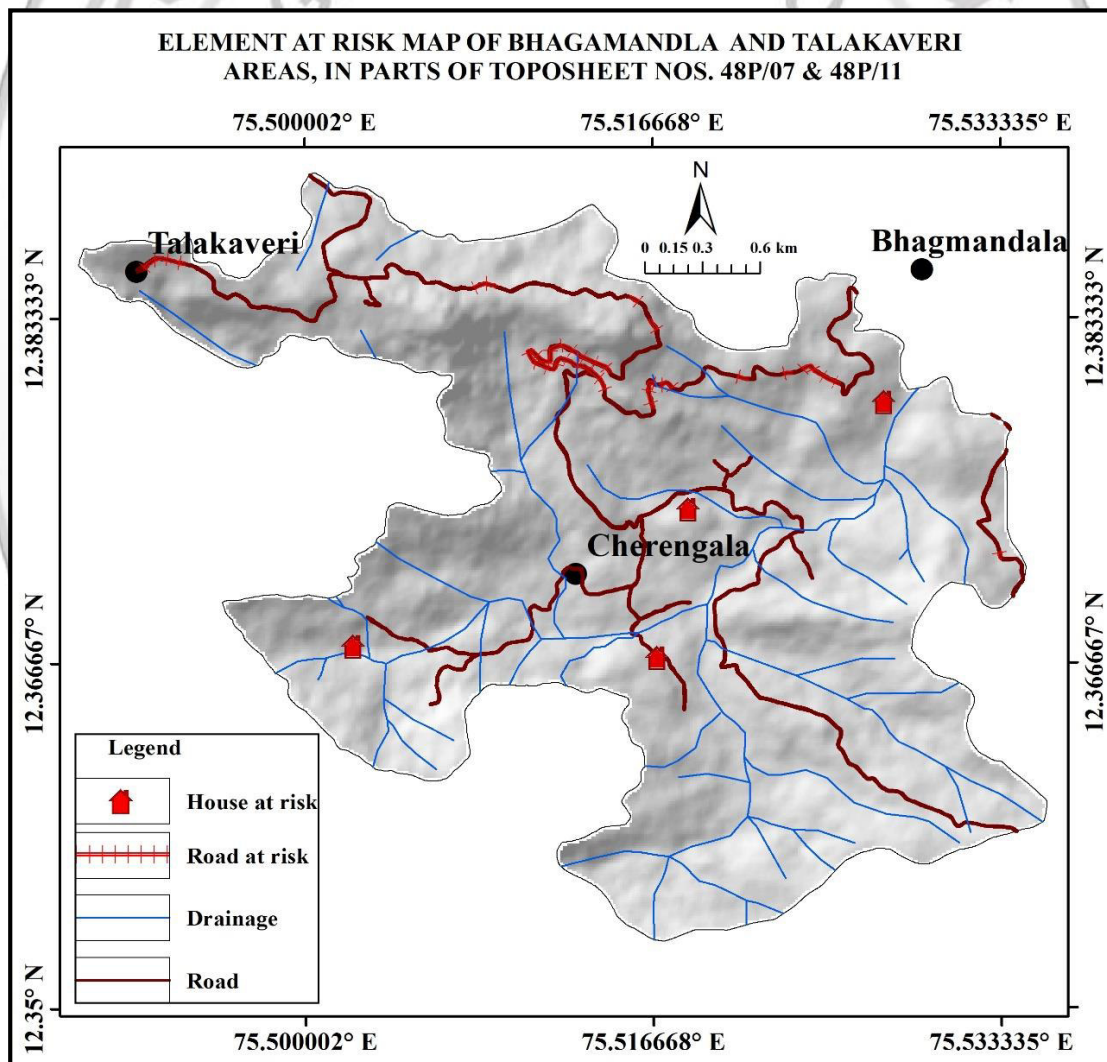


Fig. 7.1: Element at risk map

The zone near the hairpin bends along the Bhagmandala-Talakaveri road section is characterized by rocks with poor to fair rock RMR classes. The area also has sheared granite along with the Enderbite making such zones vulnerable to landslides. The major element at risk

has already been done in the area. Any roadblock in this region will cut off the vehicular traffic to Talakaveri as this is the only approach road to the temple. It is recommended to stabilize the landslide-affected stretches by providing support measures for existing landslides and avoid any further slope modification or deforestation in the zone.



Fig. 7.2: Vulnerable zone at the hairpin bend on Bhagamandala-Talakaveri road

The vulnerable road stretch near Takalaveri temple starts after the entry gate of the temple and extends till the police outpost near the temple as marked in Fig. 7.3. It is recommended to provide stabilization to all the cut slopes in this zone as the area has a huge influx of tourists throughout the year. Proper drainage channelization should also be done to carry the excess runoff away from the area. Any further slope cuts in the zone should be avoided.



Fig. 7.3: Vulnerable road stretch near Talakaveri temple



Fig. 7.4: Vulnerable houses near Cherengala

7.2 Landslide management map

The Landslide Management map (Fig. 7.5) is prepared to provide a ready reference to stakeholders on specific trouble spots, safe shelter locations and remedial measures for each vulnerable locality. The specific locations mentioned in the landslide management map and

element at risk map are aimed to provide necessary information to the administration regarding the trouble spots so that the resources are optimally utilised in the study area.

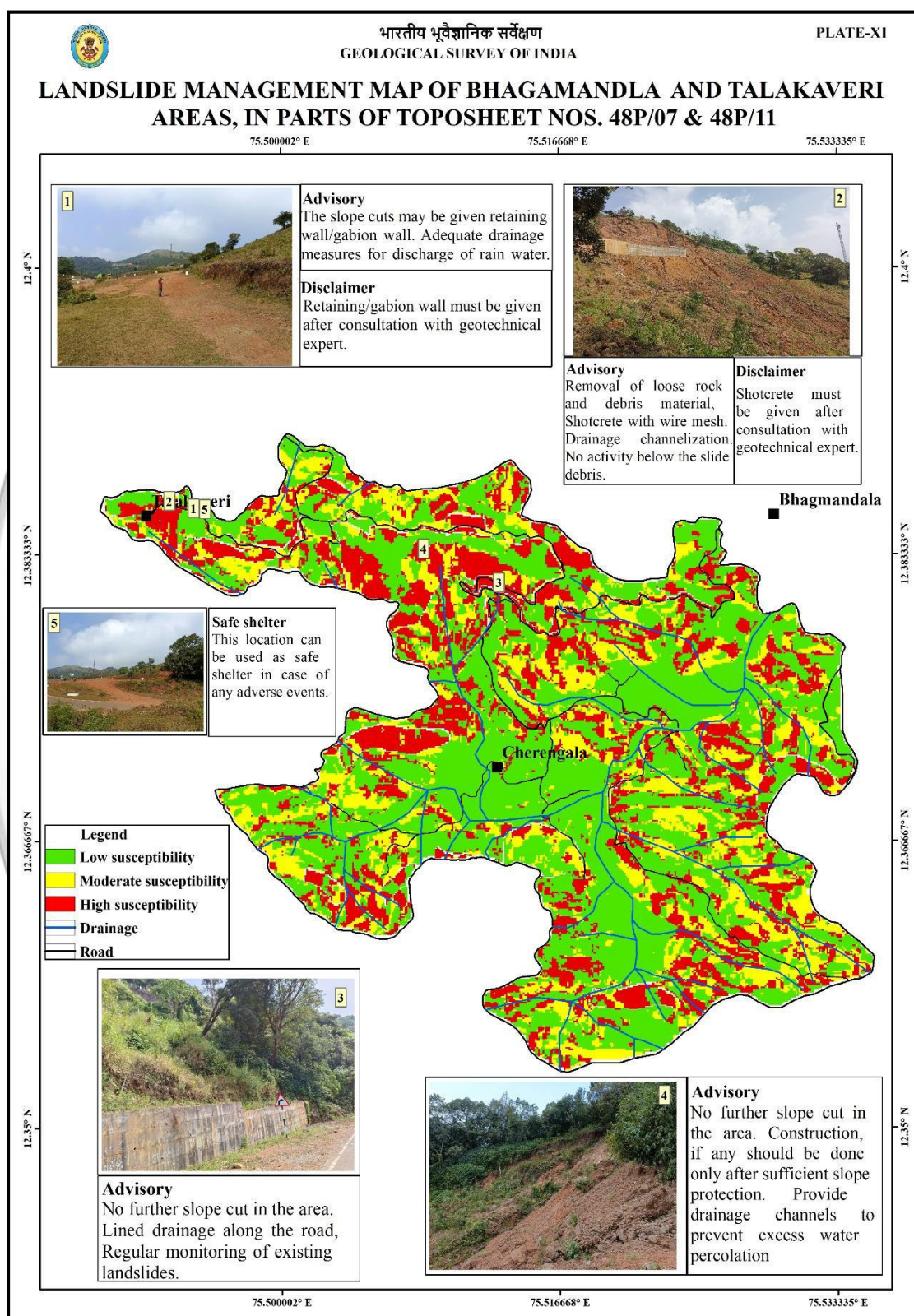


Fig. 7.5: Landslide management map

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

1. The study area, spanning 10 sq.km, lies in SOI toposheet no's 48P/07 & 48P/11 and is bounded by latitudes 12°21'00"N to 12°23'30"N and longitudes 75°29'00"E to 75°32'30"E respectively. The study area is located in Kodagu district, Karnataka around 36 km away from Madikeri town. The area is a part of the Western Ghats. The minimum and maximum elevations of the area are 789m (near Bhagamandala) and 1256m (near Talakaveri) respectively. The study area is having mostly low to extremely low relief. Relatively higher relief is observed in the Northern part of the area. The area is drained by Cauvery River and its tributaries. The highest drainage order observed in the area is 5 and the prominent drainage pattern in the area is dendritic in nature.
2. The dominant litho unit in the study area is Enderbite. The rock is generally massive in most of the places however; it shows metamorphic bandings at few localities. The Enderbite is intruded by white to buff colored granite at places. The granite body is sheared and show elongated quartz grains. The Enderbite has also undergone alteration which has been classified as altered enderbite.
3. The proposed study area is a part of the Kaveri river basin and the Kaveri River originates within the proposed area. The study area experiences inflow of tourists and devotees visiting the Talakaveri Temple (origin of the Kaveri River) and Brahmagiri hills.
4. The landslide incidence map of the study area was prepared using pre-field landslides digitized from multi-temporal satellite imagery of Google Earth and using the data collected during fieldwork which includes a total no of 45 landslides/slope instabilities with 22 debris slides and 23 rockslides. The majority of the landslides in the study area are along the cut slopes of the road and in the back slopes of a few settlements where the slope has been modified and has their causative factors linked to anthropogenic activities. These landslides are observed to be smaller in dimensions; however, they may reactivate during incessant rainfalls. The most prominent landslide is the Talakaveri slide, a debris slide that occurred in 2020.
5. For this study, Slope, Relative Relief (RR), Geomorphon/Landform, Stream Power Index (SPI), Land Use Land Cover (LULC), Slope Forming Material (SFM), Overburden thickness, Geotechnical property (GT), and Kinematic disposition of joints were chosen as various variables that are significant from the slope stability point of view. Apart from Slope, Relative Relief, Landform and SPI, which are DEM derived products, all the other maps are field based thematic maps.

6. The ratings are assigned heuristically based on the field observations, landslide inventory data and knowledge of the terrain conditions. Since the rocky slopes, debris covered slopes and cut slopes have different factors governing the initiation of landslides, the susceptibility modelling for them was carried out separately with a different set of thematic maps used for each of the models.
7. For rockslide domain, Kinematic failure, Geotechnical, Geomorphon, Slope and Relative Relief maps are used and for debris slide domain, Slope, Geomorphon/Landform, Stream Power Index, Relative Relief, Land Use Land Cover, Slope Forming Material and Geotechnical maps are used. For the cut slope domain, Relative Relief, Slope, Geotechnical and Overburden thickness are used. The final thematic maps were integrated in GIS platform using the Multi Class Index Overlay method (Bonham-Carter, 1994). The susceptibility maps for rock slide, debris slide and cut slope domains were combined to form the final landslide susceptibility map.
8. The landslide susceptibility map classifies 26% (2.6 sq km) of the study area into “High”, 22% (2.2 sq km) of area into “Moderate” and 52% (5.2 sq km) of the area into “Low” susceptibility classes.
9. The Landslide Management map provides a ready reference to stakeholders on specific trouble spots, safe shelter locations and remedial measures for each vulnerable locality. The specific locations mentioned in the landslide management map and element at risk map are aimed to provide necessary information to the administration regarding the trouble spots so that the resources are optimally utilised in the study area.

8.2 Recommendations

1. The landslide susceptibility map shows the possible locations for landslide initiation and should always be studied by taking into account the possible flow path of the landslide. Settlements or other important elements at risk in the downslope may also get affected if they are in the flow path of the landslide.
2. The High susceptible zones are to be avoided for any planning and construction activities. However, if any construction is unavoidable in high zones, detailed site specific studies must be carried out and proper mitigation measures are to be taken.
3. Slope cuts for road widening or construction of houses should be avoided whenever possible. However, in unavoidable circumstances, proper support structures should be provided for the stability of the slope.
4. Construction of retaining walls should adhere to existing design guidelines such as IS 14458 (part 2): 1997. Provisions for water seepage should be given in all support walls and maintained annually for the longevity of the structure.

5. The Talakaveri landslide is one of the major landslides in the area. The slide zone should be given proper lined drainage to divert excess rainwater away from the zone. The diverted water should be drained out to natural drainage channels and not to natural slopes. The natural drainages in the hill slope should not be modified or obstructed. The slide scar has many open joints and precarious boulders on the slope. The boulders and debris material may be cleared from the slide scar and shotcreting may be done to prevent further aggravation. Slope cuts should be strictly avoided in and around the slide zone and a retaining wall with adequate weep holes may be provided for any exposed slope cut. The run-out path of the landslide has a huge amount of loose debris material and any construction/parking area should be strictly avoided in the downslope. A retaining wall may be provided for the cut slopes in the newly constructed parking areas near the temple.
6. Majority of the landslides in the area are caused by anthropogenic activities with rainfall acting as a trigger. Cut slopes along the road should be given adequate support measures like gabion walls or retaining walls. Toe drains along the road should be lined and maintained annually for an unhindered flow of excess water.
7. It is recommended that priority should be given to increasing awareness amongst people through Community-Based Disaster Management Programme (CBDMP) since the most vital factor is the response of the public to the advice/call of administration and geoscientists during the major landslide events. The awareness should include information about the potential danger, its identification and communication, the physical significance of a hazard and inherent uncertainties, ways to reduce landslide risk and the available local mitigation options. Villages or communities located in and around highly susceptible areas should be given priority in holding CBDMP. The public awareness program will only be helpful when the public response to their call is positive.

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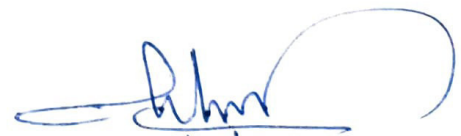
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Standard Operating Procedure (SOP) for Meso scale (1:10,000/5000) Landslide Susceptibility Mapping, 2021.

FIVE POINT PROFORMA

Title of the report: Meso-scale (1:10,000) Landslide Susceptibility Mapping in Bhagamandla and TalaKaveri Hill Townships, Kodagu district, Karnataka	
1. Background of the investigation at whose instance or with what particular objective in view the investigation was undertaken.	The present item is linked with Meso Scale Landslide Susceptibility Mapping (MLSM) Programme of GSI. The item was taken up with a view to prepare 1:10,000 scale landslide susceptibility map on GIS platform by integrating rated and weighted thematic geo-factor map, to identify the causative factors and to suggest preliminary mitigation measures
2. Whether the item of the investigation was included in the approved program for the year concerned. If so, particulars, such as item No. page reference etc. may be given.	Item Code No.: M4LSSM/NC/SR/SU-KG/2022/42401 FSP: 2022-23
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.	Field Initiation Date: 30/08/2022 No. of Personnel Involved: 02 Field Days: 1. Rahul Vadakkedath, Senior Geologist: 94 days 2. Manisha Biswal, Senior Geologist: 93 days
4. Brief comments by Director / Supervisory officer on the conclusion and recommendation by the author(s) with suggestions for implementing the same.	The susceptibility map for landslides divides the study area into different classes: "High" susceptibility covers 26% (2.6 Sq. Km), "Moderate" covers 22% (2.2 Sq. Km), and "Low" susceptibility covers 52% (5.2 Sq. Km) of the total area. Implementing effective land use strategies and applying scientific techniques to adjust slopes for construction endeavours would contribute to sustainable development in this region while minimizing the potential risks associated with landslides. It is recommended to avoid planning and construction activities in the High susceptibility zones. However, if construction in these areas is unavoidable, it becomes crucial to conduct thorough site-specific assessments and implement appropriate mitigation measures.
5. Please state specifically how the results of the investigation were achieved compared with the objective for which it was undertaken	The stated objective of the item was preparation of Meso-scale Landslide Susceptibility Mapping, which has been successfully achieved. Specific pieces of advice given by the Supervisor after field inspection visit(s) are recorded in Tour Notes for the relevant period.

Place: Bangalore
Date: 29/09/2023


29/09/2023
(R Sajeed)

Director (G) & Supervisory Officer



Geological Survey of India
Certificate of Quality of the report

Project/Division: *NLSM*

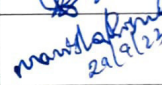
FSP No: M4LSSM/NC/SR/SU-KG/2022/42401

Mission: *IV*

Title of the report: Meso-scale (1:10,000) Landslide Susceptibility Mapping in Bhagmandala and Talakaveri hill townships, Kodagu district, 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 the required laboratory analysis, compilation and synthesis of field data, coalition of the data and writing of the report as per the approved guidelines. The duration of field stay of each officer(s) is as against his/her name.

Name(s)/Designation of the Field Officer	Total field stay during the FSP (no. of days)	Signature with date
1. Rahul Vadakkedath, Sr. Geologist	94	 29/9/23
2. Manisha Biswal, Sr. Geologist	93	 29/9/23

Part-B

This is to certify that drilling has been carried out and completed as per the table given below:

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

Part-C

This is to certify that geophysical component of the item has been carried out as per the table given below:

Name(s)/Designation of Geophysist	Date of commencement of work	Date of completion of work	Signature with date of the Geophysist
NA			

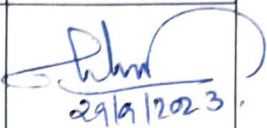
Part-D

This is to certify that the chemical analysis of the geological samples has been carried out as per the table given below:

Name of Director in charge of the Chemical Lab	Dates of receipt of samples from the field officer/party	Date of providing complete analytical results to the field officer	Signature with date of the Director Chemistry
NA			

Part-E

This is to certify that the below mentioned Supervisory Officer(s) 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 below table. 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)/Designation of the Supervisory Officer	No. of inspection visits made to the field area	Total no. of days spent on inspection visit	Signature with date
Dr R Sajeev, Director	2	6	 29/6/2023

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(s)/Designation of the Regional Mission Head	Signature with date

Part-G

This is to certify that the above report has been scrutinized at various levels and has also been peer reviewed. On being satisfied regarding the scientific contents and the Quality of the report, the undersigned has accorded approval for its circulation

Name(s)/Designation of the Regional HoD	Signature with date

CHECK LIST FOR PEER REVIEWER

Topics		Comments of Peer Reviewer
1.	Whether the aims and objectives of the item has been achieved	
2.	Density of data collection required for achieving the target	
3.	Analysis and interpretation of the basic data	
4.	Collection of samples as per NQT	
5.	Analytical data incorporated, analysed and proper interpretation	
6.	Requisite lab studies, petrology, petrography and its interpretation	
7.	Has the report brought out the required outcome keeping in view the aims, objective and in light of the back ground information provided in the item/NQT	
8.	Has the investigation been brought to a logical conclusion and recommended properly for follow up	
9.	Grade (in a scale 1-10), Specially from the quality, content and usefulness for end user	
10.	General comments on Report and scope for follow up/ improvement	

Date:

Signature:

Place:

Name:

Designation:



APPENDIX-IV

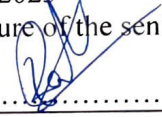
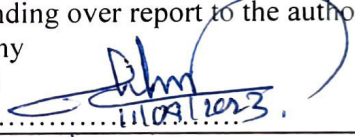
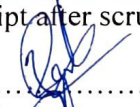
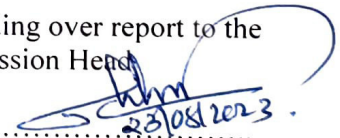
Geological Survey of India
Data sheet on report movement in connection with its scrutiny

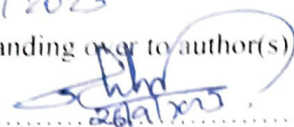
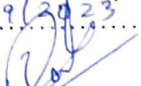
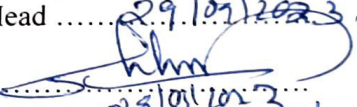
Project/Division: Meso Scale (1:10,000) Landslide Susceptibility Mapping

FSP No: M4LSSM/NC/SR/SU-KG/2022/42401

Mission: IV

Title of the report: Meso-scale (1:10,000) Landslide Susceptibility Mapping in Bhagamandla and TalaKaveri Hill Townships, Kodagu district, Karnataka.

Name of author(s) 1. Rahul Vadakkedath, Senior Geologist 2. Manisha Biswal, Senior Geologist	Date of submission of report to the Supervisory Officer 02/08/2023 Signature of the senior most author 
Name of Supervisory Officer Dr. R. Sajeed, Director	Date of receipt of report 02/08/2023 Date of completion of scrutiny 11/08/2023 Date of handing over report to the author after scrutiny 11/08/2023 Signature 
Name of author(s) To whom the report has been handed over by the Supervisory Officer 1. Rahul Vadakkedath, Senior Geologist 2. Manisha Biswal, Senior Geologist	Date of receipt after scrutiny 11/08/2023 Signature.....  Date of resubmission 23/08/2023 Signature..... 
Supervisory Officer Dr. R. Sajeed, Director	Date of receipt after modification 23/08/2023 Date of handing over report to the Regional Mission Head 23/08/2023 Signature 
Name of Regional Mission Head	Date of receipt of report Date of handing over the report after peer review to the Project Director Signature.....

Name of Supervisory Officer Dr. R. Sajeelv, Director	Date of receipt from the Regional Mission Head after peer review 26/09/2023 Date of handing over to author(s) Signature..... 
Name of author(s) 1. Rahul Vadakkedath, Senior Geologist 2. Manisha Biswal, Senior Geologist	Date of receipt of report from Supervisory Officer 26/09/2023 Date of handing over report after modification to Supervisory Officer 27/09/2023 Signature..... 
Name of Supervisory Officer Dr. R. Sajeelv, Director	Date of receipt of report after modification from the author(s) 27/09/2023 Date of handing over report to Regional Mission Head 29/09/2023 Signature..... 
Name of Regional Mission Head	Date of receipt after modification from the Project Director..... Date of handing over the report to the HoD of the Region for approval Signature.....
Name of the HoD of the Region	Date of receipt of report for approval Date of approval..... Date of sending back report to Project Director..... Signature of the HoD.....
Name of the Project Director	Date of receipt of report after approval of HoD..... Date of circulation of report..... Signature.....

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/01
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Bhagamandla-Talakaveri road, SH-90, Cherengala
7	Latitude	12.380182
8	Longitude	75.514365
9	Landslide category	
10	Length	~9m
11	Width	~10m
12	Height	~7m
13	Area	--
14	Depth	~2m
15	Volume	--
16	Run out distance	>50m till nala
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Suspended
21	Distribution	Confined
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	2019 monsoon as informed by locals
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Sheared granite
28	Structure	J150°/75°→320°, J2 325°/50°→55°, J3 45°/65°→135°, J4 60°/47°→330°
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked and damaged
36	Infrastructure	--
37	Land use land cover	--

	affected	
38	Geo-scientific Causes	Saturation of debris exposed in slope cut due to heavy rainfall
39	Remedial measures	--
40	Remarks, if any	Tilting of trees observed near crown area
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P07/2022/02
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/07
5	Name of the slide	Tala Kaveri landslide
6	NH/SH/Locality	Bhagamandla-Talakaveri road, SH-90, Near Talakaveri temple
7	Latitude	12.386287
8	Longitude	75.493640
9	Landslide category	II
10	Length	~55m
11	Width	~65m
12	Height	~45m
13	Area	--
14	Depth	>5m
15	Volume	--
16	Run out distance	~1 km
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Advancing
22	Style	Single
23	Failure mechanism	Deep translational
24	Initiation year	The landslide was first reported by GSI in 2017 when cracks were identified in the crown area.
25	Reactivation details	It reactivated on 09/08/2019 blocking the approach road to the temple.
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite and granite
28	Structure	J1 125°/64°→215°, J2 305°/45°→35°, J3 15°/88°→105°, J4 20°/56°→290°
29	Land use/ Land cover	Sparse vegetation
30	Hydrological condition	Dry
31	Triggering Factor	Rainfall
32	Death of persons	05
33	People affected	05
34	Live-stock loss	--

35	Communication affected	Road blocked and damaged
36	Infrastructure	One house washed away
37	Land use land cover affected	Vegetation
38	Geo-scientific Causes	The landslide was first reported by GSI in 2017 when cracks were identified in the crown area. It was subsequently reported when it reactivated on 09/08/2019 blocking the approach road to the temple. The landslide which initiated as a cut slope failure retrogressed over the years before reactivating on 06/08/2020 after intense rainfall. The area received antecedent rainfall of 172 mm and 185 mm followed by 478 mm rainfall on the date of initiation of the landslide. The extreme rainfall acted as the trigger for the main landslide event in the already destabilized zone. Previous photographs of the slide zone reveal a considerable amount of debris material in the slope. The antecedent rainfall during 04/08/2020 to 06/08/2020 might have oversaturated the debris material and the rainfall event of 478 mm on 06/08/2020 acted as a trigger. The landslide would have washed out the debris material in the down slope leading to the massive debris flow.
39	Remedial measures	1. The natural drainage channels in the hill slope are discharging the runoff water directly to the approach road to Talakaveri temple. The water may be channelized using lined toe drains and drained away from the area. 2. There are many benches and ditches above the crown of the landslide which are made for afforestation. Rainwater should not be allowed to collect in these areas. Hence, the ditches may be filled with soil and the benches may be given a gradient so that the water is drained off the surface. 3. The loose rocks in the flanks of the slide may be mechanically removed and the exposed rocky area may be provided with shotcrete treatment. 4. The left and right flanks of the landslide have debris material in the slope. These areas are to be protected with RCC breast wall to prevent further retrogradation of the landslide. While designing the walls, adequate weep holes should be given in the wall for draining out the excess water. 5. There should not be any further slope in the zone without providing support measures. 6. The police outpost near the Talakaveri temple is also constructed after a steep slope cut without any support measures. A breast wall may be provided in this location for the stability of the slope 7. The design parameters of the walls should be

		finalized after detailed site-specific studies
40	Remarks, if any	
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	



No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/03
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.379230
8	Longitude	75.527712
9	Landslide category	III
10	Length	~5m
11	Width	~8m
12	Height	~4m
13	Area	--
14	Depth	0-1m
15	Volume	--
16	Run out distance	~2 m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow planar
24	Initiation year	2019 monsoon as informed by locals
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	weathered granite
28	Structure	J1 342°/70°→72°
29	Land use/ Land cover	Plantation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Highly weathered granite resting on a slope cut, slided because of rainfall. Along the joint plane ($342^{\circ}/70^{\circ} \rightarrow 72^{\circ}$) failure has occurred.
39	Remedial measures	Suitable retaining wall as per site condition
40	Remarks, if any	A house is located below the slide
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/04
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.375952
8	Longitude	75.529408
9	Landslide category	III
10	Length	~3m
11	Width	~6m
12	Height	~2m
13	Area	--
14	Depth	2-3m
15	Volume	--
16	Run out distance	~5 m
17	Type of Material	Debris
18	Type of movement	Slump
19	Rate of movement	Rapid
20	Activity	Suspended
21	Distribution	Confined
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	2019 as informed by locals
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Plantation and moderate vegetation
30	Hydrological condition	Dry
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	One family
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	Plantation

38	Geo-scientific Causes	High water discharge during rain caused slumping and covered the well.
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/05
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.379372
8	Longitude	75.523307
9	Landslide category	III
10	Length	~7m
11	Width	~5m
12	Height	~3m
13	Area	--
14	Depth	>5m
15	Volume	--
16	Run out distance	~15-20 m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Suspended
21	Distribution	Confined
22	Style	Single
23	Failure mechanism	Deep rotational
24	Initiation year	09/08/2019 as informed by locals
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Plantation and moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road damaged
36	Infrastructure	--
37	Land use land cover affected	Plantation

38	Geo-scientific Causes	Saturation of debris by incessant rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide 	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/06
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.378642
8	Longitude	75.522113
9	Landslide category	III
10	Length	~6m
11	Width	~5m
12	Height	~3m
13	Area	--
14	Depth	>5m
15	Volume	--
16	Run out distance	~50-100 m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Suspended
21	Distribution	Confined
22	Style	Single
23	Failure mechanism	Deep rotational
24	Initiation year	09/08/2019 as informed by locals
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Plantation and moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	Plantation

38	Geo-scientific Causes	Saturation of debris by incessant rainfall
39	Remedial measures	--
40	Remarks, if any	Nala flowing below slide towards N150° and slide direction is N150°.
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

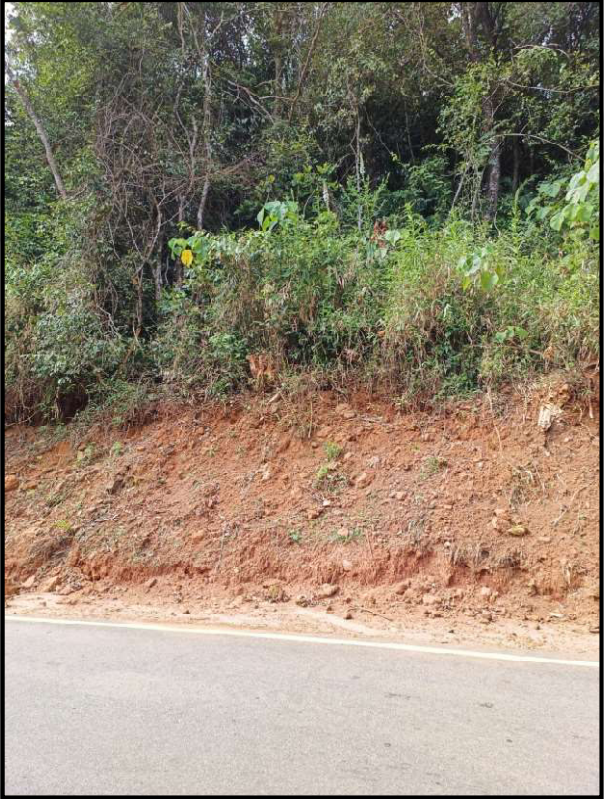
No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/07
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.373797
8	Longitude	75.519708
9	Landslide category	III
10	Length	~6m
11	Width	~15m
12	Height	~6m
13	Area	--
14	Depth	~2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Suspended
21	Distribution	Confined
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	09/08/2019 as informed by locals
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Plantation
30	Hydrological condition	Dry
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	One family
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	One house damaged
37	Land use land cover affected	--

38	Geo-scientific Causes	Cut slope failure due to heavy rainfall
39	Remedial measures	Retaining wall
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/08
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.374252
8	Longitude	75.518455
9	Landslide category	III
10	Length	~8m
11	Width	~4m
12	Height	~7m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock (Highly weathered behaving as debris)
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	August 2019 as informed by locals
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Weathered Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation in the up slope
30	Hydrological condition	Wet
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	One building damaged
37	Land use land cover affected	Forest

38	Geo-scientific Causes	Oversaturation of debris due to heavy rainfall
39	Remedial measures	Retaining wall with appropriate weep holes.
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/09
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.380165
8	Longitude	75.525498
9	Landslide category	III
10	Length	~3m
11	Width	~8m
12	Height	~2.5m
13	Area	--
14	Depth	~2-3m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Multiple
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Oversaturation of debris due to heavy rainfall
39	Remedial measures	Gabion wall
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/10
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.380450
8	Longitude	75.525045
9	Landslide category	III
10	Length	~3m
11	Width	~12m
12	Height	~2.5m
13	Area	--
14	Depth	~2-3m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Multiple
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Oversaturation of debris due to heavy rainfall
39	Remedial measures	Gabion wall
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/11
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.380877
8	Longitude	75.524278
9	Landslide category	III
10	Length	~8m
11	Width	~12m
12	Height	~7m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 330°/85°→60°, J2 330°/35°→60°, J3 100°/65°→190°
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Weathered rock exposed on road cut having valley facing joint
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

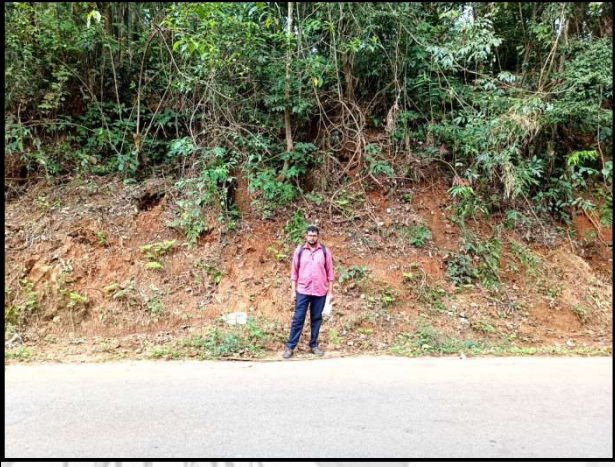
No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/12
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.380853
8	Longitude	75.523998
9	Landslide category	III
10	Length	~8m
11	Width	~10m
12	Height	~7m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~10m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 330°/85°→60°, J2 330°/35°→60°, J3 100°/65°→190°
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Weathered rock exposed on road cut
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide 	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/13
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.380597
8	Longitude	75.523178
9	Landslide category	III
10	Length	~6m
11	Width	~10m
12	Height	~5m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 310°-vertical, J2 110°/25°→200°, J3 355°/40°→85°, J4 85°/70°→355°
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover	--

	affected	
38	Geo-scientific Causes	Highly jointed rock exposed on cut slope
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/14
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.380333
8	Longitude	75.520903
9	Landslide category	III
10	Length	~5m
11	Width	~15m
12	Height	~4m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~10m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Multiple
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Saturation of debris due to rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/15
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.380138
8	Longitude	75.516737
9	Landslide category	III
10	Length	~6m
11	Width	~12m
12	Height	~5m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Multiple
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Saturation of debris due to rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/16
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala
7	Latitude	12.379932
8	Longitude	75.516482
9	Landslide category	III
10	Length	~8m
11	Width	~15m
12	Height	~7m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Highly weathered and sheared rock exposed on road cut
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/17
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Kodi road, Cherengala
7	Latitude	12.379768
8	Longitude	75.512708
9	Landslide category	III
10	Length	~8m
11	Width	~10m
12	Height	~7m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~20m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Suspended
21	Distribution	Confined
22	Style	Single
23	Failure mechanism	Shallow planar
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Plantation in upslope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Highly weathered rock resting over cut slope, failed due to oversaturation
39	Remedial measures	Gabion wall
40	Remarks, if any	One house in the down slope shifted due to slide
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/18
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Kodi road, Cherengala
7	Latitude	12.378937
8	Longitude	75.512517
9	Landslide category	III
10	Length	~8m
11	Width	~30m
12	Height	~7m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~10m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Multiple
23	Failure mechanism	Shallow rotational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation by rainfall
39	Remedial measures	Gabion wall
40	Remarks, if any	
41	Photos. Sketch of Plan & section of the slide 	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/19
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Bhagamandla
7	Latitude	12.371728
8	Longitude	75.533278
9	Landslide category	III
10	Length	~7m
11	Width	~12m
12	Height	~6m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~3m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Inactive
21	Distribution	Enlarging
22	Style	Multiple
23	Failure mechanism	Shallow translational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Retrograde Enderbite
28	Structure	--
29	Land use/ Land cover	Coffee plantation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	Plantation

38	Geo-scientific Causes	Highly weathered rock exposed along cut slope
39	Remedial measures	--
40	Remarks, if any	
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/20
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Kodi
7	Latitude	12.367555
8	Longitude	75.502328
9	Landslide category	III
10	Length	~5m
11	Width	~6m
12	Height	~4m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	2022 July
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Coffee plantation
30	Hydrological condition	Dry
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	One family
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	One house
37	Land use land cover affected	--

38	Geo-scientific Causes	Cut slope failure during rainfall
39	Remedial measures	Loose scaling, retaining wall
40	Remarks, if any	
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/21
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.380947
8	Longitude	75.513193
9	Landslide category	III
10	Length	~20m
11	Width	~25m
12	Height	~18m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~20m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Multiple
23	Failure mechanism	Shallow rotational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 50°-vertical, J2 125°/30°→35°, J3 310°/40°→220°
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Dripping
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation by rainfall and water seepage
39	Remedial measures	retaining wall given
40	Remarks, if any	Tilting of trees observed
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/22
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.381008
8	Longitude	75.513000
9	Landslide category	III
10	Length	~5m
11	Width	~12m
12	Height	~4m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	2020
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 50°-vertical, J2 125°/30°→35°, J3 310°/40°→220°
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation by rainfall.
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/23
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.380992
8	Longitude	75.511998
9	Landslide category	III
10	Length	~6m
11	Width	~25m
12	Height	~5m
13	Area	--
14	Depth	>5m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Multiple
23	Failure mechanism	Deep rotational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation by rainfall.
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/24
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.381488
8	Longitude	75.511160
9	Landslide category	III
10	Length	~9m
11	Width	~30m
12	Height	~8m
13	Area	--
14	Depth	>5m
15	Volume	--
16	Run out distance	~7m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Deep rotational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Cut slope, plantation upslope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Loose debris saturation by rainfall.
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/25
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.381898
8	Longitude	75.512563
9	Landslide category	III
10	Length	~10m
11	Width	~20m
12	Height	~8m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~8m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Granite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Highly weathered rock and debris saturation due to rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/26
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.381198
8	Longitude	75.513338
9	Landslide category	III
10	Length	~10m
11	Width	~15m
12	Height	~8m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 120°/30°→30°, J2 310°/55°→40°, J3 285°/80°→195°
29	Land use/ Land cover	Sparse vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation by rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/27
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.380998
8	Longitude	75.514303
9	Landslide category	III
10	Length	~18m
11	Width	~10m
12	Height	~15m
13	Area	--
14	Depth	~3m
15	Volume	--
16	Run out distance	~10m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Moderately dissected hill
27	Geology	Enderbite
28	Structure	J1 60°/68°→150°, J2 130°/46°→220°, J3 310°/73°→40°
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Valley dipping joint daylighted in cut slope, heavy rainfall
39	Remedial measures	Loose scaling, RCC breast wall
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/28
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.380998
8	Longitude	75.514303
9	Landslide category	III
10	Length	~10m
11	Width	~9m
12	Height	~9m
13	Area	--
14	Depth	~3m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	2019
25	Reactivation details	--
26	Geomorphology	Moderately dissected hill
27	Geology	Enderbite
28	Structure	J1 60°/68°→150°, J2 130°/46°→220°, J3 310°/73°→40°
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Valley dipping joint daylighted in cut slope, heavy rainfall
39	Remedial measures	Loose scaling, RCC breast wall
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/29
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.380947
8	Longitude	75.515263
9	Landslide category	III
10	Length	~7m
11	Width	~8m
12	Height	~6m
13	Area	--
14	Depth	~3m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 60°/68°→150°, J2 130°/46°→220°, J3 310°/73°→40°
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation by rainfall
39	Remedial measures	Lined drainage, gabion wall
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/30
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.382953
8	Longitude	75.516983
9	Landslide category	III
10	Length	~5m
11	Width	~15m
12	Height	~4m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 140°/45°→50°, J2 210° - sub vertical, J3 290° - sub vertical, J4 285°/35°→195°,
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover	--

	affected	
38	Geo-scientific Causes	Highly weathered rock failed along valley facing joints
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/31
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.384172
8	Longitude	75.515870
9	Landslide category	III
10	Length	~7m
11	Width	~18m
12	Height	~5m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Multiple
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 200°/80°→290°, J2 255°/55°→345°, J3 135°/60°→45°,
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Planar failure along valley facing joints
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/32
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.384928
8	Longitude	75.508825
9	Landslide category	II
10	Length	~15m
11	Width	~30m
12	Height	~12m
13	Area	--
14	Depth	>5m
15	Volume	--
16	Run out distance	~50m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Deep translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 250°/45°→160°, J2 200°-Vertical
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked and damaged
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Highly weathered rock behaving as debris material failed due to rainfall
39	Remedial measures	Retaining wall given
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/33
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Cherengala, SH-90
7	Latitude	12.384862
8	Longitude	75.508253
9	Landslide category	III
10	Length	~7m
11	Width	~15m
12	Height	~5m
13	Area	--
14	Depth	~2-5m
15	Volume	--
16	Run out distance	~4m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Deep translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 250°/45°→160°, J2 200°-Vertical
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	Road blocked and damaged
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Highly weathered rock behaving as debris material failed due to rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/34
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri
7	Latitude	12.383911
8	Longitude	75.508262
9	Landslide category	III
10	Length	~85m
11	Width	~65m
12	Height	~60m
13	Area	--
14	Depth	~5-10m
15	Volume	--
16	Run out distance	~1000m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Deep translational
24	Initiation year	2020
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 225°/85°→315°, J2 120°/55°→30°, J3 235°/65°→325°,
29	Land use/ Land cover	Dense vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Highly weathered rock behaving as debris material failed due to rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/35
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.385603
8	Longitude	75.504802
9	Landslide category	III
10	Length	~5m
11	Width	~12m
12	Height	~4m
13	Area	--
14	Depth	~2-4m
15	Volume	--
16	Run out distance	~2m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 225°/85°→315°, J2 120°/55°→30°, J3 235°/65°→325°,
29	Land use/ Land cover	Dense vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Weathered rock exposed along cut slope
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/36
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri
7	Latitude	12.387272
8	Longitude	75.501302
9	Landslide category	III
10	Length	~3m
11	Width	~10m
12	Height	~3m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~4m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 225°/85°→315°, J2 120°/55°→30°, J3 235°/65°→325°,
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation due to rainfall
39	Remedial measures	Provision of lined drainage along road
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/37
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.384950
8	Longitude	75.501342
9	Landslide category	III
10	Length	~5m
11	Width	~10m
12	Height	~4m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~2m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Widening
22	Style	Multiple
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 225°/85°→315°, J2 120°/55°→30°, J3 235°/65°→325°,
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Cut slope failure,
39	Remedial measures	No further slope cut is recommended
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/38
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.384253
8	Longitude	75.501427
9	Landslide category	III
10	Length	~7m
11	Width	~10m
12	Height	~5m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~3m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 310°/75°→40°, J2 10°/75°→100°,
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Cut slope failure on a spur,
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/39
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.384158
8	Longitude	75.501330
9	Landslide category	III
10	Length	~8m
11	Width	~12m
12	Height	~7m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~3m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 310°/75°→40°, J2 10°/75°→100°,
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Cut slope failure on a spur,
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/40
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.384010
8	Longitude	75.501107
9	Landslide category	III
10	Length	~5m
11	Width	~8m
12	Height	~4m
13	Area	--
14	Depth	~1-2m
15	Volume	--
16	Run out distance	~2m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 310°/75°→40°, J2 10°/75°→100°, J3 230°/50°→140°, J4 40°/37°→110°,
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover	--

	affected	
38	Geo-scientific Causes	Weathered rock exposed along road cut
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/41
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.383217
8	Longitude	75.500423
9	Landslide category	III
10	Length	~5m
11	Width	~7m
12	Height	~4m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~3m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Weathered rock exposed along road cut
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P11/2022/42
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/11
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.383183
8	Longitude	75.500270
9	Landslide category	III
10	Length	~10m
11	Width	~8m
12	Height	~8m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Rock
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Enlarging
22	Style	Single
23	Failure mechanism	Shallow translational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	J1 245°/40°→155° (Valley dipping joint)
29	Land use/ Land cover	Cut slope
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Weathered rock exposed along road cut, Failure along valley dipping joint
39	Remedial measures	Breast wall
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P07/2022/43
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/07
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.383956
8	Longitude	75.498101
9	Landslide category	III
10	Length	~3m
11	Width	~5m
12	Height	~2m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~2m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation due to rainfall
39	Remedial measures	--
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P07/2022/44
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/07
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.383862
8	Longitude	75.497520
9	Landslide category	II
10	Length	~5m
11	Width	~13m
12	Height	~4m
13	Area	--
14	Depth	~0-1m
15	Volume	--
16	Run out distance	~5m
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation due to rainfall
39	Remedial measures	Retaining wall with adequate weep holes
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

No	Field	
1	Slide No (LS .No.)	KA/Kod/48P07/2022/45
2	State	Karnataka
3	District	Kodagu
4	Toposheet	48P/07
5	Name of the slide	
6	NH/SH/Locality	Near Talakaveri, SH-90
7	Latitude	12.384437
8	Longitude	75.496813
9	Landslide category	II
10	Length	~6m
11	Width	~12m
12	Height	~5m
13	Area	--
14	Depth	~0-2m
15	Volume	--
16	Run out distance	--
17	Type of Material	Debris
18	Type of movement	Slide
19	Rate of movement	Rapid
20	Activity	Active
21	Distribution	Retrogressive
22	Style	Single
23	Failure mechanism	Shallow rotational
24	Initiation year	--
25	Reactivation details	--
26	Geomorphology	Lowly dissected hill
27	Geology	Enderbite
28	Structure	--
29	Land use/ Land cover	Moderate vegetation
30	Hydrological condition	Damp
31	Triggering Factor	Rainfall
32	Death of persons	--
33	People affected	--
34	Live-stock loss	--
35	Communication affected	--
36	Infrastructure	--
37	Land use land cover affected	--

38	Geo-scientific Causes	Debris saturation due to rainfall
39	Remedial measures	Retaining wall with adequate weep holes, lining of drainage and maintenance of the same
40	Remarks, if any	--
41	Photos. Sketch of Plan & section of the slide	
42	Summary/Abstract	

Daily rainfall data of rain gauge station no 468, Kodagu District, Madikeri Taluk, Bhagamandla Hobli (Year 2009-2022)

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
24/11/2009	0	13/01/2010	0	03/03/2010	0
25/11/2009	0	14/01/2010	0	04/03/2010	0
26/11/2009	3.5	15/01/2010	0	05/03/2010	0
27/11/2009	0.5	16/01/2010	0.5	06/03/2010	0
28/11/2009	0	17/01/2010	1	07/03/2010	0
29/11/2009	0	18/01/2010	0	08/03/2010	0
30/11/2009	0	19/01/2010	1.5	09/03/2010	0
01/12/2009	0	20/01/2010	1	10/03/2010	39.1
02/12/2009	0	21/01/2010	0.5	11/03/2010	0
03/12/2009	0	22/01/2010	0	12/03/2010	0
04/12/2009	0.5	23/01/2010	0.5	13/03/2010	0
05/12/2009	5.5	24/01/2010	0	14/03/2010	0
06/12/2009	0	25/01/2010	1	15/03/2010	0
07/12/2009	0.5	26/01/2010	0.5	16/03/2010	0
08/12/2009	0	27/01/2010	1.5	17/03/2010	19
09/12/2009	0	28/01/2010	0	19/03/2010	0
10/12/2009	0	29/01/2010	1	20/03/2010	0
11/12/2009	0	30/01/2010	1.5	21/03/2010	0
12/12/2009	0	31/01/2010	0	22/03/2010	0
13/12/2009	0	01/02/2010	1	23/03/2010	0
14/12/2009	0	02/02/2010	1.5	24/03/2010	0
15/12/2009	0.5	03/02/2010	0.5	26/03/2010	0
17/12/2009	0	04/02/2010	0	27/03/2010	0
18/12/2009	0	05/02/2010	1	28/03/2010	0
19/12/2009	0	06/02/2010	0.5	29/03/2010	0
20/12/2009	0	07/02/2010	0	31/03/2010	0
21/12/2009	0	08/02/2010	0	02/04/2010	0
22/12/2009	0	09/02/2010	0.5	03/04/2010	0
23/12/2009	0	10/02/2010	14.3	05/04/2010	0.5
24/12/2009	0	11/02/2010	1	06/04/2010	0
25/12/2009	0	12/02/2010	0	07/04/2010	0
26/12/2009	0	13/02/2010	0.5	08/04/2010	0
27/12/2009	32.5	14/02/2010	0	09/04/2010	14.5
28/12/2009	66	15/02/2010	0.5	10/04/2010	24.2
29/12/2009	1	16/02/2010	1	11/04/2010	0
30/12/2009	33.5	17/02/2010	0	12/04/2010	0.5
31/12/2009	1.5	18/02/2010	0	13/04/2010	0
01/01/2010	22	19/02/2010	0	14/04/2010	0
02/01/2010	0	20/02/2010	0.5	15/04/2010	0.5
03/01/2010	0	21/02/2010	0	16/04/2010	0
04/01/2010	0.5	22/02/2010	0	17/04/2010	0
05/01/2010	0	23/02/2010	0	18/04/2010	35
06/01/2010	0	24/02/2010	0.5	19/04/2010	12.5
07/01/2010	0	25/02/2010	0	20/04/2010	0
08/01/2010	0	26/02/2010	0	21/04/2010	0
09/01/2010	0	27/02/2010	0	22/04/2010	0
10/01/2010	9.3	28/02/2010	0	23/04/2010	2
11/01/2010	6	01/03/2010	0.5	24/04/2010	5
12/01/2010	0	02/03/2010	0	25/04/2010	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
26/04/2010	0	20/06/2010	9	08/08/2010	37.5
27/04/2010	0	21/06/2010	3	09/08/2010	6
28/04/2010	1	22/06/2010	0	10/08/2010	6
29/04/2010	19	23/06/2010	12.5	11/08/2010	7
30/04/2010	0	24/06/2010	36.5	12/08/2010	18.5
01/05/2010	2.5	25/06/2010	23.5	13/08/2010	6.5
02/05/2010	4	26/06/2010	72	14/08/2010	14.5
03/05/2010	1.5	27/06/2010	68.5	15/08/2010	0
04/05/2010	0	28/06/2010	6	16/08/2010	13.5
05/05/2010	0	29/06/2010	30	17/08/2010	10
07/05/2010	8	30/06/2010	5.5	22/08/2010	31.5
08/05/2010	0.5	01/07/2010	15.5	23/08/2010	6.5
09/05/2010	11	02/07/2010	24.5	24/08/2010	17.5
10/05/2010	14.8	03/07/2010	31.5	25/08/2010	84
11/05/2010	11	04/07/2010	26	26/08/2010	46.5
12/05/2010	8	05/07/2010	62.5	27/08/2010	52
13/05/2010	0	06/07/2010	41	28/08/2010	25.5
14/05/2010	0	07/07/2010	21	29/08/2010	25
15/05/2010	0	08/07/2010	41	30/08/2010	23.5
16/05/2010	23.5	09/07/2010	15.5	31/08/2010	131.5
17/05/2010	1	10/07/2010	8.8	01/09/2010	11.5
19/05/2010	3.5	11/07/2010	14	02/09/2010	1.5
20/05/2010	22	12/07/2010	0	03/09/2010	25.5
21/05/2010	3	13/07/2010	17	04/09/2010	12
22/05/2010	9.5	14/07/2010	1	05/09/2010	5
23/05/2010	1	15/07/2010	12	06/09/2010	28.5
24/05/2010	16.5	16/07/2010	18.5	07/09/2010	45.5
25/05/2010	0	17/07/2010	36.5	08/09/2010	87.5
26/05/2010	0	18/07/2010	15	09/09/2010	52
27/05/2010	0.5	19/07/2010	45	10/09/2010	5
28/05/2010	0	20/07/2010	80.5	11/09/2010	42.5
01/06/2010	0	21/07/2010	49	12/09/2010	0
02/06/2010	0	22/07/2010	62.5	13/09/2010	11.5
03/06/2010	1	23/07/2010	27	14/09/2010	26
04/06/2010	0	24/07/2010	13.5	15/09/2010	30.5
06/06/2010	22	25/07/2010	55	16/09/2010	27.5
07/06/2010	4	26/07/2010	33.5	17/09/2010	14
08/06/2010	16.5	27/07/2010	102.5	18/09/2010	0
09/06/2010	0	28/07/2010	149	19/09/2010	0
10/06/2010	5.1	29/07/2010	82	20/09/2010	3
11/06/2010	2.5	30/07/2010	121.5	21/09/2010	0.5
12/06/2010	16.5	31/07/2010	94	22/09/2010	18
13/06/2010	84.5	01/08/2010	39.5	23/09/2010	2
14/06/2010	121	02/08/2010	23	24/09/2010	5.5
15/06/2010	67.5	03/08/2010	39	25/09/2010	0
16/06/2010	24.5	04/08/2010	86.5	26/09/2010	13
17/06/2010	26	05/08/2010	34	27/09/2010	13
18/06/2010	25	06/08/2010	22.5	28/09/2010	9
19/06/2010	28	07/08/2010	19.5	29/09/2010	0.7

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
30/09/2010	0	29/11/2010	0	04/02/2011	0
10/10/2010	7.2	30/11/2010	0	05/02/2011	0
13/10/2010	2	01/12/2010	0	06/02/2011	0
14/10/2010	1.7	02/12/2010	0	07/02/2011	0
15/10/2010	9.1	03/12/2010	7	08/02/2011	0
16/10/2010	0.2	06/12/2010	0	09/02/2011	0
17/10/2010	5.5	07/12/2010	0	10/02/2011	0
18/10/2010	4.8	08/12/2010	0	11/02/2011	0
19/10/2010	0.3	09/12/2010	0	12/02/2011	0
20/10/2010	3.6	10/12/2010	0	13/02/2011	0
21/10/2010	0.6	11/12/2010	0	14/02/2011	0
22/10/2010	13.5	13/12/2010	0	15/02/2011	0
23/10/2010	31	14/12/2010	0	16/02/2011	0
24/10/2010	2	15/12/2010	0	17/02/2011	0
25/10/2010	0	16/12/2010	0	18/02/2011	0
26/10/2010	0	17/12/2010	0	19/02/2011	0
27/10/2010	3	18/12/2010	0	20/02/2011	0
28/10/2010	38.5	20/12/2010	0	21/02/2011	0
29/10/2010	26	21/12/2010	0	22/02/2011	0
30/10/2010	30.5	23/12/2010	0	23/02/2011	0
31/10/2010	6	27/12/2010	0	24/02/2011	0
01/11/2010	41.5	28/12/2010	0	25/02/2011	0
02/11/2010	11	29/12/2010	0	26/02/2011	0
03/11/2010	2.5	30/12/2010	0	27/02/2011	0
04/11/2010	0.5	31/12/2010	0	28/02/2011	0
05/11/2010	7.5	01/01/2011	0	01/03/2011	0
06/11/2010	72.5	02/01/2011	0	02/03/2011	0
07/11/2010	3	03/01/2011	0	03/03/2011	0
08/11/2010	2.5	04/01/2011	0	04/03/2011	0
09/11/2010	0.5	05/01/2011	0	05/03/2011	0
10/11/2010	0	06/01/2011	0	06/03/2011	0
11/11/2010	15.5	07/01/2011	0	07/03/2011	0
12/11/2010	33.5	08/01/2011	0	08/03/2011	0
13/11/2010	0	10/01/2011	0	09/03/2011	0
14/11/2010	0	20/01/2011	0	10/03/2011	0
15/11/2010	4.3	21/01/2011	0	11/03/2011	0
16/11/2010	0.5	22/01/2011	0	12/03/2011	2
17/11/2010	7.3	23/01/2011	0	13/03/2011	0
18/11/2010	39.5	24/01/2011	0	14/03/2011	0
19/11/2010	0.5	25/01/2011	0	15/03/2011	0
20/11/2010	0.5	26/01/2011	0	16/03/2011	0
21/11/2010	1.5	27/01/2011	0	17/03/2011	0
22/11/2010	17.5	28/01/2011	0	18/03/2011	0
23/11/2010	4.5	29/01/2011	0	19/03/2011	0
24/11/2010	9	30/01/2011	0	20/03/2011	0
25/11/2010	0	31/01/2011	0	21/03/2011	0
26/11/2010	0	01/02/2011	0	22/03/2011	0
27/11/2010	7	02/02/2011	0	23/03/2011	0
28/11/2010	0	03/02/2011	0	24/03/2011	2

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
25/03/2011	0	13/05/2011	0	01/07/2011	9
26/03/2011	0	14/05/2011	0.5	02/07/2011	41.5
27/03/2011	6.5	15/05/2011	10	03/07/2011	11.5
28/03/2011	8.5	16/05/2011	8.5	04/07/2011	5
29/03/2011	0	17/05/2011	0	05/07/2011	27.5
30/03/2011	7	18/05/2011	13.5	06/07/2011	40.5
31/03/2011	0	19/05/2011	0	07/07/2011	29
01/04/2011	0	20/05/2011	0	08/07/2011	39.5
02/04/2011	0	21/05/2011	0	09/07/2011	19
03/04/2011	0	22/05/2011	0	10/07/2011	4.5
04/04/2011	0	23/05/2011	0	11/07/2011	20
05/04/2011	0	24/05/2011	0	12/07/2011	3
06/04/2011	0	25/05/2011	2	13/07/2011	30.5
07/04/2011	0	26/05/2011	22.5	14/07/2011	4.5
08/04/2011	0	27/05/2011	2.5	15/07/2011	63
09/04/2011	0	28/05/2011	14.5	16/07/2011	52.5
10/04/2011	6	29/05/2011	0	17/07/2011	194
11/04/2011	4.5	30/05/2011	6.5	18/07/2011	74
12/04/2011	0	31/05/2011	1	19/07/2011	102
13/04/2011	0	01/06/2011	2.5	20/07/2011	28
14/04/2011	6	02/06/2011	5.5	21/07/2011	27
15/04/2011	7	03/06/2011	86.5	22/07/2011	4
16/04/2011	1	04/06/2011	70.5	23/07/2011	29
17/04/2011	14	05/06/2011	71	24/07/2011	60.7
18/04/2011	0	06/06/2011	66.5	25/07/2011	95
19/04/2011	2.5	07/06/2011	15	26/07/2011	26
20/04/2011	7.5	08/06/2011	57.5	27/07/2011	15
21/04/2011	32	09/06/2011	26	28/07/2011	13
22/04/2011	14.5	10/06/2011	55	29/07/2011	14.5
23/04/2011	45.5	11/06/2011	46.5	30/07/2011	0
24/04/2011	10.5	12/06/2011	3	31/07/2011	43.5
25/04/2011	0	13/06/2011	45.5	01/08/2011	21
26/04/2011	7.5	14/06/2011	69.5	02/08/2011	35
27/04/2011	0	15/06/2011	61	03/08/2011	42
28/04/2011	0	16/06/2011	16.5	04/08/2011	76
29/04/2011	0	17/06/2011	50.5	05/08/2011	57
30/04/2011	0	18/06/2011	178.5	06/08/2011	125.6
01/05/2011	18	19/06/2011	37	07/08/2011	62.5
02/05/2011	1	20/06/2011	9	08/08/2011	86
03/05/2011	0	21/06/2011	3	09/08/2011	21
04/05/2011	0.5	22/06/2011	0.5	10/08/2011	18.5
05/05/2011	0	23/06/2011	40.5	11/08/2011	23.5
06/05/2011	0	24/06/2011	43	12/08/2011	96
07/05/2011	0	25/06/2011	47	13/08/2011	49.9
08/05/2011	0	26/06/2011	97.5	14/08/2011	9.3
09/05/2011	0	27/06/2011	87	15/08/2011	3.3
10/05/2011	0	28/06/2011	91.5	16/08/2011	18.3
11/05/2011	0	29/06/2011	9.5	17/08/2011	9.1
12/05/2011	28.5	30/06/2011	9.5	18/08/2011	2.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
19/08/2011	11.5	07/10/2011	0	25/11/2011	0
20/08/2011	14.6	08/10/2011	0	26/11/2011	0
21/08/2011	58	09/10/2011	0	27/11/2011	0
22/08/2011	8.9	10/10/2011	20.5	28/11/2011	0
23/08/2011	21.5	11/10/2011	39.5	29/11/2011	0
24/08/2011	11.5	12/10/2011	67.5	30/11/2011	0.5
25/08/2011	7.5	13/10/2011	4	01/12/2011	0
26/08/2011	22.5	14/10/2011	17	02/12/2011	1.5
27/08/2011	10	15/10/2011	1.5	03/12/2011	0.5
28/08/2011	10	16/10/2011	6	04/12/2011	0
29/08/2011	28.5	17/10/2011	2.5	05/12/2011	0.5
30/08/2011	34.9	18/10/2011	2.5	06/12/2011	0
31/08/2011	58.5	19/10/2011	53.5	07/12/2011	0
01/09/2011	64.5	20/10/2011	7	08/12/2011	0
02/09/2011	180	21/10/2011	2	09/12/2011	0
03/09/2011	111.5	22/10/2011	5.5	10/12/2011	0
04/09/2011	76	23/10/2011	0	11/12/2011	0.5
05/09/2011	11.5	24/10/2011	28	12/12/2011	0
06/09/2011	7.5	25/10/2011	12	13/12/2011	0
07/09/2011	27	26/10/2011	2.5	14/12/2011	0
08/09/2011	8.5	27/10/2011	0	15/12/2011	0
09/09/2011	5.5	28/10/2011	8	16/12/2011	0
10/09/2011	12.5	29/10/2011	0	17/12/2011	0
11/09/2011	36	30/10/2011	24.5	18/12/2011	0
12/09/2011	21.5	31/10/2011	0	19/12/2011	0
13/09/2011	13	01/11/2011	0	20/12/2011	0
14/09/2011	8	02/11/2011	11.5	21/12/2011	0
15/09/2011	27.5	03/11/2011	40	22/12/2011	0
16/09/2011	37	04/11/2011	1.5	23/12/2011	0
17/09/2011	14	05/11/2011	1	24/12/2011	0
18/09/2011	3	06/11/2011	10	25/12/2011	0
19/09/2011	9	07/11/2011	20	26/12/2011	0
20/09/2011	3	08/11/2011	2.5	27/12/2011	0
21/09/2011	19	09/11/2011	0.5	28/12/2011	0
22/09/2011	7.5	10/11/2011	0	29/12/2011	0
23/09/2011	0	11/11/2011	0	30/12/2011	0
24/09/2011	0	12/11/2011	0	31/12/2011	0
25/09/2011	0	13/11/2011	0	01/01/2012	0
26/09/2011	0.5	14/11/2011	0	02/01/2012	0
27/09/2011	0	15/11/2011	0.5	03/01/2012	0
28/09/2011	0	16/11/2011	0	04/01/2012	0.5
29/09/2011	0	17/11/2011	0	05/01/2012	0
30/09/2011	0	18/11/2011	0	06/01/2012	0
01/10/2011	0	19/11/2011	0	07/01/2012	0
02/10/2011	0	20/11/2011	0	08/01/2012	0.5
03/10/2011	0	21/11/2011	0	09/01/2012	0
04/10/2011	0	22/11/2011	0	10/01/2012	0
05/10/2011	0	23/11/2011	0	11/01/2012	0.5
06/10/2011	0	24/11/2011	0	12/01/2012	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
13/01/2012	0	02/03/2012	0	20/04/2012	0
14/01/2012	0	03/03/2012	0	21/04/2012	12.5
15/01/2012	0	04/03/2012	0	22/04/2012	0
16/01/2012	0	05/03/2012	0	23/04/2012	22.5
17/01/2012	0	06/03/2012	0	24/04/2012	45
18/01/2012	0	07/03/2012	0	25/04/2012	6
19/01/2012	0.5	08/03/2012	0	26/04/2012	9
20/01/2012	0	09/03/2012	0	27/04/2012	0.5
21/01/2012	0	10/03/2012	0	28/04/2012	19
22/01/2012	0	11/03/2012	0	29/04/2012	15
23/01/2012	0.5	12/03/2012	0	30/04/2012	0
24/01/2012	0	13/03/2012	0	01/05/2012	0.5
25/01/2012	0	14/03/2012	12.5	02/05/2012	0
26/01/2012	0	15/03/2012	0.5	03/05/2012	0
27/01/2012	0	16/03/2012	0	04/05/2012	0
28/01/2012	0	17/03/2012	1.5	05/05/2012	0
29/01/2012	0.5	18/03/2012	0	06/05/2012	0
30/01/2012	0	19/03/2012	0	07/05/2012	0
31/01/2012	0	20/03/2012	0	08/05/2012	0
01/02/2012	0	21/03/2012	0	09/05/2012	0
02/02/2012	0	22/03/2012	0	10/05/2012	0
03/02/2012	0	23/03/2012	0	11/05/2012	0.5
04/02/2012	0	24/03/2012	0	12/05/2012	27.5
05/02/2012	0	25/03/2012	0	13/05/2012	0
06/02/2012	0	26/03/2012	0	14/05/2012	0
07/02/2012	0	27/03/2012	0	15/05/2012	5
08/02/2012	0	28/03/2012	0	16/05/2012	0
09/02/2012	0.5	29/03/2012	0	17/05/2012	0
10/02/2012	0	30/03/2012	0	18/05/2012	0
11/02/2012	0	31/03/2012	0	19/05/2012	0
12/02/2012	6.5	01/04/2012	12	20/05/2012	0
13/02/2012	0.5	02/04/2012	0	21/05/2012	0
14/02/2012	0	03/04/2012	9	22/05/2012	0
15/02/2012	0	04/04/2012	0	23/05/2012	0
16/02/2012	0	05/04/2012	0	24/05/2012	0
17/02/2012	0	06/04/2012	0	25/05/2012	0
18/02/2012	0	07/04/2012	6.5	26/05/2012	0
19/02/2012	0	08/04/2012	19.5	27/05/2012	0
20/02/2012	0	09/04/2012	1.5	28/05/2012	1
21/02/2012	0	10/04/2012	0	29/05/2012	0
22/02/2012	0	11/04/2012	0	30/05/2012	0
23/02/2012	0	12/04/2012	0	31/05/2012	0
24/02/2012	0	13/04/2012	0	01/06/2012	0
25/02/2012	0	14/04/2012	0	02/06/2012	0
26/02/2012	0	15/04/2012	0	03/06/2012	1
27/02/2012	0	16/04/2012	0	04/06/2012	4.5
28/02/2012	0	17/04/2012	10.5	05/06/2012	39.5
29/02/2012	0	18/04/2012	0	06/06/2012	15.5
01/03/2012	0	19/04/2012	44.5	07/06/2012	21

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
08/06/2012	10	27/07/2012	49	14/09/2012	12
09/06/2012	2.5	28/07/2012	26.5	15/09/2012	8
10/06/2012	11	29/07/2012	22.5	16/09/2012	11.5
11/06/2012	0.5	30/07/2012	12	17/09/2012	4.5
12/06/2012	8.5	31/07/2012	18	18/09/2012	16
13/06/2012	14	01/08/2012	16.5	19/09/2012	9.5
14/06/2012	11	02/08/2012	9.5	20/09/2012	0
15/06/2012	55.5	03/08/2012	16.5	21/09/2012	0
16/06/2012	4	04/08/2012	15	22/09/2012	0
17/06/2012	66	05/08/2012	34	23/09/2012	0
18/06/2012	115.5	06/08/2012	51.5	24/09/2012	0
19/06/2012	73.5	07/08/2012	126.5	25/09/2012	0
20/06/2012	17	08/08/2012	66.5	26/09/2012	0
21/06/2012	14.5	09/08/2012	63	27/09/2012	0
22/06/2012	20.5	10/08/2012	48	28/09/2012	0
23/06/2012	24	11/08/2012	86	29/09/2012	2
24/06/2012	9	12/08/2012	80.5	30/09/2012	46.5
25/06/2012	8.5	13/08/2012	24.5	01/10/2012	12.5
26/06/2012	25	14/08/2012	1	02/10/2012	25
27/06/2012	44	15/08/2012	0.5	03/10/2012	12.5
28/06/2012	4	16/08/2012	4	04/10/2012	0.5
29/06/2012	36.5	17/08/2012	22	05/10/2012	1
30/06/2012	26	18/08/2012	31.5	06/10/2012	0
01/07/2012	45	19/08/2012	17.5	07/10/2012	0
02/07/2012	51.5	20/08/2012	1.5	08/10/2012	0.5
03/07/2012	204.5	21/08/2012	1	09/10/2012	0
04/07/2012	108	22/08/2012	6	10/10/2012	1
05/07/2012	35	23/08/2012	0	11/10/2012	0
06/07/2012	4	24/08/2012	3.5	12/10/2012	0.5
07/07/2012	19.5	25/08/2012	8	13/10/2012	0
08/07/2012	12	26/08/2012	63	14/10/2012	0
09/07/2012	24.5	27/08/2012	16.5	15/10/2012	9
10/07/2012	7.5	28/08/2012	47.5	16/10/2012	44
11/07/2012	0	29/08/2012	35.5	17/10/2012	0
12/07/2012	0	30/08/2012	44	18/10/2012	0.5
13/07/2012	0	31/08/2012	37.5	19/10/2012	0
14/07/2012	0	01/09/2012	74.5	20/10/2012	1.5
15/07/2012	25	02/09/2012	34	21/10/2012	8
16/07/2012	2.5	03/09/2012	62.5	22/10/2012	4.5
17/07/2012	0	04/09/2012	50	23/10/2012	5.5
18/07/2012	22	05/09/2012	38	24/10/2012	0
19/07/2012	7.5	06/09/2012	10.5	25/10/2012	0
20/07/2012	14	07/09/2012	13.5	26/10/2012	0
21/07/2012	26.5	08/09/2012	11.5	27/10/2012	0
22/07/2012	34	09/09/2012	15.5	28/10/2012	0.5
23/07/2012	19.5	10/09/2012	109	29/10/2012	0
24/07/2012	21.5	11/09/2012	7	30/10/2012	0
25/07/2012	5.5	12/09/2012	24.5	31/10/2012	0
26/07/2012	34	13/09/2012	21.5	01/11/2012	28

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
02/11/2012	42.5	21/12/2012	0	08/02/2013	0
03/11/2012	10	22/12/2012	0	09/02/2013	0
04/11/2012	5	23/12/2012	0	10/02/2013	7
05/11/2012	76	24/12/2012	0	11/02/2013	0
06/11/2012	0	25/12/2012	0	12/02/2013	0
07/11/2012	0	26/12/2012	0	13/02/2013	0
08/11/2012	0.5	27/12/2012	0	14/02/2013	0
09/11/2012	30	28/12/2012	0	15/02/2013	0
10/11/2012	0	29/12/2012	0	16/02/2013	2
11/11/2012	0	30/12/2012	0	17/02/2013	6
12/11/2012	24	31/12/2012	0.5	18/02/2013	0.5
13/11/2012	6.5	01/01/2013	0	19/02/2013	0
14/11/2012	0	02/01/2013	0	20/02/2013	0
15/11/2012	0	03/01/2013	0	21/02/2013	0
16/11/2012	0	04/01/2013	0.5	22/02/2013	0
17/11/2012	0	05/01/2013	0	23/02/2013	0
18/11/2012	0.5	06/01/2013	0	24/02/2013	0
19/11/2012	0	07/01/2013	0	25/02/2013	0
20/11/2012	0.5	08/01/2013	0	26/02/2013	0
21/11/2012	0	09/01/2013	0	27/02/2013	0
22/11/2012	0	10/01/2013	0	28/02/2013	0
23/11/2012	1	11/01/2013	0.5	01/03/2013	0
24/11/2012	0.5	12/01/2013	0	02/03/2013	0
25/11/2012	0.5	13/01/2013	0	03/03/2013	0
26/11/2012	0	14/01/2013	0	04/03/2013	0
27/11/2012	0	15/01/2013	0	05/03/2013	0
28/11/2012	0	16/01/2013	0	06/03/2013	0
29/11/2012	0	17/01/2013	0	07/03/2013	0
30/11/2012	0	18/01/2013	0	08/03/2013	10.5
01/12/2012	0	19/01/2013	0	09/03/2013	0
02/12/2012	0	20/01/2013	0	10/03/2013	1.5
03/12/2012	0	21/01/2013	0.5	11/03/2013	0
04/12/2012	0	22/01/2013	0	12/03/2013	7.5
05/12/2012	10	23/01/2013	0	13/03/2013	0
06/12/2012	0	24/01/2013	0	14/03/2013	0
07/12/2012	0	25/01/2013	0	15/03/2013	0
08/12/2012	0	26/01/2013	0	16/03/2013	0
09/12/2012	0	27/01/2013	0	17/03/2013	1.5
10/12/2012	0	28/01/2013	0	18/03/2013	0
11/12/2012	0	29/01/2013	0.5	19/03/2013	0.5
12/12/2012	0	30/01/2013	0	20/03/2013	0
13/12/2012	0	31/01/2013	0	21/03/2013	0
14/12/2012	0	01/02/2013	0	22/03/2013	0
15/12/2012	0.5	02/02/2013	0	23/03/2013	0
16/12/2012	0	03/02/2013	0	24/03/2013	0
17/12/2012	0	04/02/2013	0.5	25/03/2013	0
18/12/2012	0	05/02/2013	0	26/03/2013	0
19/12/2012	0	06/02/2013	0	27/03/2013	0
20/12/2012	0	07/02/2013	0	28/03/2013	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
29/03/2013	0	17/05/2013	0	05/07/2013	138.5
30/03/2013	0	18/05/2013	0	06/07/2013	50.5
31/03/2013	0	19/05/2013	0	07/07/2013	139
01/04/2013	0	20/05/2013	0	08/07/2013	44.5
02/04/2013	0	21/05/2013	32.5	09/07/2013	14
03/04/2013	0	22/05/2013	0	10/07/2013	24
04/04/2013	0	23/05/2013	0	11/07/2013	82.5
05/04/2013	0	24/05/2013	0	12/07/2013	57.5
06/04/2013	0	25/05/2013	0	13/07/2013	75
07/04/2013	0	26/05/2013	0	14/07/2013	32
08/04/2013	0	27/05/2013	6	15/07/2013	19
09/04/2013	0	28/05/2013	11.5	16/07/2013	33
10/04/2013	0	29/05/2013	29.5	17/07/2013	36.5
11/04/2013	33.5	30/05/2013	0.5	18/07/2013	45.5
12/04/2013	0	31/05/2013	43.5	19/07/2013	108
13/04/2013	0	01/06/2013	16.5	20/07/2013	88
14/04/2013	0	02/06/2013	12	21/07/2013	80
15/04/2013	0	03/06/2013	60.5	22/07/2013	50
16/04/2013	0	04/06/2013	7.5	23/07/2013	55.5
17/04/2013	0	05/06/2013	1	24/07/2013	37.5
18/04/2013	0	06/06/2013	8.5	25/07/2013	45.5
19/04/2013	0	07/06/2013	30	26/07/2013	48.5
20/04/2013	0	08/06/2013	23	27/07/2013	60.5
21/04/2013	0	09/06/2013	41	28/07/2013	103
22/04/2013	0	10/06/2013	23.5	29/07/2013	73.5
23/04/2013	0	11/06/2013	55.5	30/07/2013	6
24/04/2013	0	12/06/2013	88	31/07/2013	81.5
25/04/2013	0	13/06/2013	18.5	01/08/2013	177.5
26/04/2013	32.5	14/06/2013	124.5	02/08/2013	262.5
27/04/2013	5	15/06/2013	109	03/08/2013	79
28/04/2013	0	16/06/2013	156.5	04/08/2013	101
29/04/2013	1.5	17/06/2013	94	05/08/2013	108.5
30/04/2013	0	18/06/2013	113.5	06/08/2013	50
01/05/2013	0	19/06/2013	26.5	07/08/2013	34.5
02/05/2013	0	20/06/2013	100.5	08/08/2013	46.5
03/05/2013	0	21/06/2013	16.5	09/08/2013	40.5
04/05/2013	0	22/06/2013	51.5	10/08/2013	26.5
05/05/2013	0	23/06/2013	29.5	11/08/2013	19.5
06/05/2013	0	24/06/2013	66	12/08/2013	26.5
07/05/2013	0	25/06/2013	160	13/08/2013	26.5
08/05/2013	0	26/06/2013	183	14/08/2013	39.5
09/05/2013	0.5	27/06/2013	98.5	15/08/2013	4.5
10/05/2013	0	28/06/2013	19	16/08/2013	24.5
11/05/2013	1	29/06/2013	23	17/08/2013	10.5
12/05/2013	15.5	30/06/2013	0	18/08/2013	37.5
13/05/2013	3	01/07/2013	0	19/08/2013	27
14/05/2013	0	02/07/2013	30	20/08/2013	3
15/05/2013	0	03/07/2013	62	21/08/2013	24.5
16/05/2013	0	04/07/2013	160.5	22/08/2013	7

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
23/08/2013	25.5	11/10/2013	0	29/11/2013	0
24/08/2013	18	12/10/2013	0.5	30/11/2013	0
25/08/2013	34.5	13/10/2013	38	01/12/2013	0
26/08/2013	2.5	14/10/2013	0.5	02/12/2013	2
27/08/2013	4	15/10/2013	0	03/12/2013	0.5
28/08/2013	0	16/10/2013	6	04/12/2013	0
29/08/2013	1.5	17/10/2013	30	05/12/2013	0
30/08/2013	0	18/10/2013	4	06/12/2013	0
31/08/2013	1	19/10/2013	62	07/12/2013	0
01/09/2013	3.5	20/10/2013	66	08/12/2013	0
02/09/2013	48	21/10/2013	0.5	09/12/2013	0
03/09/2013	5.5	22/10/2013	4.5	10/12/2013	0
04/09/2013	15.5	23/10/2013	2.5	11/12/2013	0.5
05/09/2013	0	24/10/2013	0.5	12/12/2013	0
06/09/2013	35	25/10/2013	0	13/12/2013	0
07/09/2013	33	26/10/2013	0.5	14/12/2013	0
08/09/2013	15	27/10/2013	0	15/12/2013	0
09/09/2013	10.5	28/10/2013	0.5	16/12/2013	0.5
10/09/2013	0	29/10/2013	0	17/12/2013	0
11/09/2013	1	30/10/2013	0.5	18/12/2013	0
12/09/2013	5.5	31/10/2013	47.5	19/12/2013	0
13/09/2013	9	01/11/2013	3	20/12/2013	0
14/09/2013	26	02/11/2013	0.5	21/12/2013	0
15/09/2013	2	03/11/2013	0	22/12/2013	0.5
16/09/2013	48.5	04/11/2013	0	23/12/2013	0
17/09/2013	24.5	05/11/2013	0	24/12/2013	0
18/09/2013	48.5	06/11/2013	0	25/12/2013	0
19/09/2013	111.5	07/11/2013	0	26/12/2013	0
20/09/2013	39	08/11/2013	0	27/12/2013	0
21/09/2013	39.5	09/11/2013	0.5	28/12/2013	0
22/09/2013	24.5	10/11/2013	0	29/12/2013	0
23/09/2013	0	11/11/2013	0	30/12/2013	0
24/09/2013	4	12/11/2013	0	31/12/2013	0.5
25/09/2013	6.5	13/11/2013	0.5	01/01/2014	0
26/09/2013	1	14/11/2013	0	02/01/2014	0
27/09/2013	0.5	15/11/2013	0	03/01/2014	0
28/09/2013	0	16/11/2013	0	04/01/2014	0
29/09/2013	4.5	17/11/2013	1	05/01/2014	0
30/09/2013	2.5	18/11/2013	0	06/01/2014	0
01/10/2013	14.5	19/11/2013	0	07/01/2014	0.5
02/10/2013	7	20/11/2013	0.5	08/01/2014	0
03/10/2013	0.5	21/11/2013	0	09/01/2014	0
04/10/2013	0	22/11/2013	0.5	10/01/2014	0
05/10/2013	0	23/11/2013	0	11/01/2014	0
06/10/2013	25	24/11/2013	1	12/01/2014	0
07/10/2013	23.5	25/11/2013	0.5	13/01/2014	0
08/10/2013	14.5	26/11/2013	13	14/01/2014	0
09/10/2013	0	27/11/2013	23.5	15/01/2014	0
10/10/2013	2.5	28/11/2013	12.5	16/01/2014	1.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
17/01/2014	0	07/03/2014	0	25/04/2014	0
18/01/2014	25.5	08/03/2014	0	26/04/2014	0
19/01/2014	0.5	09/03/2014	0	27/04/2014	12
20/01/2014	0	10/03/2014	0	28/04/2014	0
21/01/2014	0	11/03/2014	0	29/04/2014	1.5
22/01/2014	0	12/03/2014	0	30/04/2014	0
23/01/2014	0	13/03/2014	0	01/05/2014	5
24/01/2014	0	14/03/2014	0	02/05/2014	2.5
25/01/2014	0	15/03/2014	0	03/05/2014	49.5
26/01/2014	0	16/03/2014	0	04/05/2014	24
27/01/2014	0	17/03/2014	0	05/05/2014	0.5
28/01/2014	0	18/03/2014	0	06/05/2014	7.5
29/01/2014	0	19/03/2014	0	07/05/2014	23
30/01/2014	0	20/03/2014	0	08/05/2014	9.5
31/01/2014	0	21/03/2014	0	09/05/2014	118
01/02/2014	0	22/03/2014	0	10/05/2014	0.5
02/02/2014	0	23/03/2014	0	11/05/2014	0
03/02/2014	0	24/03/2014	0.5	12/05/2014	4.5
04/02/2014	0	25/03/2014	0	13/05/2014	0
05/02/2014	0	26/03/2014	0	14/05/2014	0
06/02/2014	0	27/03/2014	0	15/05/2014	0
07/02/2014	0	28/03/2014	0	16/05/2014	0
08/02/2014	0	29/03/2014	0	17/05/2014	0
09/02/2014	0	30/03/2014	0	18/05/2014	0
10/02/2014	0	31/03/2014	0	19/05/2014	0
11/02/2014	0	01/04/2014	0	20/05/2014	9
12/02/2014	0	02/04/2014	1.5	21/05/2014	4
13/02/2014	0	03/04/2014	0	22/05/2014	17.5
14/02/2014	0	04/04/2014	0	23/05/2014	0
15/02/2014	0	05/04/2014	0	24/05/2014	0
16/02/2014	0	06/04/2014	0	25/05/2014	0
17/02/2014	0	07/04/2014	6.5	26/05/2014	0
18/02/2014	0	08/04/2014	0	27/05/2014	0
19/02/2014	0	09/04/2014	0	28/05/2014	0
20/02/2014	0	10/04/2014	2.5	29/05/2014	4.5
21/02/2014	0	11/04/2014	0	30/05/2014	40.5
22/02/2014	0	12/04/2014	32	31/05/2014	0
23/02/2014	0	13/04/2014	0	01/06/2014	7.5
24/02/2014	0	14/04/2014	10	02/06/2014	0
25/02/2014	0	15/04/2014	17	03/06/2014	24.5
26/02/2014	0	16/04/2014	8.5	04/06/2014	0
27/02/2014	0	17/04/2014	3.5	05/06/2014	0
28/02/2014	3.5	18/04/2014	0	06/06/2014	0.5
01/03/2014	0	19/04/2014	14	07/06/2014	0.5
02/03/2014	0	20/04/2014	1	08/06/2014	1.5
03/03/2014	0	21/04/2014	1.5	09/06/2014	15.5
04/03/2014	0	22/04/2014	0	10/06/2014	10
05/03/2014	0	23/04/2014	0	11/06/2014	22.5
06/03/2014	0	24/04/2014	0	12/06/2014	33.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
13/06/2014	31	01/08/2014	163.5	19/09/2014	37.5
14/06/2014	12.5	02/08/2014	86	20/09/2014	4.5
15/06/2014	12	03/08/2014	91	21/09/2014	3
16/06/2014	14.5	04/08/2014	65	22/09/2014	8
17/06/2014	46.5	05/08/2014	134.5	23/09/2014	24.5
18/06/2014	46.5	06/08/2014	120	24/09/2014	6.5
19/06/2014	118	07/08/2014	86	25/09/2014	0.5
20/06/2014	147	08/08/2014	33.5	26/09/2014	3
21/06/2014	64.5	09/08/2014	44.5	27/09/2014	23.5
22/06/2014	1.5	10/08/2014	33.5	28/09/2014	0
23/06/2014	19.5	11/08/2014	22.5	29/09/2014	5
24/06/2014	9	12/08/2014	41.5	30/09/2014	4.5
25/06/2014	5	13/08/2014	10	01/10/2014	11
26/06/2014	1	14/08/2014	12.5	02/10/2014	6
27/06/2014	0	15/08/2014	7.5	03/10/2014	0.5
28/06/2014	0	16/08/2014	1	04/10/2014	4.5
29/06/2014	1.5	17/08/2014	0	05/10/2014	0
30/06/2014	2.5	18/08/2014	10.5	06/10/2014	41
01/07/2014	16.5	19/08/2014	3.5	07/10/2014	30
02/07/2014	46	20/08/2014	7.5	08/10/2014	0
03/07/2014	2	21/08/2014	2.5	09/10/2014	0
04/07/2014	1	22/08/2014	31.5	10/10/2014	0
05/07/2014	0.5	23/08/2014	29	11/10/2014	2
06/07/2014	28	24/08/2014	7.5	12/10/2014	3.5
07/07/2014	37	25/08/2014	10	13/10/2014	1
08/07/2014	11	26/08/2014	7.5	14/10/2014	0
09/07/2014	10.5	27/08/2014	0.5	15/10/2014	0
10/07/2014	38	28/08/2014	16.5	16/10/2014	2
11/07/2014	20.5	29/08/2014	20.5	17/10/2014	0
12/07/2014	22.5	30/08/2014	45.5	18/10/2014	15
13/07/2014	125	31/08/2014	97	19/10/2014	17.5
14/07/2014	116	01/09/2014	80.5	20/10/2014	1
15/07/2014	63	02/09/2014	87	21/10/2014	8
16/07/2014	40	03/09/2014	35.5	22/10/2014	0
17/07/2014	16	04/09/2014	77	23/10/2014	0
18/07/2014	6.5	05/09/2014	27	24/10/2014	4
19/07/2014	56.5	06/09/2014	15.5	25/10/2014	18.5
20/07/2014	47.5	07/09/2014	71	26/10/2014	15.5
21/07/2014	39.5	08/09/2014	10	27/10/2014	0.5
22/07/2014	74.5	09/09/2014	22.5	28/10/2014	13
23/07/2014	32.5	10/09/2014	10.5	29/10/2014	8.5
24/07/2014	72.5	11/09/2014	13	30/10/2014	0
25/07/2014	30	12/09/2014	0.5	31/10/2014	0
26/07/2014	26	13/09/2014	21.5	01/11/2014	0
27/07/2014	34	14/09/2014	14.5	02/11/2014	7.5
28/07/2014	37.5	15/09/2014	22.5	03/11/2014	10
29/07/2014	6	16/09/2014	17.5	04/11/2014	0.5
30/07/2014	38	17/09/2014	16.5	05/11/2014	0
31/07/2014	154	18/09/2014	1	06/11/2014	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
07/11/2014	0.5	26/12/2014	0	13/02/2015	0
08/11/2014	0	27/12/2014	0	14/02/2015	0
09/11/2014	0	28/12/2014	0	15/02/2015	0
10/11/2014	0	29/12/2014	0	16/02/2015	0
11/11/2014	1	30/12/2014	0.5	17/02/2015	0.5
12/11/2014	7.5	31/12/2014	0	18/02/2015	0
13/11/2014	2	01/01/2015	0	19/02/2015	0
14/11/2014	0.5	02/01/2015	0	20/02/2015	18.5
15/11/2014	7.5	03/01/2015	0	21/02/2015	0
16/11/2014	0	04/01/2015	0.5	22/02/2015	0
17/11/2014	0	05/01/2015	0	23/02/2015	0
18/11/2014	0	06/01/2015	0	24/02/2015	0
19/11/2014	0	07/01/2015	0	25/02/2015	0
20/11/2014	0	08/01/2015	0	26/02/2015	0
21/11/2014	0	09/01/2015	0	27/02/2015	0
22/11/2014	0	10/01/2015	0	28/02/2015	0
23/11/2014	0	11/01/2015	0	01/03/2015	0
24/11/2014	0.5	12/01/2015	0	02/03/2015	0.5
25/11/2014	0	13/01/2015	0	03/03/2015	0
26/11/2014	0	14/01/2015	0	04/03/2015	0
27/11/2014	0	15/01/2015	0	05/03/2015	0
28/11/2014	0	16/01/2015	0	06/03/2015	0
29/11/2014	0	17/01/2015	0	07/03/2015	0
30/11/2014	0	18/01/2015	0	08/03/2015	1
01/12/2014	0	19/01/2015	0.5	09/03/2015	28
02/12/2014	0	20/01/2015	0	10/03/2015	1
03/12/2014	0	21/01/2015	0	11/03/2015	0.5
04/12/2014	0	22/01/2015	0	12/03/2015	0
05/12/2014	0	23/01/2015	0	13/03/2015	0
06/12/2014	0	24/01/2015	0	14/03/2015	0
07/12/2014	0	25/01/2015	0	15/03/2015	6.5
08/12/2014	0	26/01/2015	0.5	16/03/2015	6
09/12/2014	4	27/01/2015	0	17/03/2015	0
10/12/2014	0.5	28/01/2015	0	18/03/2015	0
11/12/2014	12	29/01/2015	0	19/03/2015	0
12/12/2014	0	30/01/2015	0	20/03/2015	0
13/12/2014	7	31/01/2015	0	21/03/2015	0
14/12/2014	6.5	01/02/2015	0	22/03/2015	0
15/12/2014	2.5	02/02/2015	0	23/03/2015	0
16/12/2014	1	03/02/2015	0	24/03/2015	0
17/12/2014	0	04/02/2015	0	25/03/2015	0
18/12/2014	0	05/02/2015	0	26/03/2015	0
19/12/2014	0	06/02/2015	0	27/03/2015	0
20/12/2014	0	07/02/2015	0	28/03/2015	0
21/12/2014	0	08/02/2015	0	29/03/2015	8
22/12/2014	0	09/02/2015	0	30/03/2015	0
23/12/2014	0	10/02/2015	0	31/03/2015	14.5
24/12/2014	0.5	11/02/2015	0	01/04/2015	13.5
25/12/2014	0	12/02/2015	0	02/04/2015	23

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
03/04/2015	0	22/05/2015	0	10/07/2015	46
04/04/2015	0	23/05/2015	0	11/07/2015	78
05/04/2015	0	24/05/2015	0	12/07/2015	22.5
06/04/2015	0	25/05/2015	0	13/07/2015	0
07/04/2015	0	26/05/2015	0	14/07/2015	0
08/04/2015	0.5	27/05/2015	0	15/07/2015	50
09/04/2015	0.5	28/05/2015	5.5	16/07/2015	9.5
10/04/2015	0	29/05/2015	0	17/07/2015	41
11/04/2015	3	30/05/2015	18.5	18/07/2015	98
12/04/2015	0.5	31/05/2015	0	19/07/2015	58.5
13/04/2015	32.5	01/06/2015	13	20/07/2015	100
14/04/2015	1	02/06/2015	10	21/07/2015	71.5
15/04/2015	0	03/06/2015	83.5	22/07/2015	20.5
16/04/2015	0	04/06/2015	2	23/07/2015	56.5
17/04/2015	0.5	05/06/2015	32.5	24/07/2015	22.5
18/04/2015	0	06/06/2015	0	25/07/2015	22
19/04/2015	0	07/06/2015	0	26/07/2015	28.5
20/04/2015	0	08/06/2015	5	27/07/2015	42
21/04/2015	0	09/06/2015	10.5	28/07/2015	30
22/04/2015	7.5	10/06/2015	24	29/07/2015	1.5
23/04/2015	0	11/06/2015	0.5	30/07/2015	0
24/04/2015	8	12/06/2015	24	31/07/2015	7.5
25/04/2015	2	13/06/2015	18	01/08/2015	1.5
26/04/2015	2.5	14/06/2015	31.5	02/08/2015	13
27/04/2015	21.5	15/06/2015	12.5	03/08/2015	29.5
28/04/2015	0	16/06/2015	11	04/08/2015	46
29/04/2015	1	17/06/2015	17	05/08/2015	34
30/04/2015	18.5	18/06/2015	11.5	06/08/2015	79
01/05/2015	17.5	19/06/2015	47.5	07/08/2015	37.5
02/05/2015	0	20/06/2015	193	08/08/2015	39.5
03/05/2015	47.5	21/06/2015	169	09/08/2015	36
04/05/2015	9.5	22/06/2015	107	10/08/2015	35
05/05/2015	1.5	23/06/2015	98	11/08/2015	45.5
06/05/2015	25	24/06/2015	115.5	12/08/2015	13.5
07/05/2015	9.5	25/06/2015	118.5	13/08/2015	31.5
08/05/2015	0	26/06/2015	88	14/08/2015	19
09/05/2015	19	27/06/2015	16.5	15/08/2015	15.5
10/05/2015	0	28/06/2015	16	16/08/2015	35.5
11/05/2015	3.5	29/06/2015	2	17/08/2015	3.5
12/05/2015	11.5	30/06/2015	12	18/08/2015	1
13/05/2015	14.5	01/07/2015	0.5	19/08/2015	15
14/05/2015	54.5	02/07/2015	1.5	20/08/2015	0
15/05/2015	14	03/07/2015	2.5	21/08/2015	0.5
16/05/2015	0	04/07/2015	22.5	22/08/2015	6
17/05/2015	11	05/07/2015	23	23/08/2015	23
18/05/2015	2	06/07/2015	15	24/08/2015	17.5
19/05/2015	3	07/07/2015	3.5	25/08/2015	9.5
20/05/2015	1.5	08/07/2015	5.5	26/08/2015	6.5
21/05/2015	0	09/07/2015	55	27/08/2015	19.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
28/08/2015	9.5	16/10/2015	0	04/12/2015	0
29/08/2015	0.5	17/10/2015	1	05/12/2015	0
30/08/2015	0	18/10/2015	0	06/12/2015	0
31/08/2015	2	19/10/2015	0	07/12/2015	0
01/09/2015	0	20/10/2015	0.5	08/12/2015	0
02/09/2015	0	21/10/2015	26.5	09/12/2015	0
03/09/2015	0	22/10/2015	2.5	10/12/2015	0
04/09/2015	7	23/10/2015	0.5	11/12/2015	0
05/09/2015	11	24/10/2015	0	12/12/2015	0
06/09/2015	4	25/10/2015	0	13/12/2015	0
07/09/2015	13.5	26/10/2015	0.5	14/12/2015	0
08/09/2015	118	27/10/2015	0	15/12/2015	0
09/09/2015	4.5	28/10/2015	3.5	16/12/2015	22.5
10/09/2015	4.5	29/10/2015	16	17/12/2015	0.5
11/09/2015	15.5	30/10/2015	53	18/12/2015	0
12/09/2015	5	31/10/2015	15	19/12/2015	0
13/09/2015	0.5	01/11/2015	6.5	20/12/2015	0
14/09/2015	7.5	02/11/2015	17	21/12/2015	0.5
15/09/2015	1.5	03/11/2015	14	22/12/2015	0
16/09/2015	28.5	04/11/2015	0.5	23/12/2015	0
17/09/2015	16.5	05/11/2015	13	24/12/2015	0.5
18/09/2015	0	06/11/2015	13	25/12/2015	0
19/09/2015	15.5	07/11/2015	3.5	26/12/2015	0
20/09/2015	12	08/11/2015	0	27/12/2015	0
21/09/2015	2.5	09/11/2015	0	28/12/2015	0
22/09/2015	1.5	10/11/2015	0	29/12/2015	0
23/09/2015	0	11/11/2015	0.5	30/12/2015	0
24/09/2015	1.5	12/11/2015	13.5	31/12/2015	0
25/09/2015	13.5	13/11/2015	47.5	01/01/2016	0
26/09/2015	0	14/11/2015	0	02/01/2016	0
27/09/2015	9.5	15/11/2015	0	03/01/2016	0
28/09/2015	37.5	16/11/2015	2	04/01/2016	0
29/09/2015	12.5	17/11/2015	0	05/01/2016	0
30/09/2015	27	18/11/2015	1.5	06/01/2016	0
01/10/2015	16.5	19/11/2015	0	07/01/2016	0
02/10/2015	4.5	20/11/2015	0.5	08/01/2016	0
03/10/2015	1.5	21/11/2015	2	09/01/2016	0
04/10/2015	26	22/11/2015	0	10/01/2016	0
05/10/2015	31.5	23/11/2015	0	11/01/2016	0
06/10/2015	23	24/11/2015	0	12/01/2016	0
07/10/2015	16	25/11/2015	34	13/01/2016	0
08/10/2015	9.5	26/11/2015	0	14/01/2016	0.5
09/10/2015	32.5	27/11/2015	0	15/01/2016	0
10/10/2015	2	28/11/2015	0	16/01/2016	0
11/10/2015	7	29/11/2015	0	17/01/2016	0
12/10/2015	9	30/11/2015	0	18/01/2016	0
13/10/2015	1	01/12/2015	0	19/01/2016	1.5
14/10/2015	0	02/12/2015	0	20/01/2016	0
15/10/2015	0.5	03/12/2015	2.5	21/01/2016	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
22/01/2016	0	11/03/2016	0	29/04/2016	0
23/01/2016	0	12/03/2016	0	30/04/2016	0
24/01/2016	0	13/03/2016	0	01/05/2016	0
25/01/2016	0	14/03/2016	0	01/06/2016	0.5
26/01/2016	0	15/03/2016	0	02/06/2016	1.5
27/01/2016	0	16/03/2016	0	03/06/2016	38.5
28/01/2016	0	17/03/2016	0	04/06/2016	0
29/01/2016	0	18/03/2016	0	05/06/2016	1
30/01/2016	0	19/03/2016	0	06/06/2016	19
31/01/2016	0	20/03/2016	0	07/06/2016	2.5
01/02/2016	0	21/03/2016	0	08/06/2016	0
02/02/2016	0	22/03/2016	0	09/06/2016	57
03/02/2016	0	23/03/2016	0	10/06/2016	60.5
04/02/2016	0	24/03/2016	0	11/06/2016	30
05/02/2016	0	25/03/2016	14	12/06/2016	12
06/02/2016	0	26/03/2016	0	13/06/2016	39.5
07/02/2016	0	27/03/2016	0	14/06/2016	23
08/02/2016	0	28/03/2016	0	15/06/2016	1.5
09/02/2016	0	29/03/2016	0	16/06/2016	13
10/02/2016	0	30/03/2016	0	17/06/2016	25.5
11/02/2016	0	31/03/2016	0	18/06/2016	5
12/02/2016	0	01/04/2016	0	19/06/2016	23
13/02/2016	0	02/04/2016	3.5	20/06/2016	19
14/02/2016	0	03/04/2016	2.5	21/06/2016	15.5
15/02/2016	0	04/04/2016	0	22/06/2016	29.5
16/02/2016	0	05/04/2016	0	23/06/2016	62.5
17/02/2016	0	06/04/2016	71	24/06/2016	25.5
18/02/2016	0	07/04/2016	0	25/06/2016	30.5
19/02/2016	0	08/04/2016	0	26/06/2016	15.5
20/02/2016	0	09/04/2016	0	27/06/2016	56.5
21/02/2016	0	10/04/2016	0	28/06/2016	75.5
22/02/2016	0	11/04/2016	0	29/06/2016	270
23/02/2016	0	12/04/2016	0	30/06/2016	122.5
24/02/2016	0	13/04/2016	0.5	01/07/2016	87
25/02/2016	0	14/04/2016	0	02/07/2016	40
26/02/2016	0	15/04/2016	0	03/07/2016	53
27/02/2016	0	16/04/2016	0	04/07/2016	69.5
28/02/2016	0	17/04/2016	3	05/07/2016	78
29/02/2016	0	18/04/2016	0	06/07/2016	17
01/03/2016	0	19/04/2016	0	07/07/2016	46.5
02/03/2016	0	20/04/2016	0	08/07/2016	13.5
03/03/2016	0	21/04/2016	0	09/07/2016	22
04/03/2016	0	22/04/2016	0	10/07/2016	81.5
05/03/2016	0	23/04/2016	0	11/07/2016	110
06/03/2016	0	24/04/2016	0	12/07/2016	40.5
07/03/2016	0	25/04/2016	0	13/07/2016	45.5
08/03/2016	0	26/04/2016	0	14/07/2016	11.5
09/03/2016	0	27/04/2016	0	15/07/2016	24.5
10/03/2016	0	28/04/2016	0	16/07/2016	23.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
17/07/2016	17.5	04/09/2016	3	23/10/2016	0
18/07/2016	18.5	05/09/2016	0	24/10/2016	1
19/07/2016	43	06/09/2016	0.5	25/10/2016	0
20/07/2016	11.5	07/09/2016	8.5	26/10/2016	0
21/07/2016	37	08/09/2016	0.5	27/10/2016	0.5
22/07/2016	28	09/09/2016	3	28/10/2016	0
23/07/2016	21	10/09/2016	0	29/10/2016	0
24/07/2016	36.5	11/09/2016	0	30/10/2016	0
25/07/2016	12	12/09/2016	0	31/10/2016	0
26/07/2016	0	13/09/2016	0	01/11/2016	26
27/07/2016	16.5	14/09/2016	0	02/11/2016	46
28/07/2016	22	15/09/2016	1.5	03/11/2016	0
29/07/2016	23	16/09/2016	10	04/11/2016	8
30/07/2016	10	17/09/2016	13	05/11/2016	0
31/07/2016	32	18/09/2016	0	06/11/2016	0
01/08/2016	11.5	19/09/2016	5	07/11/2016	0
02/08/2016	12	20/09/2016	0.5	08/11/2016	0
03/08/2016	51	21/09/2016	0	09/11/2016	0
04/08/2016	24	22/09/2016	19.5	10/11/2016	0.5
05/08/2016	47.5	23/09/2016	37	11/11/2016	0
06/08/2016	29	24/09/2016	34.5	12/11/2016	0
07/08/2016	49.5	25/09/2016	21	13/11/2016	0
08/08/2016	19.5	26/09/2016	17.5	14/11/2016	0
09/08/2016	14	27/09/2016	15	15/11/2016	11
10/08/2016	35	28/09/2016	0.5	16/11/2016	0
11/08/2016	4.5	29/09/2016	1	17/11/2016	0
12/08/2016	39.5	30/09/2016	0	18/11/2016	0
13/08/2016	20	01/10/2016	0	19/11/2016	0
14/08/2016	8.5	02/10/2016	0	20/11/2016	0
15/08/2016	17	03/10/2016	0	21/11/2016	0.5
16/08/2016	42.5	04/10/2016	0	22/11/2016	0
17/08/2016	30	05/10/2016	0	23/11/2016	0
18/08/2016	71	06/10/2016	0	24/11/2016	0.5
19/08/2016	62	07/10/2016	0	25/11/2016	0
20/08/2016	6.5	08/10/2016	0	26/11/2016	0
21/08/2016	0.5	09/10/2016	5	27/11/2016	0
22/08/2016	26	10/10/2016	0.5	28/11/2016	0
23/08/2016	11.5	11/10/2016	1	29/11/2016	0
24/08/2016	29	12/10/2016	5	30/11/2016	0
25/08/2016	6	13/10/2016	5	01/12/2016	0.5
26/08/2016	23.5	14/10/2016	44	02/12/2016	0.5
27/08/2016	7.5	15/10/2016	44	03/12/2016	0
28/08/2016	13.5	16/10/2016	0	04/12/2016	2
29/08/2016	14.5	17/10/2016	0	05/12/2016	0
30/08/2016	13.5	18/10/2016	0	06/12/2016	1.5
31/08/2016	11	19/10/2016	1	07/12/2016	0
01/09/2016	11.5	20/10/2016	0	08/12/2016	0
02/09/2016	5	21/10/2016	0	09/12/2016	0
03/09/2016	10	22/10/2016	0	10/12/2016	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
11/12/2016	0	29/01/2017	0	19/03/2017	0
12/12/2016	0	30/01/2017	0	20/03/2017	0
13/12/2016	3.5	31/01/2017	0	21/03/2017	0
14/12/2016	2.5	01/02/2017	0	22/03/2017	7
15/12/2016	4.5	02/02/2017	0.5	23/03/2017	0
16/12/2016	0	03/02/2017	0	24/03/2017	0
17/12/2016	0	04/02/2017	0	25/03/2017	0
18/12/2016	0	05/02/2017	0	26/03/2017	0
19/12/2016	0	06/02/2017	0	27/03/2017	0
20/12/2016	0	07/02/2017	0	28/03/2017	0
21/12/2016	0	08/02/2017	0	29/03/2017	0
22/12/2016	0	09/02/2017	0	30/03/2017	0
23/12/2016	0	10/02/2017	0	31/03/2017	0
24/12/2016	0	11/02/2017	0	01/04/2017	0
25/12/2016	0	12/02/2017	0	02/04/2017	0
26/12/2016	0	13/02/2017	0	03/04/2017	0
27/12/2016	0	14/02/2017	0	04/04/2017	0
28/12/2016	0	15/02/2017	0	05/04/2017	0.5
29/12/2016	0	16/02/2017	0	06/04/2017	0
30/12/2016	0	17/02/2017	0	07/04/2017	38.5
31/12/2016	0	18/02/2017	0	08/04/2017	0.5
01/01/2017	0	19/02/2017	0	09/04/2017	0
02/01/2017	0	20/02/2017	0	10/04/2017	2
03/01/2017	0	21/02/2017	0	11/04/2017	0
04/01/2017	0	22/02/2017	0	12/04/2017	17.5
05/01/2017	0	23/02/2017	0	13/04/2017	0
06/01/2017	0	24/02/2017	0	14/04/2017	21
07/01/2017	0	25/02/2017	0	15/04/2017	0.5
08/01/2017	0	26/02/2017	0	16/04/2017	0
09/01/2017	0	27/02/2017	0	17/04/2017	0
10/01/2017	0	28/02/2017	0	18/04/2017	0
11/01/2017	0	01/03/2017	0	19/04/2017	0
12/01/2017	0	02/03/2017	0	20/04/2017	0
13/01/2017	0	03/03/2017	0	21/04/2017	0
14/01/2017	0	04/03/2017	0	22/04/2017	3
15/01/2017	0	05/03/2017	0	23/04/2017	0
16/01/2017	0	06/03/2017	0	24/04/2017	0
17/01/2017	0	07/03/2017	0	25/04/2017	0
18/01/2017	0	08/03/2017	0	26/04/2017	0
19/01/2017	0	09/03/2017	0	27/04/2017	1
20/01/2017	0	10/03/2017	0	28/04/2017	10.5
21/01/2017	0	11/03/2017	0	29/04/2017	0.5
22/01/2017	0	12/03/2017	0	30/04/2017	0
23/01/2017	0	13/03/2017	0	01/05/2017	0
24/01/2017	0	14/03/2017	0	02/05/2017	43.5
25/01/2017	0	15/03/2017	0	03/05/2017	7
26/01/2017	0	16/03/2017	0	04/05/2017	0
27/01/2017	0	17/03/2017	0	05/05/2017	0
28/01/2017	43	18/03/2017	0	06/05/2017	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
07/05/2017	0	25/06/2017	45.5	13/08/2017	0
08/05/2017	4.5	26/06/2017	108	14/08/2017	0
09/05/2017	0	27/06/2017	89.5	15/08/2017	1
10/05/2017	67	28/06/2017	54.5	16/08/2017	12.5
11/05/2017	0	29/06/2017	50	17/08/2017	43
12/05/2017	1.5	30/06/2017	37.5	18/08/2017	44.5
13/05/2017	16.5	01/07/2017	32.5	19/08/2017	44.5
14/05/2017	0.5	02/07/2017	23.5	20/08/2017	50.5
15/05/2017	27	03/07/2017	39.5	21/08/2017	56.5
16/05/2017	0	04/07/2017	53	22/08/2017	44
17/05/2017	0	05/07/2017	20	23/08/2017	9.5
18/05/2017	0	06/07/2017	27.5	24/08/2017	22
19/05/2017	1.5	07/07/2017	21	25/08/2017	31.5
20/05/2017	0	08/07/2017	16	26/08/2017	10.5
21/05/2017	25	09/07/2017	9	27/08/2017	62
22/05/2017	0	10/07/2017	16.5	28/08/2017	56
23/05/2017	11	11/07/2017	9	29/08/2017	108
24/05/2017	3.5	12/07/2017	6.5	30/08/2017	57
25/05/2017	0	13/07/2017	17	31/08/2017	7.5
26/05/2017	0	14/07/2017	30.5	01/09/2017	0.5
27/05/2017	2.5	15/07/2017	17.5	02/09/2017	0.5
28/05/2017	0.5	16/07/2017	16.5	03/09/2017	0
29/05/2017	21	17/07/2017	20	04/09/2017	0.5
30/05/2017	22.5	18/07/2017	52.5	05/09/2017	1
31/05/2017	20	19/07/2017	181.5	06/09/2017	11
01/06/2017	1.5	20/07/2017	265.5	07/09/2017	1
02/06/2017	13.5	21/07/2017	40.5	08/09/2017	5
03/06/2017	16	22/07/2017	40.5	09/09/2017	6.5
04/06/2017	16.5	23/07/2017	12.5	10/09/2017	3.5
05/06/2017	32.5	24/07/2017	13	11/09/2017	7.5
06/06/2017	4.5	25/07/2017	14	12/09/2017	0.5
07/06/2017	10.5	26/07/2017	10	13/09/2017	3
08/06/2017	1	27/07/2017	8.5	14/09/2017	6
09/06/2017	4.5	28/07/2017	43.5	15/09/2017	12.5
10/06/2017	21.5	29/07/2017	9.5	16/09/2017	14
11/06/2017	51.5	30/07/2017	5	17/09/2017	63.5
12/06/2017	81	31/07/2017	6.5	18/09/2017	66.5
13/06/2017	27	01/08/2017	24	19/09/2017	112
14/06/2017	38.5	02/08/2017	1	20/09/2017	30
15/06/2017	21	03/08/2017	9.5	21/09/2017	13
16/06/2017	13.5	04/08/2017	54	22/09/2017	3
17/06/2017	38.5	05/08/2017	71	23/09/2017	0
18/06/2017	12.5	06/08/2017	35.5	24/09/2017	0.5
19/06/2017	10	07/08/2017	42.5	25/09/2017	2.5
20/06/2017	5.5	08/08/2017	20	26/09/2017	25
21/06/2017	22.5	09/08/2017	15	27/09/2017	50
22/06/2017	8	10/08/2017	4.5	28/09/2017	25.5
23/06/2017	3	11/08/2017	0	29/09/2017	18
24/06/2017	13.5	12/08/2017	52	30/09/2017	9

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
01/10/2017	8.5	19/11/2017	0	07/01/2018	0
02/10/2017	6.5	20/11/2017	0	08/01/2018	0
03/10/2017	0.5	21/11/2017	0.5	09/01/2018	0
04/10/2017	11.5	22/11/2017	0	10/01/2018	0
05/10/2017	0.5	23/11/2017	0	11/01/2018	0
06/10/2017	6.5	24/11/2017	0	12/01/2018	0
07/10/2017	23	25/11/2017	0	13/01/2018	0
08/10/2017	4.5	26/11/2017	0.5	14/01/2018	0
09/10/2017	8	27/11/2017	0	15/01/2018	0
10/10/2017	0	28/11/2017	0	16/01/2018	0
11/10/2017	2	29/11/2017	0	17/01/2018	0
12/10/2017	0	30/11/2017	0	18/01/2018	0
13/10/2017	1	01/12/2017	0	19/01/2018	0
14/10/2017	10	02/12/2017	4	20/01/2018	0
15/10/2017	41.5	03/12/2017	2	21/01/2018	0
16/10/2017	0.5	04/12/2017	0	22/01/2018	0
17/10/2017	0	05/12/2017	0.5	23/01/2018	0
18/10/2017	0.5	06/12/2017	0	24/01/2018	0
19/10/2017	0	07/12/2017	0	25/01/2018	0
20/10/2017	0.5	08/12/2017	0	26/01/2018	0
21/10/2017	3.5	09/12/2017	0.5	27/01/2018	0
22/10/2017	0	10/12/2017	0	28/01/2018	0
23/10/2017	0.5	11/12/2017	0	29/01/2018	0
24/10/2017	0	12/12/2017	0.5	30/01/2018	0
25/10/2017	0	13/12/2017	0	31/01/2018	0
26/10/2017	1	14/12/2017	0.5	01/02/2018	0
27/10/2017	1.5	15/12/2017	0	02/02/2018	0
28/10/2017	34	16/12/2017	0	03/02/2018	0
29/10/2017	0	17/12/2017	0	04/02/2018	0
30/10/2017	0	18/12/2017	0	05/02/2018	0
31/10/2017	0	19/12/2017	0	06/02/2018	0
01/11/2017	0	20/12/2017	0	07/02/2018	0
02/11/2017	0	21/12/2017	0	08/02/2018	0
03/11/2017	0	22/12/2017	0	09/02/2018	0
04/11/2017	0	23/12/2017	0	10/02/2018	0.5
05/11/2017	5	24/12/2017	0	11/02/2018	0
06/11/2017	0	25/12/2017	0	13/02/2018	0
07/11/2017	10	26/12/2017	0	14/02/2018	0
08/11/2017	0	27/12/2017	0	15/02/2018	0
09/11/2017	0.5	28/12/2017	0	16/02/2018	0
10/11/2017	0.5	29/12/2017	0	17/02/2018	0
11/11/2017	0	30/12/2017	0.5	18/02/2018	0
12/11/2017	0	31/12/2017	0	19/02/2018	0
13/11/2017	0	01/01/2018	0	20/02/2018	0
14/11/2017	0	02/01/2018	0	21/02/2018	0
15/11/2017	0	03/01/2018	0.5	22/02/2018	0
16/11/2017	0.5	04/01/2018	0	23/02/2018	0
17/11/2017	0	05/01/2018	0	24/02/2018	0
18/11/2017	0	06/01/2018	0	25/02/2018	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
26/02/2018	0	16/04/2018	12	04/06/2018	0.5
27/02/2018	0	17/04/2018	0.5	05/06/2018	17.5
28/02/2018	0	18/04/2018	13.5	06/06/2018	4
01/03/2018	0	19/04/2018	7.5	07/06/2018	18.5
02/03/2018	0	20/04/2018	1.5	08/06/2018	72
03/03/2018	0	21/04/2018	0	09/06/2018	98.5
04/03/2018	0	22/04/2018	22.5	10/06/2018	174.5
05/03/2018	0	23/04/2018	3.5	11/06/2018	205.5
06/03/2018	0	24/04/2018	1.5	12/06/2018	132.5
07/03/2018	0	25/04/2018	0	13/06/2018	200.5
08/03/2018	0	26/04/2018	0	14/06/2018	187.5
09/03/2018	0	27/04/2018	0	15/06/2018	4
10/03/2018	0	28/04/2018	0	16/06/2018	81
11/03/2018	0	29/04/2018	0	17/06/2018	18
12/03/2018	0	30/04/2018	0	18/06/2018	25.5
13/03/2018	0	01/05/2018	0	19/06/2018	36.5
14/03/2018	13	02/05/2018	0.5	20/06/2018	74
15/03/2018	2	03/05/2018	0	21/06/2018	35.5
16/03/2018	1	04/05/2018	15.5	22/06/2018	9.5
17/03/2018	0	05/05/2018	0	23/06/2018	18.5
18/03/2018	0	06/05/2018	0	24/06/2018	12.5
19/03/2018	44.5	07/05/2018	0	25/06/2018	16
20/03/2018	35.5	08/05/2018	23.5	26/06/2018	20.5
21/03/2018	0	09/05/2018	55.5	27/06/2018	146.5
22/03/2018	0	10/05/2018	0	28/06/2018	151.5
23/03/2018	0	11/05/2018	2	29/06/2018	37
24/03/2018	0	12/05/2018	57.5	30/06/2018	2.5
25/03/2018	0	13/05/2018	0	01/07/2018	34
26/03/2018	0	14/05/2018	5.5	02/07/2018	1.5
27/03/2018	0	15/05/2018	0	03/07/2018	11.5
28/03/2018	0	16/05/2018	11	04/07/2018	8.5
29/03/2018	0	17/05/2018	14	05/07/2018	11
30/03/2018	0	18/05/2018	1	06/07/2018	3
31/03/2018	0	19/05/2018	0	07/07/2018	141.5
01/04/2018	0	20/05/2018	4.5	08/07/2018	128.5
02/04/2018	0	21/05/2018	0	09/07/2018	90.5
03/04/2018	0	22/05/2018	10.5	10/07/2018	169.5
04/04/2018	0	23/05/2018	0	11/07/2018	173
05/04/2018	1	24/05/2018	0	12/07/2018	119.5
06/04/2018	0	25/05/2018	65	13/07/2018	142.5
07/04/2018	1.5	26/05/2018	22.5	14/07/2018	146.5
08/04/2018	4.5	27/05/2018	9	15/07/2018	83
09/04/2018	0	28/05/2018	40.5	16/07/2018	74.5
10/04/2018	0	29/05/2018	3.5	17/07/2018	132
11/04/2018	9	30/05/2018	62	18/07/2018	75.5
12/04/2018	0.5	31/05/2018	0.5	19/07/2018	73
13/04/2018	21.5	01/06/2018	0	20/07/2018	88.5
14/04/2018	11.5	02/06/2018	0	21/07/2018	52.5
15/04/2018	3.5	03/06/2018	0	22/07/2018	61.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
23/07/2018	26.5	10/09/2018	0	29/10/2018	0
24/07/2018	34.5	11/09/2018	0	30/10/2018	0
25/07/2018	15	12/09/2018	0	31/10/2018	0
26/07/2018	40.5	13/09/2018	0	01/11/2018	0
27/07/2018	6.5	14/09/2018	0	02/11/2018	0
28/07/2018	38.5	15/09/2018	0	03/11/2018	0
29/07/2018	37.5	16/09/2018	0	04/11/2018	3
30/07/2018	4	17/09/2018	3.5	05/11/2018	0
31/07/2018	44.5	18/09/2018	4.5	06/11/2018	0
01/08/2018	8.5	19/09/2018	0	07/11/2018	0
02/08/2018	16.5	20/09/2018	0	08/11/2018	0.5
03/08/2018	85.5	21/09/2018	0	09/11/2018	0
04/08/2018	51.5	22/09/2018	0	10/11/2018	0
05/08/2018	10	23/09/2018	1	11/11/2018	0
06/08/2018	26	24/09/2018	4.5	12/11/2018	0.5
07/08/2018	4	25/09/2018	0.5	13/11/2018	0
08/08/2018	155	26/09/2018	9	14/11/2018	0
09/08/2018	63	27/09/2018	13	15/11/2018	0
10/08/2018	26.5	28/09/2018	1.5	16/11/2018	0
11/08/2018	58.5	29/09/2018	27.5	17/11/2018	0
12/08/2018	66.5	30/09/2018	1.5	18/11/2018	0
13/08/2018	124.5	01/10/2018	3	19/11/2018	0
14/08/2018	288.5	02/10/2018	1	20/11/2018	1
15/08/2018	221	03/10/2018	0	21/11/2018	0
16/08/2018	163	04/10/2018	17.5	22/11/2018	0
17/08/2018	96.5	05/10/2018	0	23/11/2018	0
18/08/2018	59	06/10/2018	18.5	24/11/2018	21
19/08/2018	96.5	07/10/2018	0	25/11/2018	15
20/08/2018	37.5	08/10/2018	0	26/11/2018	0.5
21/08/2018	36	09/10/2018	31.5	27/11/2018	0
22/08/2018	23	10/10/2018	51.5	28/11/2018	0
23/08/2018	11.5	11/10/2018	0.5	29/11/2018	0
24/08/2018	6.5	12/10/2018	3.5	30/11/2018	0
25/08/2018	4	13/10/2018	0	01/12/2018	0.5
26/08/2018	1.5	14/10/2018	0	02/12/2018	0
27/08/2018	9	15/10/2018	3	03/12/2018	0
28/08/2018	31.5	16/10/2018	0	04/12/2018	0
29/08/2018	40.5	17/10/2018	10.5	05/12/2018	0
30/08/2018	17	18/10/2018	0	06/12/2018	0.5
31/08/2018	14.5	19/10/2018	3.5	07/12/2018	39.5
01/09/2018	3	20/10/2018	12.5	08/12/2018	0
02/09/2018	0.5	21/10/2018	5	09/12/2018	0.5
03/09/2018	1	22/10/2018	0	10/12/2018	0
04/09/2018	0	23/10/2018	0.5	11/12/2018	0
05/09/2018	0	24/10/2018	0	12/12/2018	0
06/09/2018	0	25/10/2018	0	13/12/2018	0
07/09/2018	1.5	26/10/2018	0	14/12/2018	0
08/09/2018	2.5	27/10/2018	0	15/12/2018	0.5
09/09/2018	6	28/10/2018	0	16/12/2018	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
17/12/2018	0	04/02/2019	0	25/03/2019	0
18/12/2018	0	05/02/2019	0	26/03/2019	0
19/12/2018	0	06/02/2019	0	27/03/2019	0
20/12/2018	0.5	07/02/2019	0	28/03/2019	0
21/12/2018	0	08/02/2019	0	29/03/2019	0
22/12/2018	0	09/02/2019	0.5	30/03/2019	0
23/12/2018	0	10/02/2019	0	31/03/2019	0
24/12/2018	0	11/02/2019	0	01/04/2019	0
25/12/2018	5.5	12/02/2019	0	02/04/2019	0
26/12/2018	0	13/02/2019	0	03/04/2019	0.5
27/12/2018	0.5	14/02/2019	0	04/04/2019	0
28/12/2018	0	15/02/2019	0	05/04/2019	0
29/12/2018	0	16/02/2019	0	06/04/2019	0
30/12/2018	1.5	17/02/2019	0	07/04/2019	0
31/12/2018	0	18/02/2019	0	08/04/2019	0
01/01/2019	0	19/02/2019	0	09/04/2019	0
02/01/2019	0	20/02/2019	0	10/04/2019	1
03/01/2019	0	21/02/2019	0	11/04/2019	10.5
04/01/2019	0	22/02/2019	0	12/04/2019	3.5
05/01/2019	0	23/02/2019	0	13/04/2019	0
06/01/2019	0	24/02/2019	0	14/04/2019	0.5
07/01/2019	0	25/02/2019	0	15/04/2019	0
08/01/2019	0	26/02/2019	0	16/04/2019	0
09/01/2019	0.5	27/02/2019	0	17/04/2019	1
10/01/2019	0	28/02/2019	0	18/04/2019	10.5
11/01/2019	0	01/03/2019	0	19/04/2019	5.5
12/01/2019	0	02/03/2019	0	20/04/2019	0
13/01/2019	0	03/03/2019	0	21/04/2019	0
14/01/2019	0.5	04/03/2019	0	22/04/2019	0
15/01/2019	0	05/03/2019	0	23/04/2019	0
16/01/2019	0	06/03/2019	0	24/04/2019	0
17/01/2019	0	07/03/2019	0	25/04/2019	0
18/01/2019	0	08/03/2019	0	26/04/2019	0
19/01/2019	0.5	09/03/2019	0	27/04/2019	0
20/01/2019	0	10/03/2019	0	28/04/2019	7.5
21/01/2019	0	11/03/2019	0	29/04/2019	0
22/01/2019	0	12/03/2019	0	30/04/2019	8.5
23/01/2019	0	13/03/2019	0	01/05/2019	2
24/01/2019	0	14/03/2019	0	02/05/2019	0.5
25/01/2019	0	15/03/2019	0	03/05/2019	0.5
26/01/2019	0	16/03/2019	0	04/05/2019	0
27/01/2019	0	17/03/2019	0	05/05/2019	0
28/01/2019	0.5	18/03/2019	0	06/05/2019	0
29/01/2019	0	19/03/2019	0	07/05/2019	1
30/01/2019	0	20/03/2019	0	08/05/2019	0
31/01/2019	0	21/03/2019	0	09/05/2019	0
01/02/2019	0.5	22/03/2019	0	10/05/2019	0
02/02/2019	0	23/03/2019	0	11/05/2019	0
03/02/2019	0	24/03/2019	0	12/05/2019	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
13/05/2019	0.5	01/07/2019	18	19/08/2019	4.5
14/05/2019	0	02/07/2019	61.5	20/08/2019	4.5
15/05/2019	0	03/07/2019	32	21/08/2019	19
16/05/2019	0	04/07/2019	19	22/08/2019	32.5
17/05/2019	0.5	05/07/2019	95.5	23/08/2019	9
18/05/2019	0	06/07/2019	114	24/08/2019	15.5
19/05/2019	0	07/07/2019	64.5	25/08/2019	22
20/05/2019	2	08/07/2019	34.5	26/08/2019	5
21/05/2019	0	09/07/2019	48.5	27/08/2019	65
22/05/2019	0	10/07/2019	61.5	28/08/2019	6.5
23/05/2019	0.5	11/07/2019	36.5	29/08/2019	11
24/05/2019	3	12/07/2019	5.5	30/08/2019	29
25/05/2019	21.5	13/07/2019	33.5	31/08/2019	19.5
26/05/2019	7.5	14/07/2019	30	01/09/2019	53
27/05/2019	0	15/07/2019	16	02/09/2019	64
28/05/2019	0	16/07/2019	7.5	03/09/2019	32.5
29/05/2019	3	17/07/2019	3.5	04/09/2019	76
30/05/2019	0	18/07/2019	10.5	05/09/2019	242
31/05/2019	0	19/07/2019	46	06/09/2019	109.5
01/06/2019	0.5	20/07/2019	67	07/09/2019	34.5
02/06/2019	0	21/07/2019	75.5	08/09/2019	82
03/06/2019	25	22/07/2019	76	09/09/2019	108.5
04/06/2019	0	23/07/2019	98.5	10/09/2019	21.5
05/06/2019	0	24/07/2019	38	11/09/2019	24.5
06/06/2019	21.5	25/07/2019	37.5	12/09/2019	41.5
07/06/2019	0	26/07/2019	38.5	13/09/2019	65
08/06/2019	0	27/07/2019	5	14/09/2019	0
09/06/2019	0	28/07/2019	6.5	15/09/2019	32.5
10/06/2019	5.5	29/07/2019	8.5	16/09/2019	27
11/06/2019	33.5	30/07/2019	5.5	17/09/2019	1
12/06/2019	32.5	31/07/2019	2.5	18/09/2019	7.5
13/06/2019	45	01/08/2019	0	19/09/2019	2.5
14/06/2019	71.5	02/08/2019	5	20/09/2019	14.5
15/06/2019	54.5	03/08/2019	52.5	21/09/2019	3.5
16/06/2019	11	04/08/2019	138.5	22/09/2019	0
17/06/2019	0	05/08/2019	142.5	23/09/2019	8
18/06/2019	3.5	06/08/2019	150	24/09/2019	24
19/06/2019	28.5	07/08/2019	269	25/09/2019	10
20/06/2019	55	08/08/2019	258.5	26/09/2019	5.5
21/06/2019	7.5	09/08/2019	356.5	27/09/2019	7
22/06/2019	13	10/08/2019	169.5	28/09/2019	0.5
23/06/2019	6.5	11/08/2019	76.5	29/09/2019	0
24/06/2019	18.5	12/08/2019	34.5	30/09/2019	28
25/06/2019	6.5	13/08/2019	46.5	01/10/2019	1.5
26/06/2019	27.5	14/08/2019	26	02/10/2019	0
27/06/2019	13.5	15/08/2019	76	03/10/2019	0
28/06/2019	5	16/08/2019	23.5	04/10/2019	0.5
29/06/2019	0.5	17/08/2019	19	05/10/2019	6
30/06/2019	28	18/08/2019	2.5	06/10/2019	10.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
07/10/2019	0	25/11/2019	0	13/01/2020	0
08/10/2019	0.5	26/11/2019	0	14/01/2020	0
09/10/2019	10	27/11/2019	0	15/01/2020	0.5
10/10/2019	0.5	28/11/2019	0	16/01/2020	0
11/10/2019	0	29/11/2019	0	17/01/2020	0
12/10/2019	11.5	30/11/2019	0	18/01/2020	0
13/10/2019	2	01/12/2019	0	19/01/2020	0
14/10/2019	11.5	02/12/2019	33	20/01/2020	0
15/10/2019	16.5	03/12/2019	33.5	21/01/2020	0
16/10/2019	41	04/12/2019	0	22/01/2020	0
17/10/2019	25	05/12/2019	0	23/01/2020	0
18/10/2019	18.5	06/12/2019	0	24/01/2020	0
19/10/2019	29.5	07/12/2019	0	25/01/2020	0
20/10/2019	2.5	08/12/2019	0	26/01/2020	0
21/10/2019	24.5	09/12/2019	0	27/01/2020	0
22/10/2019	15.5	10/12/2019	0	28/01/2020	0
23/10/2019	22.5	11/12/2019	0	29/01/2020	0
24/10/2019	21.5	12/12/2019	0	30/01/2020	0
25/10/2019	44	13/12/2019	0.5	31/01/2020	0
26/10/2019	74.5	14/12/2019	0	01/02/2020	0
27/10/2019	39	15/12/2019	0	02/02/2020	0
28/10/2019	2.5	16/12/2019	0	03/02/2020	0
29/10/2019	2.5	17/12/2019	0	04/02/2020	0
30/10/2019	0.5	18/12/2019	0	05/02/2020	0
31/10/2019	0.5	19/12/2019	0	06/02/2020	0
01/11/2019	26.5	20/12/2019	0	07/02/2020	0
02/11/2019	0.5	21/12/2019	0	08/02/2020	0
03/11/2019	0	22/12/2019	0	09/02/2020	0
04/11/2019	5.5	23/12/2019	0	10/02/2020	0
05/11/2019	0	24/12/2019	0	11/02/2020	0
06/11/2019	7.5	25/12/2019	0	12/02/2020	0
07/11/2019	6.5	26/12/2019	0.5	13/02/2020	0
08/11/2019	0	27/12/2019	0.5	14/02/2020	0
09/11/2019	0.5	28/12/2019	0	15/02/2020	0
10/11/2019	0	29/12/2019	0	16/02/2020	0
11/11/2019	27	30/12/2019	0	17/02/2020	0
12/11/2019	1	31/12/2019	0.5	18/02/2020	0
13/11/2019	0	01/01/2020	0	19/02/2020	0
14/11/2019	0	02/01/2020	0	20/02/2020	0
15/11/2019	0	03/01/2020	0	21/02/2020	0
16/11/2019	0	04/01/2020	0.5	22/02/2020	0
17/11/2019	9.5	05/01/2020	0	23/02/2020	0
18/11/2019	0	06/01/2020	0	24/02/2020	0
19/11/2019	0.5	07/01/2020	0.5	25/02/2020	0
20/11/2019	0	08/01/2020	0	26/02/2020	0
21/11/2019	4	09/01/2020	0	27/02/2020	0
22/11/2019	0	10/01/2020	0.5	28/02/2020	0
23/11/2019	0	11/01/2020	0	29/02/2020	1
24/11/2019	0	12/01/2020	0	01/03/2020	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
02/03/2020	0	20/04/2020	0	08/06/2020	38
03/03/2020	8	21/04/2020	0	09/06/2020	0
04/03/2020	0	22/04/2020	5.5	10/06/2020	24
05/03/2020	0	23/04/2020	12	11/06/2020	36.5
06/03/2020	0	24/04/2020	80.5	12/06/2020	23
07/03/2020	0	25/04/2020	0	13/06/2020	2
08/03/2020	0	26/04/2020	0	14/06/2020	54.5
09/03/2020	0	27/04/2020	5.5	15/06/2020	32.5
10/03/2020	0	28/04/2020	0.5	16/06/2020	25.5
11/03/2020	0	29/04/2020	0	17/06/2020	66.5
12/03/2020	0	30/04/2020	0	18/06/2020	101.5
13/03/2020	0	01/05/2020	7	19/06/2020	21
14/03/2020	0	02/05/2020	42.5	20/06/2020	9
15/03/2020	0	03/05/2020	16	21/06/2020	5
16/03/2020	0	04/05/2020	21	22/06/2020	50
17/03/2020	0	05/05/2020	0	23/06/2020	8.5
18/03/2020	0	06/05/2020	2	24/06/2020	0.5
19/03/2020	0	07/05/2020	0	25/06/2020	2
20/03/2020	0	08/05/2020	31.5	26/06/2020	0
21/03/2020	0	09/05/2020	0	27/06/2020	10
22/03/2020	0	10/05/2020	0	28/06/2020	3
23/03/2020	0	11/05/2020	0.5	29/06/2020	42.5
24/03/2020	0	12/05/2020	29.5	30/06/2020	68
25/03/2020	0	13/05/2020	0	01/07/2020	16
26/03/2020	0	14/05/2020	0	02/07/2020	32
27/03/2020	0	15/05/2020	18	03/07/2020	60
28/03/2020	0	16/05/2020	7.5	04/07/2020	42.5
29/03/2020	0	17/05/2020	0	05/07/2020	45
30/03/2020	0	18/05/2020	127	06/07/2020	55.5
31/03/2020	5	19/05/2020	3	07/07/2020	126.5
01/04/2020	0	20/05/2020	1	08/07/2020	74
02/04/2020	0	21/05/2020	0	09/07/2020	23.5
03/04/2020	2.5	22/05/2020	7	10/07/2020	18.5
04/04/2020	0	23/05/2020	0	11/07/2020	1.5
05/04/2020	0	24/05/2020	3.5	12/07/2020	16.5
06/04/2020	7.5	25/05/2020	0	13/07/2020	10.5
07/04/2020	14.5	26/05/2020	1	14/07/2020	16
08/04/2020	0	27/05/2020	0	15/07/2020	10.5
09/04/2020	79.5	28/05/2020	12.5	16/07/2020	79
10/04/2020	7	29/05/2020	0	17/07/2020	113
11/04/2020	9.5	30/05/2020	0.5	18/07/2020	72
12/04/2020	0	31/05/2020	10	19/07/2020	45
13/04/2020	0	01/06/2020	6	20/07/2020	1
14/04/2020	0	02/06/2020	33	21/07/2020	26
15/04/2020	0	03/06/2020	56	22/07/2020	0
16/04/2020	0	04/06/2020	62.5	23/07/2020	0
17/04/2020	1	05/06/2020	2.5	24/07/2020	3.5
18/04/2020	0	06/06/2020	0.5	25/07/2020	7
19/04/2020	0	07/06/2020	61	26/07/2020	4.5

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
27/07/2020	1.5	14/09/2020	25.5	02/11/2020	9.5
28/07/2020	7.5	15/09/2020	3.5	03/11/2020	18
29/07/2020	1	16/09/2020	27	04/11/2020	12.5
30/07/2020	14.5	17/09/2020	6.5	05/11/2020	3
31/07/2020	14.5	18/09/2020	41.5	06/11/2020	7
01/08/2020	21	19/09/2020	43	07/11/2020	0
02/08/2020	26.5	20/09/2020	162	08/11/2020	0
03/08/2020	51.5	21/09/2020	126	09/11/2020	0
04/08/2020	172	22/09/2020	114.5	10/11/2020	0
05/08/2020	185	23/09/2020	25.5	11/11/2020	0
06/08/2020	478	24/09/2020	0.5	12/11/2020	0
07/08/2020	388	25/09/2020	3	13/11/2020	0
08/08/2020	191	26/09/2020	1.5	14/11/2020	3
09/08/2020	77.5	27/09/2020	27	15/11/2020	0
10/08/2020	46	28/09/2020	0	16/11/2020	0
11/08/2020	34.5	29/09/2020	0	17/11/2020	0
12/08/2020	63.5	30/09/2020	1.5	18/11/2020	0
13/08/2020	15	01/10/2020	2.5	19/11/2020	0
14/08/2020	9	02/10/2020	0	20/11/2020	0
15/08/2020	39.5	03/10/2020	1.5	21/11/2020	0
16/08/2020	28	04/10/2020	1	22/11/2020	0
17/08/2020	20.5	05/10/2020	2.5	23/11/2020	0
18/08/2020	38.5	06/10/2020	0	24/11/2020	0
19/08/2020	30	07/10/2020	2	25/11/2020	0
20/08/2020	9.5	08/10/2020	2	26/11/2020	0
21/08/2020	31	09/10/2020	10	27/11/2020	0
22/08/2020	20	10/10/2020	3	28/11/2020	0.5
23/08/2020	11	11/10/2020	37.5	29/11/2020	0
24/08/2020	8	12/10/2020	20.5	30/11/2020	0
25/08/2020	0	13/10/2020	44.5	01/12/2020	0
26/08/2020	0	14/10/2020	48.5	02/12/2020	0
27/08/2020	0	15/10/2020	89.5	03/12/2020	0
28/08/2020	0.5	16/10/2020	27.5	04/12/2020	0
29/08/2020	0	17/10/2020	0	05/12/2020	0
30/08/2020	7.5	18/10/2020	0	06/12/2020	0
31/08/2020	3.5	19/10/2020	0.5	07/12/2020	0
01/09/2020	2.5	20/10/2020	23	08/12/2020	0
02/09/2020	30.5	21/10/2020	1	09/12/2020	4.5
03/09/2020	29.5	22/10/2020	15	10/12/2020	0
04/09/2020	0	23/10/2020	12	11/12/2020	0
05/09/2020	15.5	24/10/2020	3.5	12/12/2020	0.5
06/09/2020	9.5	25/10/2020	0.5	13/12/2020	0
07/09/2020	13.5	26/10/2020	0	14/12/2020	0.5
08/09/2020	5	27/10/2020	0	15/12/2020	0.5
09/09/2020	2	28/10/2020	6.5	16/12/2020	0
10/09/2020	20.5	29/10/2020	0	17/12/2020	0
11/09/2020	44.5	30/10/2020	0.5	18/12/2020	0
12/09/2020	68	31/10/2020	0	19/12/2020	0
13/09/2020	57	01/11/2020	0	20/12/2020	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
21/12/2020	0	08/02/2021	0	29/03/2021	0
22/12/2020	0	09/02/2021	0	30/03/2021	0
23/12/2020	0	10/02/2021	0	31/03/2021	0
24/12/2020	10.5	11/02/2021	0	01/04/2021	0
25/12/2020	0	12/02/2021	0	02/04/2021	0
26/12/2020	0	13/02/2021	0	03/04/2021	0
27/12/2020	0	14/02/2021	0	04/04/2021	0
28/12/2020	0	15/02/2021	0	05/04/2021	0
29/12/2020	0	16/02/2021	0	06/04/2021	0
30/12/2020	0	17/02/2021	0	07/04/2021	0
31/12/2020	0	18/02/2021	0	08/04/2021	0
01/01/2021	0	19/02/2021	0	09/04/2021	0
02/01/2021	0	20/02/2021	9	10/04/2021	0
03/01/2021	0	21/02/2021	3.5	11/04/2021	8
04/01/2021	36	22/02/2021	7.5	12/04/2021	5.5
05/01/2021	0.5	23/02/2021	3.5	13/04/2021	33.5
06/01/2021	0.5	24/02/2021	0.5	14/04/2021	0
07/01/2021	16	25/02/2021	0	15/04/2021	16.5
08/01/2021	30	26/02/2021	0	16/04/2021	0
09/01/2021	51.5	27/02/2021	0.5	17/04/2021	11
10/01/2021	0	28/02/2021	0	18/04/2021	42.5
11/01/2021	0	01/03/2021	0	19/04/2021	14.5
12/01/2021	0	02/03/2021	0	20/04/2021	6
13/01/2021	0	03/03/2021	0	21/04/2021	0.5
14/01/2021	2	04/03/2021	0	22/04/2021	32
15/01/2021	3.5	05/03/2021	0	23/04/2021	5.5
16/01/2021	1	06/03/2021	0	24/04/2021	23.5
17/01/2021	0.5	07/03/2021	0	25/04/2021	4.5
18/01/2021	0	08/03/2021	0	26/04/2021	1
19/01/2021	0	09/03/2021	0	27/04/2021	8.5
20/01/2021	0	10/03/2021	0	28/04/2021	0
21/01/2021	0	11/03/2021	0	29/04/2021	0
22/01/2021	0	12/03/2021	0	30/04/2021	13
23/01/2021	0	13/03/2021	0	01/05/2021	0
24/01/2021	0	14/03/2021	0	02/05/2021	105
25/01/2021	0	15/03/2021	0	03/05/2021	0.5
26/01/2021	0	16/03/2021	0	04/05/2021	3.5
27/01/2021	0	17/03/2021	0.5	05/05/2021	0
28/01/2021	0	18/03/2021	0	06/05/2021	6
29/01/2021	0	19/03/2021	0	07/05/2021	3.5
30/01/2021	0	20/03/2021	0	08/05/2021	66
31/01/2021	0	21/03/2021	14	09/05/2021	0.5
01/02/2021	0	22/03/2021	0	10/05/2021	0.5
02/02/2021	0	23/03/2021	0	11/05/2021	30.5
03/02/2021	0	24/03/2021	0	12/05/2021	0.5
04/02/2021	0	25/03/2021	0	13/05/2021	0
05/02/2021	0	26/03/2021	0	14/05/2021	0.5
06/02/2021	0	27/03/2021	0	15/05/2021	42
07/02/2021	0	28/03/2021	2.5	16/05/2021	168

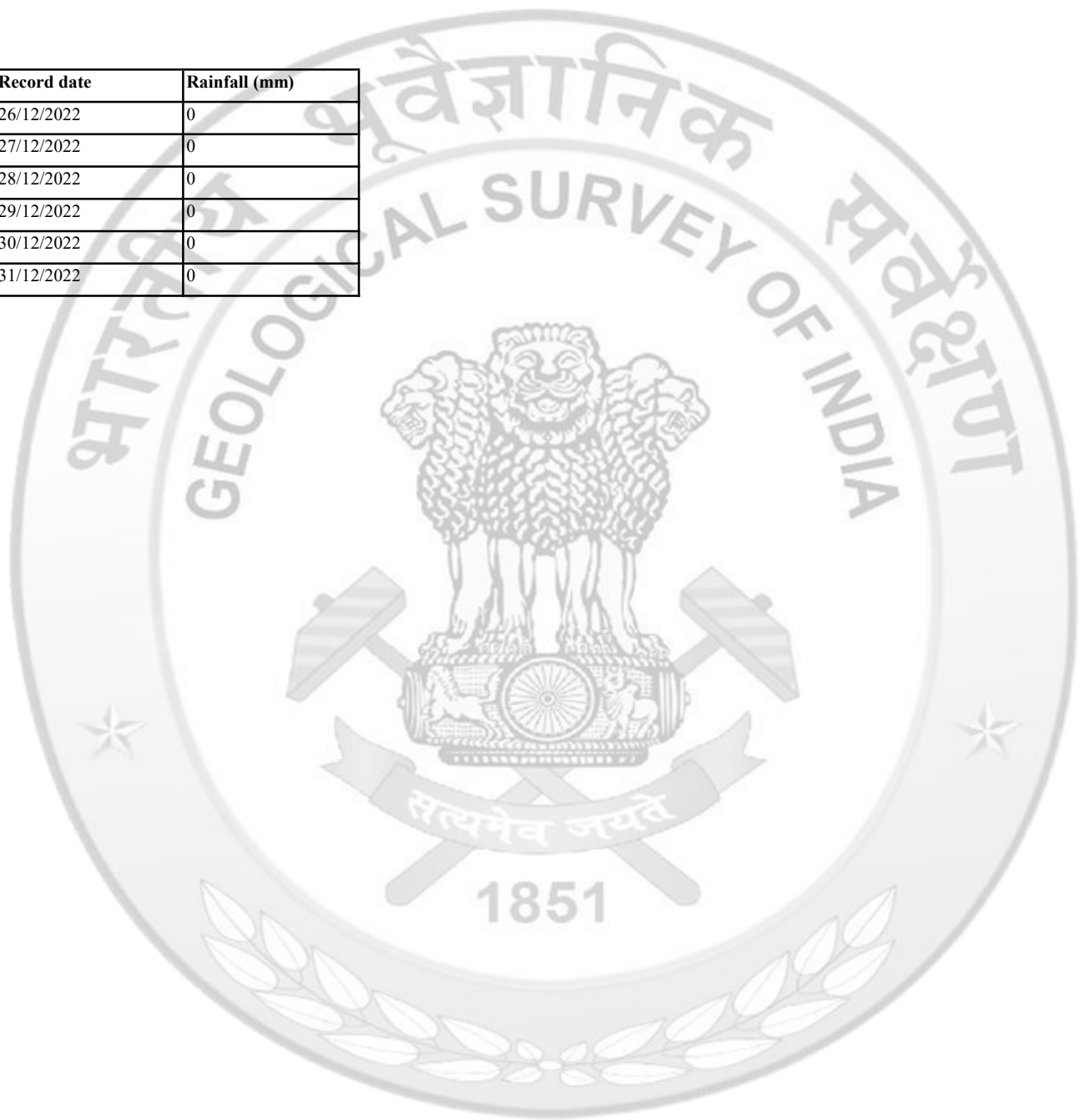
Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
17/05/2021	28.5	05/07/2021	2	23/08/2021	1
18/05/2021	34.5	06/07/2021	0	24/08/2021	4.5
19/05/2021	10.5	07/07/2021	0	25/08/2021	0
20/05/2021	11.5	08/07/2021	7	26/08/2021	0
21/05/2021	25	09/07/2021	2.5	27/08/2021	42
22/05/2021	1.5	10/07/2021	22.5	28/08/2021	62
23/05/2021	7.5	11/07/2021	70	29/08/2021	27
24/05/2021	0.5	12/07/2021	20.5	30/08/2021	33.5
25/05/2021	0	13/07/2021	42.5	31/08/2021	16.5
26/05/2021	30	14/07/2021	94.5	01/09/2021	1.5
27/05/2021	4.5	15/07/2021	105	02/09/2021	32.5
28/05/2021	0.5	16/07/2021	80	03/09/2021	43.5
29/05/2021	1	17/07/2021	18.5	04/09/2021	21
30/05/2021	19	18/07/2021	44	05/09/2021	8
31/05/2021	2	19/07/2021	44.5	06/09/2021	33
01/06/2021	3.5	20/07/2021	15.5	07/09/2021	59.5
02/06/2021	0.5	21/07/2021	36.5	08/09/2021	95
03/06/2021	0	22/07/2021	79.5	09/09/2021	1
04/06/2021	8	23/07/2021	143.5	10/09/2021	0
05/06/2021	8	24/07/2021	93.5	11/09/2021	0
06/06/2021	4	25/07/2021	47	12/09/2021	59.5
07/06/2021	2.5	26/07/2021	100	13/09/2021	38
08/06/2021	0	27/07/2021	21.5	14/09/2021	26.5
09/06/2021	2	28/07/2021	15	15/09/2021	5
10/06/2021	16.5	29/07/2021	13.5	16/09/2021	0.5
11/06/2021	16	30/07/2021	7	17/09/2021	9
12/06/2021	18	31/07/2021	8	18/09/2021	0
13/06/2021	84.5	01/08/2021	16.5	19/09/2021	0
14/06/2021	90.5	02/08/2021	4	20/09/2021	0
15/06/2021	85	03/08/2021	35	21/09/2021	0
16/06/2021	117	04/08/2021	41.5	22/09/2021	30
17/06/2021	108	05/08/2021	25.5	23/09/2021	7
18/06/2021	196.5	06/08/2021	59	24/09/2021	2.5
19/06/2021	96	07/08/2021	85.5	25/09/2021	22.5
20/06/2021	40	08/08/2021	42.5	26/09/2021	0
21/06/2021	25	09/08/2021	31	27/09/2021	1.5
22/06/2021	13	10/08/2021	4.5	28/09/2021	19
23/06/2021	4.5	11/08/2021	2	29/09/2021	1.5
24/06/2021	2	12/08/2021	11.5	30/09/2021	2
25/06/2021	0.5	13/08/2021	8	01/10/2021	1
26/06/2021	4	14/08/2021	34	02/10/2021	57
27/06/2021	19	15/08/2021	21	03/10/2021	56.5
28/06/2021	0	16/08/2021	28	04/10/2021	3.5
29/06/2021	5	17/08/2021	3	05/10/2021	0.5
30/06/2021	1	18/08/2021	11.5	06/10/2021	21
01/07/2021	0	19/08/2021	115	07/10/2021	1
02/07/2021	17.5	20/08/2021	9.5	08/10/2021	0
03/07/2021	11.5	21/08/2021	4.5	09/10/2021	4
04/07/2021	1.5	22/08/2021	10	10/10/2021	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
11/10/2021	6.5	29/11/2021	1	17/01/2022	0
12/10/2021	30.5	30/11/2021	0.5	18/01/2022	0
13/10/2021	25	01/12/2021	2.5	19/01/2022	0
14/10/2021	0	02/12/2021	19.5	20/01/2022	0
15/10/2021	5.5	03/12/2021	0	21/01/2022	0
16/10/2021	4	04/12/2021	1.5	22/01/2022	0
17/10/2021	77	05/12/2021	1	23/01/2022	0
18/10/2021	5.5	06/12/2021	0	24/01/2022	0
19/10/2021	1	07/12/2021	0.5	25/01/2022	0
20/10/2021	0	08/12/2021	0	26/01/2022	0
21/10/2021	21.5	09/12/2021	0	27/01/2022	0
22/10/2021	1	10/12/2021	2.5	28/01/2022	0
23/10/2021	9.5	11/12/2021	0.5	29/01/2022	0
24/10/2021	44	12/12/2021	0	30/01/2022	0
25/10/2021	31.5	13/12/2021	0	31/01/2022	0
26/10/2021	21	14/12/2021	0	01/02/2022	0
27/10/2021	0	15/12/2021	0	02/02/2022	0
28/10/2021	0	16/12/2021	0	03/02/2022	0
29/10/2021	0	17/12/2021	0	04/02/2022	0
30/10/2021	13	18/12/2021	0	05/02/2022	0
31/10/2021	17	19/12/2021	0	06/02/2022	0
01/11/2021	37.5	20/12/2021	0	07/02/2022	0
02/11/2021	22	21/12/2021	0	08/02/2022	0
03/11/2021	7.5	22/12/2021	0	09/02/2022	0
04/11/2021	5.5	23/12/2021	0	10/02/2022	0
05/11/2021	1.5	24/12/2021	0	11/02/2022	0
06/11/2021	12	25/12/2021	0	12/02/2022	0
07/11/2021	44	26/12/2021	0	13/02/2022	0
08/11/2021	0	27/12/2021	0	14/02/2022	0
09/11/2021	20.5	28/12/2021	0	15/02/2022	0
10/11/2021	0	29/12/2021	0	16/02/2022	0
11/11/2021	0	30/12/2021	0	17/02/2022	0
12/11/2021	1	31/12/2021	0	18/02/2022	4.5
13/11/2021	5.5	01/01/2022	0	19/02/2022	0
14/11/2021	67.5	02/01/2022	0	20/02/2022	0
15/11/2021	30.5	03/01/2022	0	21/02/2022	0
16/11/2021	2	04/01/2022	0	22/02/2022	0
17/11/2021	8	05/01/2022	0	23/02/2022	0
18/11/2021	9.5	06/01/2022	0	24/02/2022	0
19/11/2021	7.5	07/01/2022	0	25/02/2022	0
20/11/2021	35.5	08/01/2022	0	26/02/2022	0
21/11/2021	2.5	09/01/2022	0	27/02/2022	0
22/11/2021	15	10/01/2022	0	28/02/2022	0
23/11/2021	12.5	11/01/2022	0	01/03/2022	0
24/11/2021	30.5	12/01/2022	0	02/03/2022	0
25/11/2021	0.5	13/01/2022	0	03/03/2022	0
26/11/2021	0	14/01/2022	0	04/03/2022	0
27/11/2021	0	15/01/2022	0	05/03/2022	0
28/11/2021	0.5	16/01/2022	0	06/03/2022	0

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
07/03/2022	0	25/04/2022	0	13/06/2022	27.5
08/03/2022	0	26/04/2022	0	14/06/2022	4
09/03/2022	0	27/04/2022	25	15/06/2022	6.5
10/03/2022	0	28/04/2022	0	16/06/2022	8
11/03/2022	0	29/04/2022	3	17/06/2022	9
12/03/2022	0	30/04/2022	5	18/06/2022	0.5
13/03/2022	0	01/05/2022	18	19/06/2022	20.5
14/03/2022	0	02/05/2022	1	20/06/2022	7
15/03/2022	0	03/05/2022	0	21/06/2022	24.5
16/03/2022	0	04/05/2022	10	22/06/2022	20.5
17/03/2022	0	05/05/2022	22.5	23/06/2022	19.5
18/03/2022	0	06/05/2022	0.5	24/06/2022	20.5
19/03/2022	0	07/05/2022	0	25/06/2022	23
20/03/2022	0	08/05/2022	0	26/06/2022	60.5
21/03/2022	0	09/05/2022	12.5	27/06/2022	39
22/03/2022	0	10/05/2022	2	28/06/2022	28
23/03/2022	0	11/05/2022	3	29/06/2022	78.5
24/03/2022	0	12/05/2022	15	30/06/2022	49
25/03/2022	2.5	13/05/2022	34.5	01/07/2022	69.5
26/03/2022	5.5	14/05/2022	7	02/07/2022	102
27/03/2022	0	15/05/2022	1.5	03/07/2022	147
28/03/2022	0	16/05/2022	1.5	04/07/2022	122
29/03/2022	0	17/05/2022	29	05/07/2022	113.5
30/03/2022	0	18/05/2022	49.5	06/07/2022	131.5
31/03/2022	0	19/05/2022	115	07/07/2022	109
01/04/2022	0	20/05/2022	41	08/07/2022	78.5
02/04/2022	2.5	21/05/2022	6	09/07/2022	184
03/04/2022	3	22/05/2022	1	10/07/2022	166
04/04/2022	0	23/05/2022	18.5	11/07/2022	107
05/04/2022	0	24/05/2022	0	12/07/2022	84
06/04/2022	0	25/05/2022	0.5	13/07/2022	53.5
07/04/2022	0	26/05/2022	1	14/07/2022	160.5
08/04/2022	0	27/05/2022	0	15/07/2022	177
09/04/2022	12.5	28/05/2022	1	16/07/2022	73.5
10/04/2022	25	29/05/2022	3	17/07/2022	122.5
11/04/2022	0	30/05/2022	0	18/07/2022	64.5
12/04/2022	0	31/05/2022	9.5	19/07/2022	17
13/04/2022	0	01/06/2022	21	20/07/2022	23.5
14/04/2022	50.5	02/06/2022	0	21/07/2022	38
15/04/2022	56.5	03/06/2022	2.5	22/07/2022	0.5
16/04/2022	0	04/06/2022	6.5	23/07/2022	27.5
17/04/2022	0	05/06/2022	3.5	24/07/2022	26.5
18/04/2022	1.5	06/06/2022	0	25/07/2022	7
19/04/2022	5	07/06/2022	0.5	26/07/2022	6
20/04/2022	0	08/06/2022	4.5	27/07/2022	3
21/04/2022	0	09/06/2022	0.5	28/07/2022	32.5
22/04/2022	0	10/06/2022	0.5	29/07/2022	15.5
23/04/2022	5	11/06/2022	6.5	30/07/2022	61.5
24/04/2022	0	12/06/2022	14	31/07/2022	45

Record date	Rainfall (mm)	Record date	Rainfall (mm)	Record date	Rainfall (mm)
01/08/2022	81	19/09/2022	21	07/11/2022	1.5
02/08/2022	107.5	20/09/2022	16.5	08/11/2022	0
03/08/2022	99	21/09/2022	2	09/11/2022	0
04/08/2022	90	22/09/2022	0	10/11/2022	0.5
05/08/2022	133	23/09/2022	0.5	11/11/2022	0
06/08/2022	118.5	24/09/2022	6	12/11/2022	2.5
07/08/2022	149.5	25/09/2022	0.5	13/11/2022	0.5
08/08/2022	165	26/09/2022	0	14/11/2022	0
09/08/2022	21	27/09/2022	0	15/11/2022	0.5
10/08/2022	4.5	28/09/2022	0	16/11/2022	6
11/08/2022	6	29/09/2022	0	17/11/2022	0
12/08/2022	29	30/09/2022	1	18/11/2022	0.5
13/08/2022	16.5	01/10/2022	12.5	19/11/2022	0
14/08/2022	0.5	02/10/2022	12.5	20/11/2022	0
15/08/2022	3.5	03/10/2022	18	21/11/2022	0.5
16/08/2022	0	04/10/2022	1	22/11/2022	0
17/08/2022	0	05/10/2022	13.5	23/11/2022	3
18/08/2022	4	06/10/2022	19	24/11/2022	0
19/08/2022	22	07/10/2022	32	25/11/2022	2
20/08/2022	10	08/10/2022	5	26/11/2022	0.5
21/08/2022	13	09/10/2022	0	27/11/2022	0
22/08/2022	33	10/10/2022	15.5	28/11/2022	6
23/08/2022	59	11/10/2022	0	29/11/2022	45
24/08/2022	58	12/10/2022	0.5	30/11/2022	0
25/08/2022	35	13/10/2022	3.5	01/12/2022	0.5
26/08/2022	30.5	14/10/2022	27.5	02/12/2022	0
27/08/2022	24.5	15/10/2022	0.5	03/12/2022	0
28/08/2022	22	16/10/2022	76.5	04/12/2022	0
29/08/2022	25	17/10/2022	0	05/12/2022	0
30/08/2022	31.5	18/10/2022	4	06/12/2022	0
31/08/2022	27.5	19/10/2022	3.5	07/12/2022	0
01/09/2022	30	20/10/2022	45	08/12/2022	0
02/09/2022	42.5	21/10/2022	22	09/12/2022	1
03/09/2022	34	22/10/2022	8.5	10/12/2022	1
04/09/2022	18	23/10/2022	14.5	11/12/2022	1
05/09/2022	7.5	24/10/2022	0	12/12/2022	1
06/09/2022	6.5	25/10/2022	0	13/12/2022	5
07/09/2022	4.5	26/10/2022	0.5	14/12/2022	0
08/09/2022	1.5	27/10/2022	0	15/12/2022	0.5
09/09/2022	41	28/10/2022	0.5	16/12/2022	0
10/09/2022	18	29/10/2022	0	17/12/2022	0
11/09/2022	48.5	30/10/2022	0	18/12/2022	0
12/09/2022	42.5	31/10/2022	0	19/12/2022	0
13/09/2022	18	01/11/2022	0	20/12/2022	0
14/09/2022	25.5	02/11/2022	0	21/12/2022	0
15/09/2022	5.5	03/11/2022	29.5	22/12/2022	0
16/09/2022	0.5	04/11/2022	0	23/12/2022	0
17/09/2022	2	05/11/2022	0.5	24/12/2022	0
18/09/2022	6.5	06/11/2022	0	25/12/2022	0

Record date	Rainfall (mm)
26/12/2022	0
27/12/2022	0
28/12/2022	0
29/12/2022	0
30/12/2022	0
31/12/2022	0





भारत सरकार
GOVERNMENT OF INDIA

खान मंत्रालय
MINISTRY OF MINES

Annexure-VII
भू-तकनीकी प्रयोगशाला
Geotechnical Laboratory
भारतीय भूवैज्ञानिक सर्वेक्षण
Geological Survey of India
दक्षिणी क्षेत्र, हैदराबाद-68
Southern Region, Hyderabad-68.

No. 06/GT Lab/SR/2023-24

Date: 10/07/2023

To:
Rahul Vadakkedath, Sr.Geologist,
SU: Karnataka & Goa
Geological Survey of India
Vasudha Bhavan, Kumarswamy Layout,
Bengaluru- 560111.

Sub: Determination of Geotechnical properties of the UDS and rock samples.

Ref No.: 01/M4LSSM/NC/SR/SU-KG/20212/42401, Dated: 06.01.2023.

Lab. Ref. No.: 06/2023/SM-9793 & 06/2023/RM-9805.

Sir,

Please find attached herewith the test results of undisturbed soil samples (20 nos.) and rock samples (5nos.) submitted for determination of geotechnical properties in Geotechnical Lab, SR, Hyderabad pertaining to the item titled 'Meso Scale (1: 10,000) Landslide susceptibility mapping in Bhagamandla and TalaKaveri Hill Townships, Kodagu Dist, Karnataka', Item code: M4LSSM/NC/SR/SU-KG/2022/42401, FS: 2022-23.

This is for your kind information and necessary action.

Yours faithfully,

Encl: As above.

(जी.जे.एस. प्रसाद / G.J.S. Prasad)
निदेशक / Director

जी.जे.एस.प्रसाद / G.J.S.PRASAD
निदेशक / Director
भारतीय भूवैज्ञानिक सर्वेक्षण / Geological Survey of India
अभियांत्रिकी भूविज्ञान प्रभाग / Engineering Geology Div.
दक्षिणी क्षेत्र, हैदराबाद / Southern Region, Hyderabad-500068.



भू-तकनीकी प्रयोगशाला / Geotechnical Laboratory
भारतीय भूवैज्ञानिक सर्वेक्षण / Geological Survey of India
दक्षिणी क्षेत्र, हैदराबाद / Southern Region, Hyderabad

Lab. Reference No.

06/2023/SM-9793.

Sender's Name:

Shri. Rahul Vadakkedath, Sr.Geologist

Description and Location:

Bhagamandla and TalaKaveri Hill Townships, Kodagu Dist, Karnataka

Reference No.

01/M4LSSM/NC/SR/SU-KG/20212/42401, Dated: 06.01.2023.

Tests Done:

Moisture content, Specific gravity, Density, Void ratio, Porosity, Cohesion, Angle of Internal friction (Φ), Grain Size analysis

F.S.Code No. & Title:

M4LSSM/NC/SR/SU-KG/2022/42401, FS: 2022-23.

Meso Scale (1: 10,000) Landslide susceptibility mapping in Bhagamandla and TalaKaveri Hill Townships, Kodagu Dist, Karnataka.

TEST RESULTS

Sr. No.	Sample Number/Code	Specific gravity	Moisture content %	Density gm/cm ³	Dry Density gm/cm ³	Void ratio (e)	Porosity (n)	Grain Size			Cohesion (C)	Angle of Internal friction (Φ)
								Gravel %	Sand %	Silt %		
1	UDS/01	2.58	21.48	1.60	1.32	0.95	0.49	3.4	35	51.4	10.2	28.4
2	UDS/02	2.55	26.80	1.61	1.27	1.01	0.50	13.6	35.2	44	7.2	29.6
3	UDS/03	2.54	12.08	1.67	1.49	0.70	0.41	17	60.3	13.5	9.2	31.5
4	UDS/04	2.53	34.62	1.69	1.25	1.02	0.50	3.8	38	53	5.2	28.9
5	UDS/05	2.56	20.50	1.67	1.38	0.86	0.46	0	47.7	46.5	5.8	27.3
6	UDS/06	2.60	27.06	1.61	1.27	1.05	0.51	1.2	35.9	55.6	7.3	28.8
7	UDS/07	2.51	16.52	1.61	1.38	0.82	0.45	1.2	48.2	48.4	2.2	28.4
8	UDS/08	2.50	19.76	1.64	1.37	0.82	0.45	0	54.4	41.1	4.5	29.4
9	UDS/09	2.53	23.04	1.62	1.32	0.92	0.48	0	40.5	54.3	5.2	27.8
10	UDS/10	2.51	11.18	1.60	1.44	0.74	0.43	25	49.9	18.9	6.2	30.2
11	UDS/11	2.33	32.00	1.53	1.16	1.01	0.50	15.8	33.9	41.8	8.5	31.5
12	UDS/12	2.63	41.37	1.54	1.09	1.41	0.59	0.4	39	52.8	7.8	27.8
13	UDS/13	2.65	21.51	1.64	1.35	0.96	0.49	3.7	35.5	52.5	8.3	28.1
14	UDS/14	2.59	18.38	1.53	1.30	0.99	0.50	0.4	37.1	59.8	2.7	27.8
15	UDS/15	2.54	46.95	1.67	1.14	1.23	0.55	2.5	30.5	57.9	9.1	28.0

18.10.23
10.07.23

Sr. No.	Sample Number/Code	Specific gravity	Moisture content %	Density gm/cm ³	Dry Density gm/cm ³	Void ratio (e)	Porosity (n)	Grain Size				Cohesion (C)	Angle of Internal friction (Φ)
								Gravel %	Sand %	Silt %	Clay %		
16	UDS/16	2.66	11.15	1.51	1.36	0.96	0.49	25.2	38.9	26.5	9.4	0.23	33.0
17	UDS/17	2.65	19.43	1.55	1.30	1.04	0.51	1.1	34.7	53.1	11.1	0.32	28.0
18	UDS/18	2.68	25.82	1.56	1.24	1.16	0.54	1.2	32	53.6	13.2	0.31	27.2
19	UDS/19	2.63	17.01	1.52	1.30	1.02	0.50	5.6	55.2	30.1	9.1	0.24	32.1
20	UDS/20	2.61	36.25	1.55	1.14	1.29	0.56	0.4	32	57.4	10.2	0.35	24.9

Sr. No.	Sample No./Code	Liquid Limit %	Plastic Limit %	Plasticity Index	Shrinkage Limit %
1	UDS/01	45	30	15	18
2	UDS/02	34	29	5	21
3	UDS/03	46	31	15	22
4	UDS/04	42	30	12	19
5	UDS/05	39	32	7	18
6	UDS/06	39	29	10	17
7	UDS/07	41	28	13	23
8	UDS/08	44	31	13	22
9	UDS/09	40	28	12	26
10	UDS/10	37	32	5	20

B.V. Gopalakrishna
10.07.2023

(B. Venu Gopala Krishna)
Senior Geologist

Approved By

G.J.S. Prasad
10/7/23

Director
G.J.S. PRASAD / G.J.S. PRASAD
Director
भारतीय भूगर्भ सर्वेक्षण / Geological Survey of India
भूगर्भ अभियांत्रिकी विभाग / Engineering Geology Div.
दक्षिण क्षेत्र / Southern Region, Hyderabad-500058.



भू-तकनीकी प्रयोगशाला / **Geotechnical Laboratory**
भारतीय भूवैज्ञानिक सर्वेक्षण / **Geological Survey of India**
दक्षिणी क्षेत्र, हैदराबाद / **Southern Region, Hyderabad**

Lab. Reference No.

Sender's Name:

Description and Location:

Reference No.

Tests Done:

F.S.Code No. & Title:

06/2023/RM-9805

Shri. Rahul Vadakkedath, Sr.Geologist

Bhagamandla and TalaKaveri Hill Townships, Kodagu Dist, Karnataka

01/M4LSSM/NC/SR/SU-KG/20212/42401, Dated: 06.01.2023.

Specific gravity, Water Absorption, Porosity, Void Ratio, Point Load Index

M4LSSM/NC/SR/SU-KG/2022/42401, FS: 2022-23.

Meso Scale (1: 10,000) Landslide susceptibility mapping in Bhagamandla and TalaKaveri Hill Townships, Kodagu Dist, Karnataka.

TEST RESULTS

Serial No.	Sample Number/Code	Specific gravity	Water Absorption (%)	Porosity (n)	Void Ratio (e)	Point Load Index (MPa)
1	21/Rock	2.64	7.5	19.8	0.25	25.3
2	22/Rock	2.67	3.1	8.28	0.09	32.6
3	23/Rock	2.68	2.8	7.50	0.08	35.0
4	24/Rock	2.66	8.3	22.08	0.28	22.5
5	25/Rock	2.72	2.4	6.53	0.07	39.5

B.V. Gopala Krishna
10.07.2023
(B. Venu Gopala Krishna)
Senior Geologist

Approved By

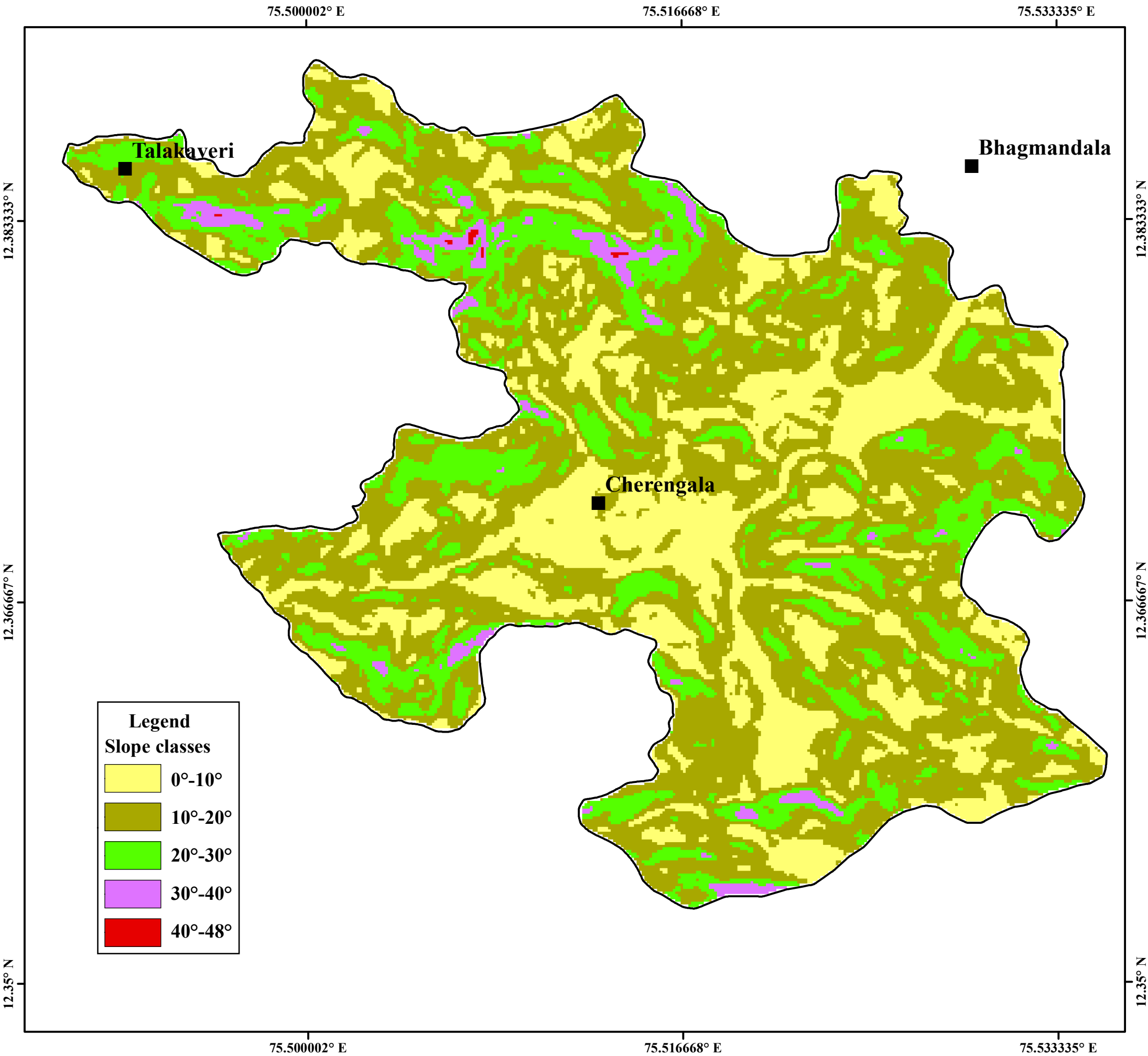
G.J.S. Prasad 10/7/23
(G.J.S. Prasad)
Director

जी.जे.एस.प्रसाद / G.J.S.PRASAD
निदेशक / Director

भारतीय भूवैज्ञानिक सर्वेक्षण / Geological Survey of India
अभियांत्रिकी भूविज्ञान प्रभाग / Engineering Geology Div.
दक्षिणी क्षेत्र, हैदराबाद / Southern Region, Hyderabad-500068.

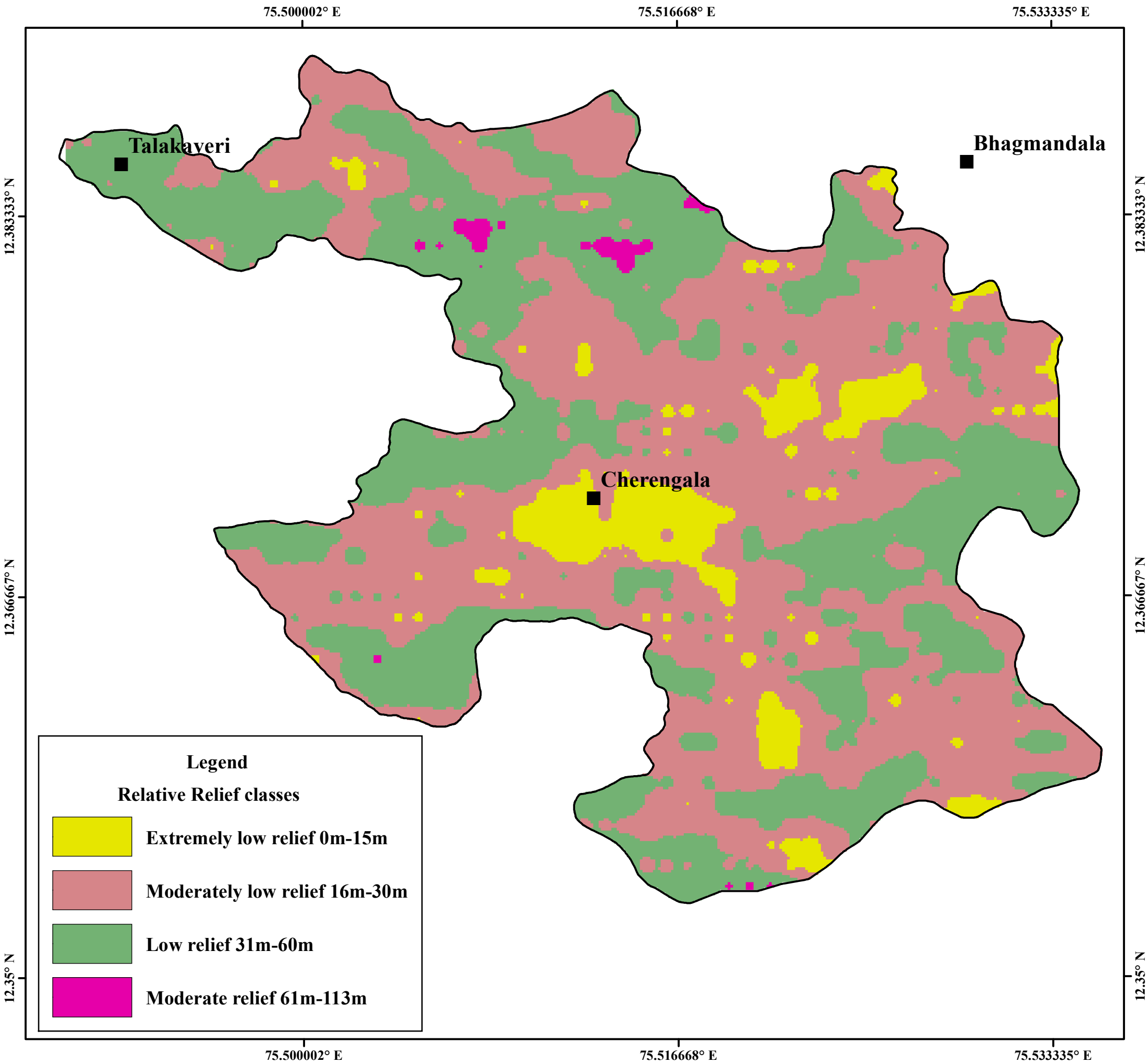


SLOPE MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



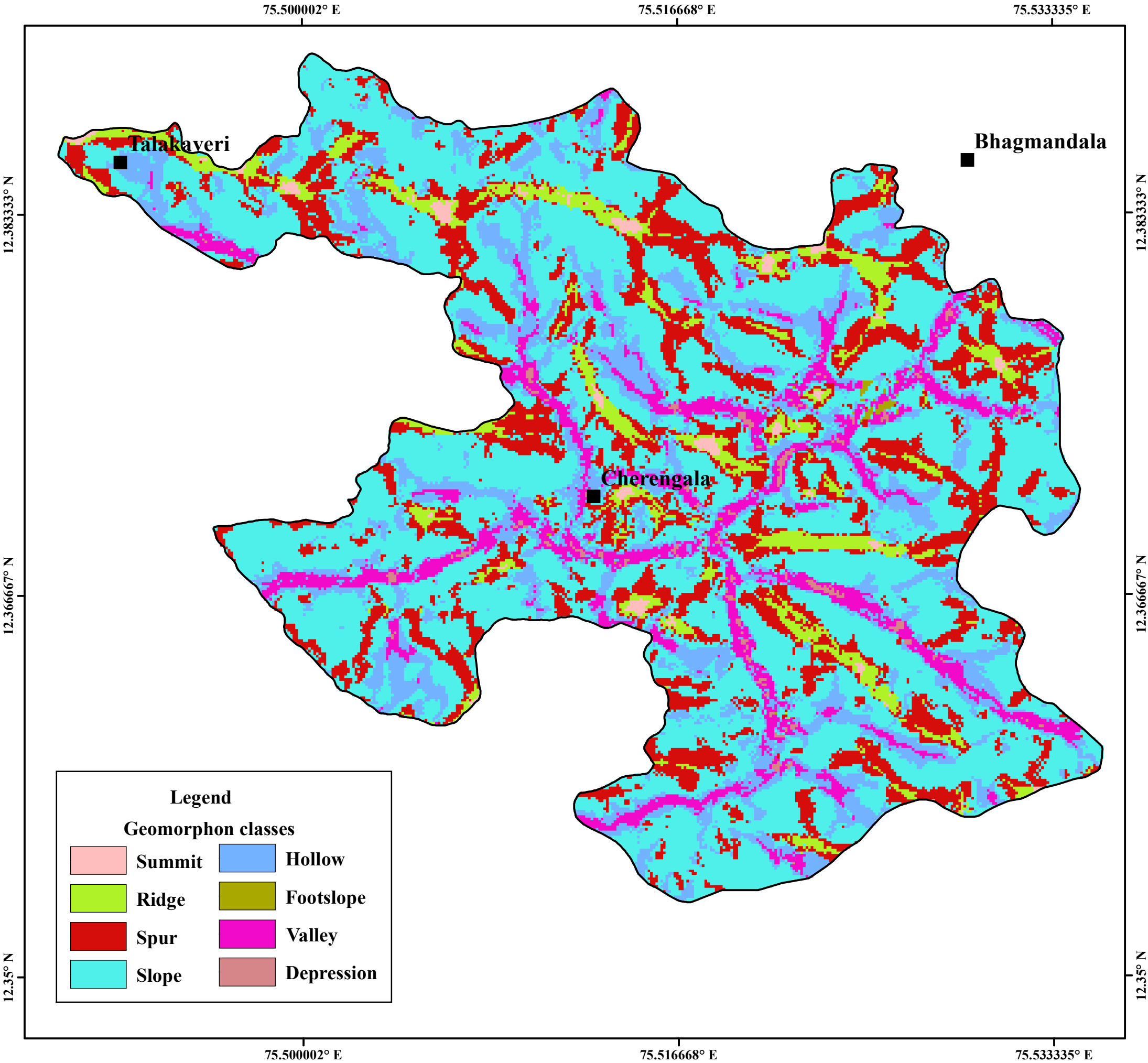


RELATIVE RELIEF MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



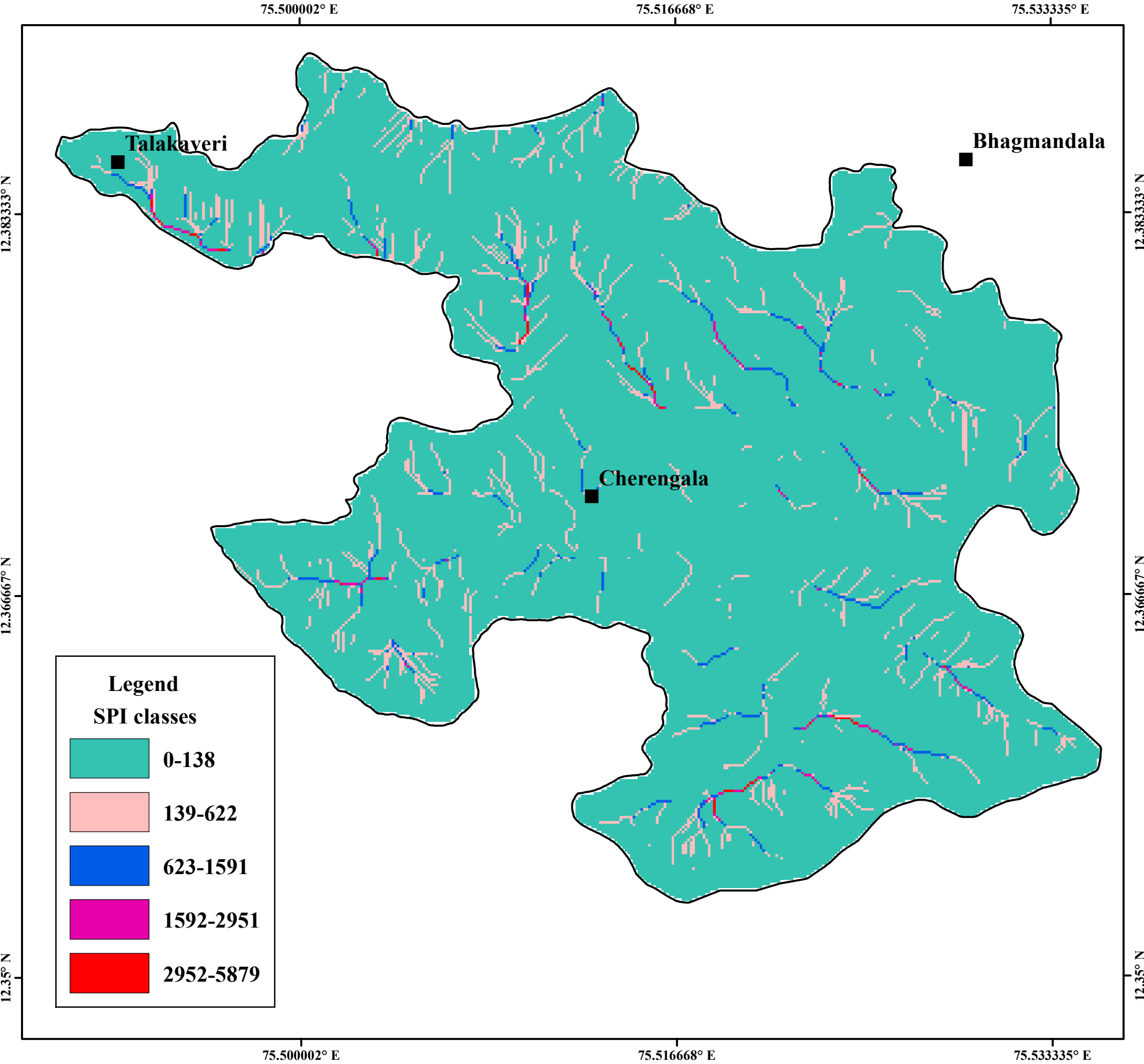


GEOMORPHON MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



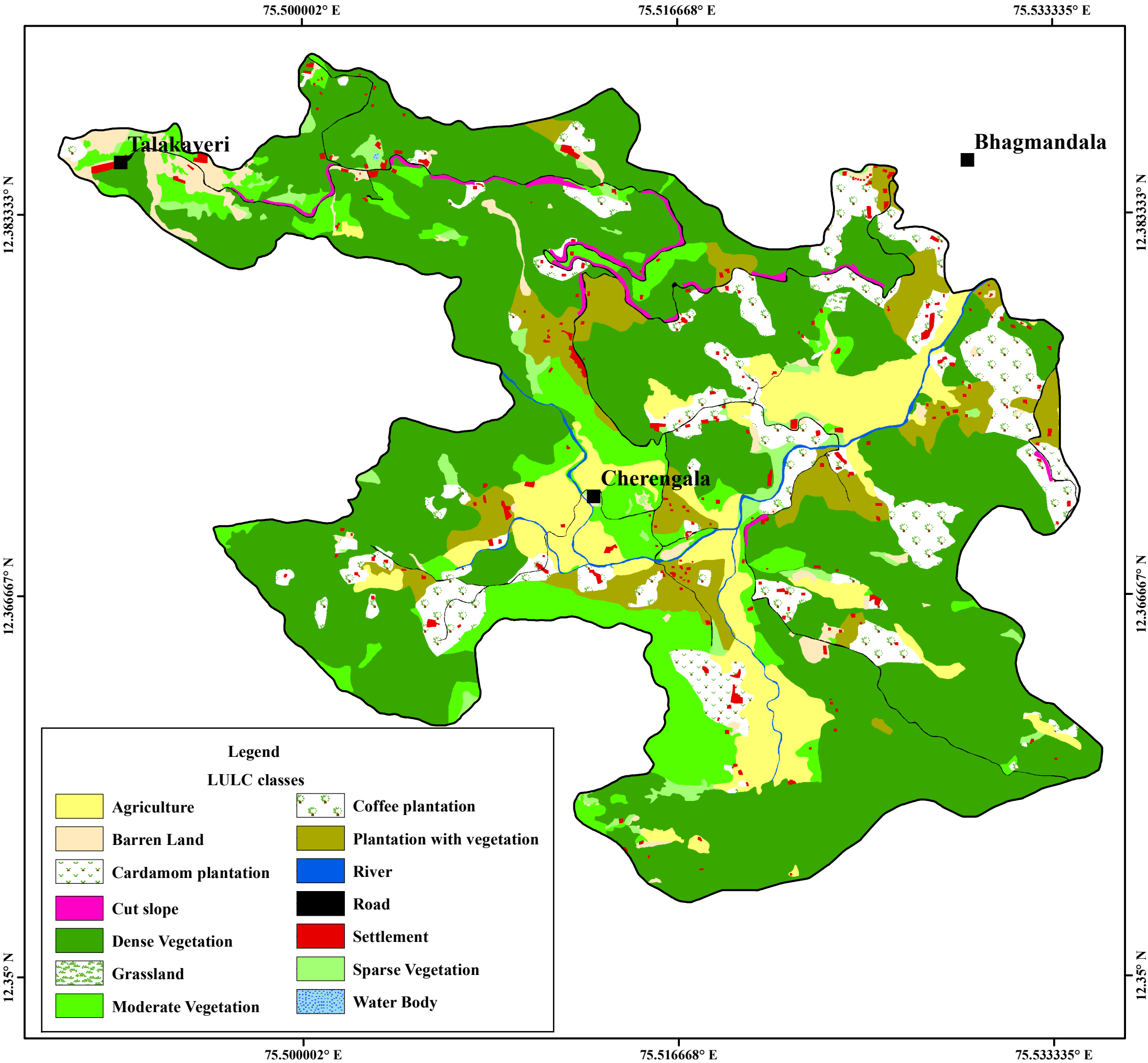


STREAM POWER INDEX MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



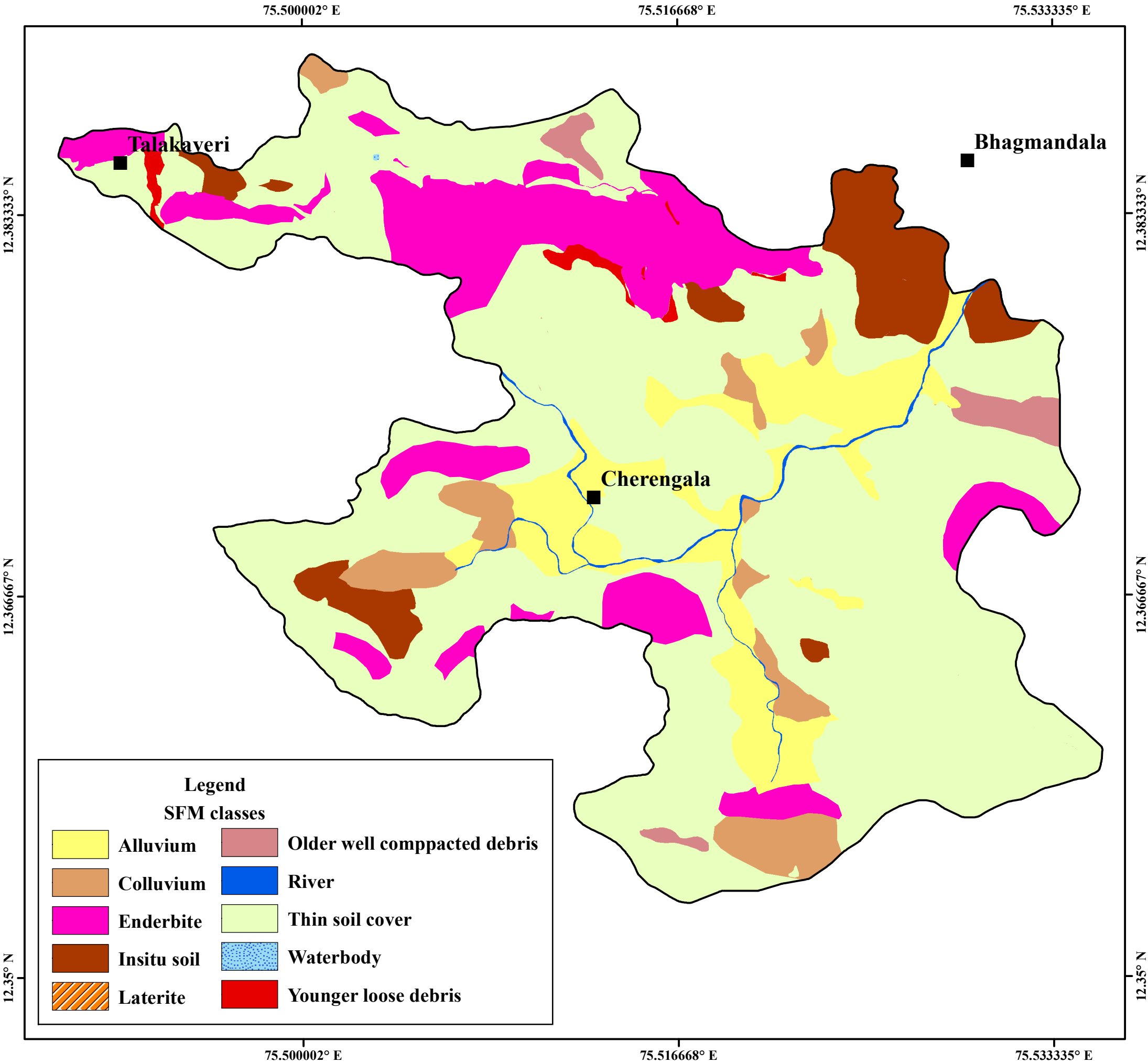


LAND USE / LAND COVER MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



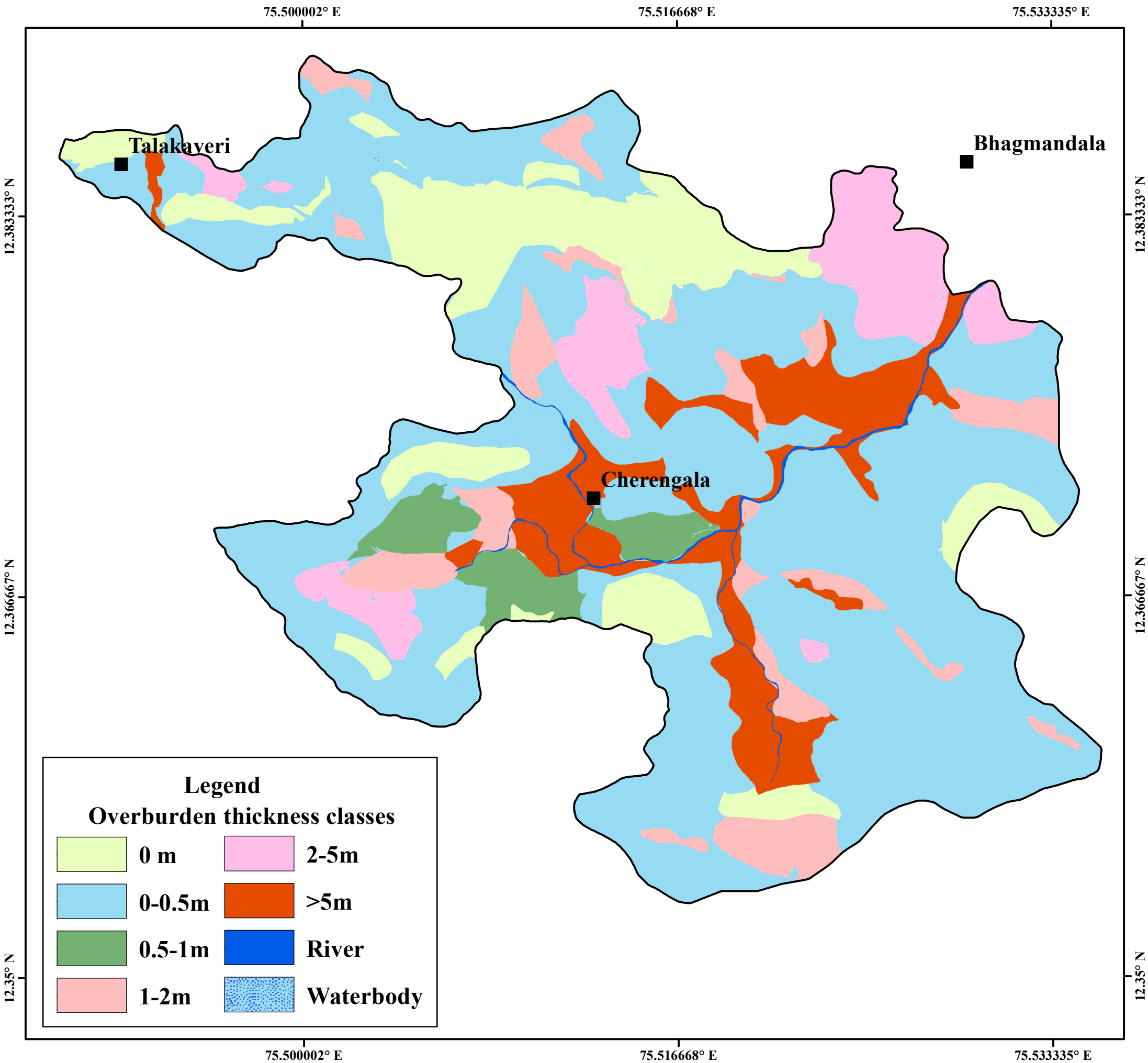


SLOPE FORMING MATERIAL MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



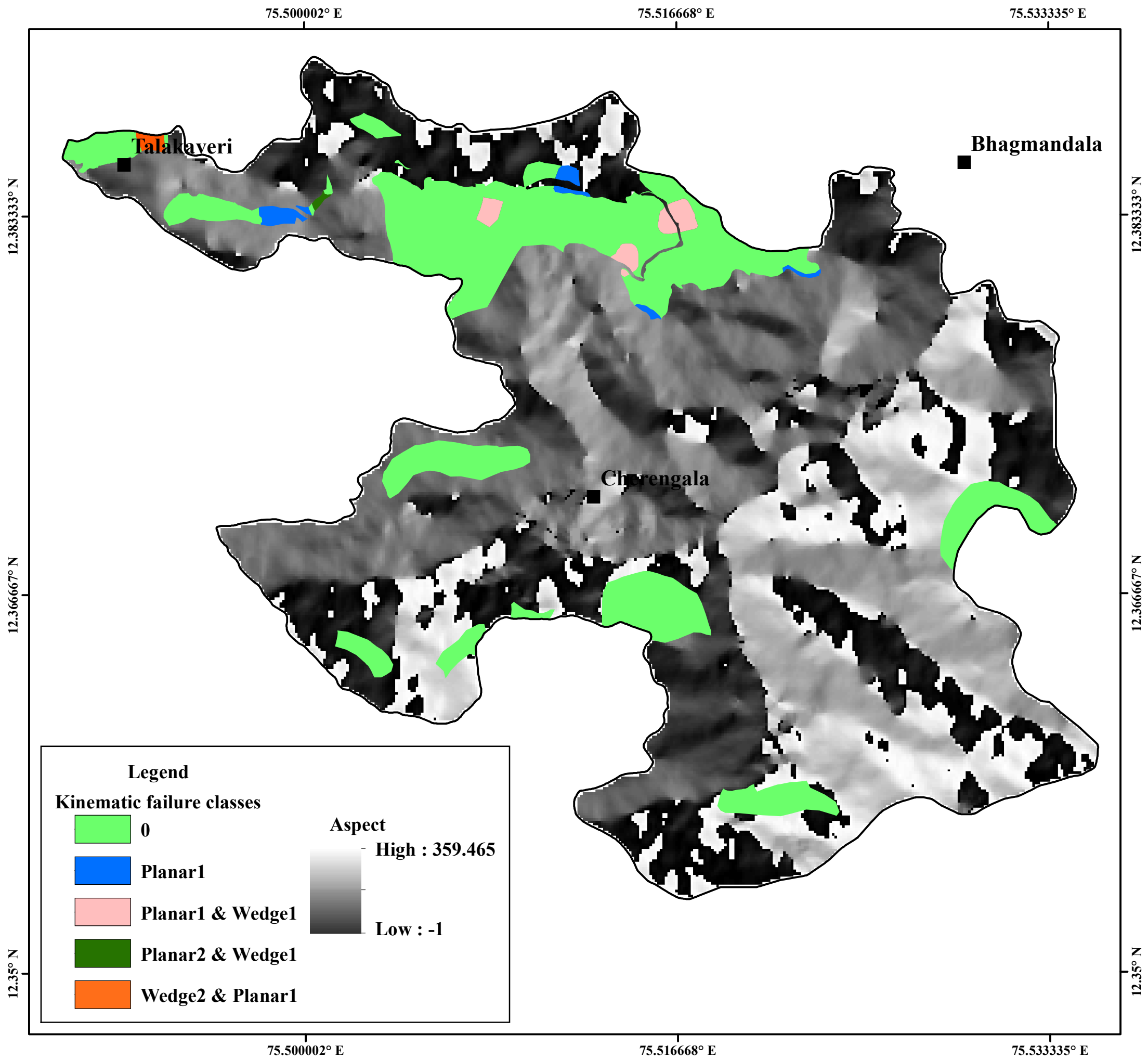


OVERBURDEN THICKNESS MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



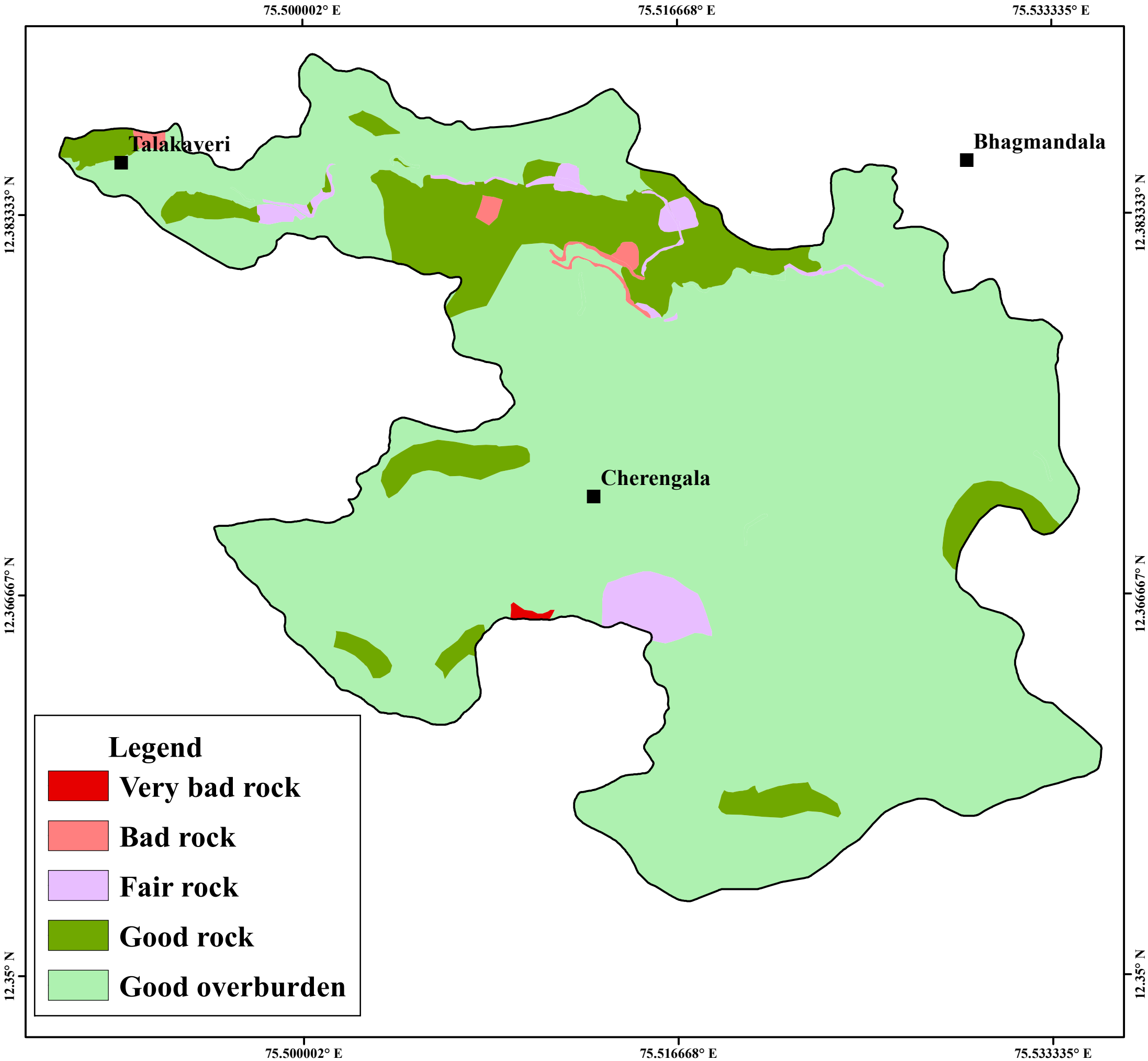


KINEMATIC FAILURE MAP OF BHAGAMANDLA AND TALAKAVERI AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



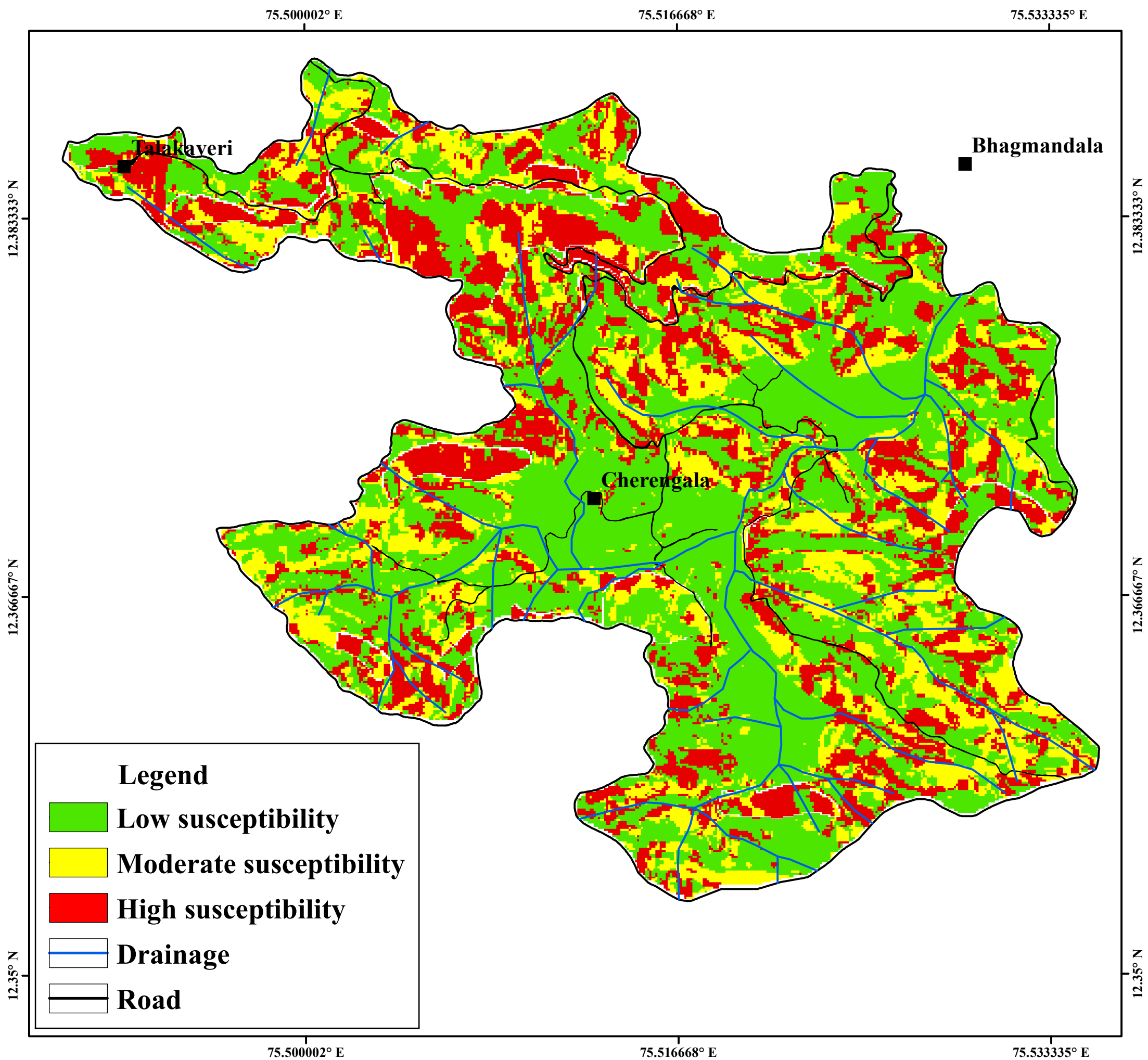


GEOTECHNICAL MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11





LANDSLIDE SUSCEPTIBILITY MAP OF BHAGAMANDLA AND TALAKAVERI AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11





LANDSLIDE MANAGEMENT MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11

75.500002° E

75.516668° E

75.533335° E

12.4° N

12.4° N



Advisory

The slope cuts may be given retaining wall/gabion wall. Adequate drainage measures for discharge of rain water.

Disclaimer

Retaining/gabion wall must be given after consultation with geotechnical expert.



Advisory

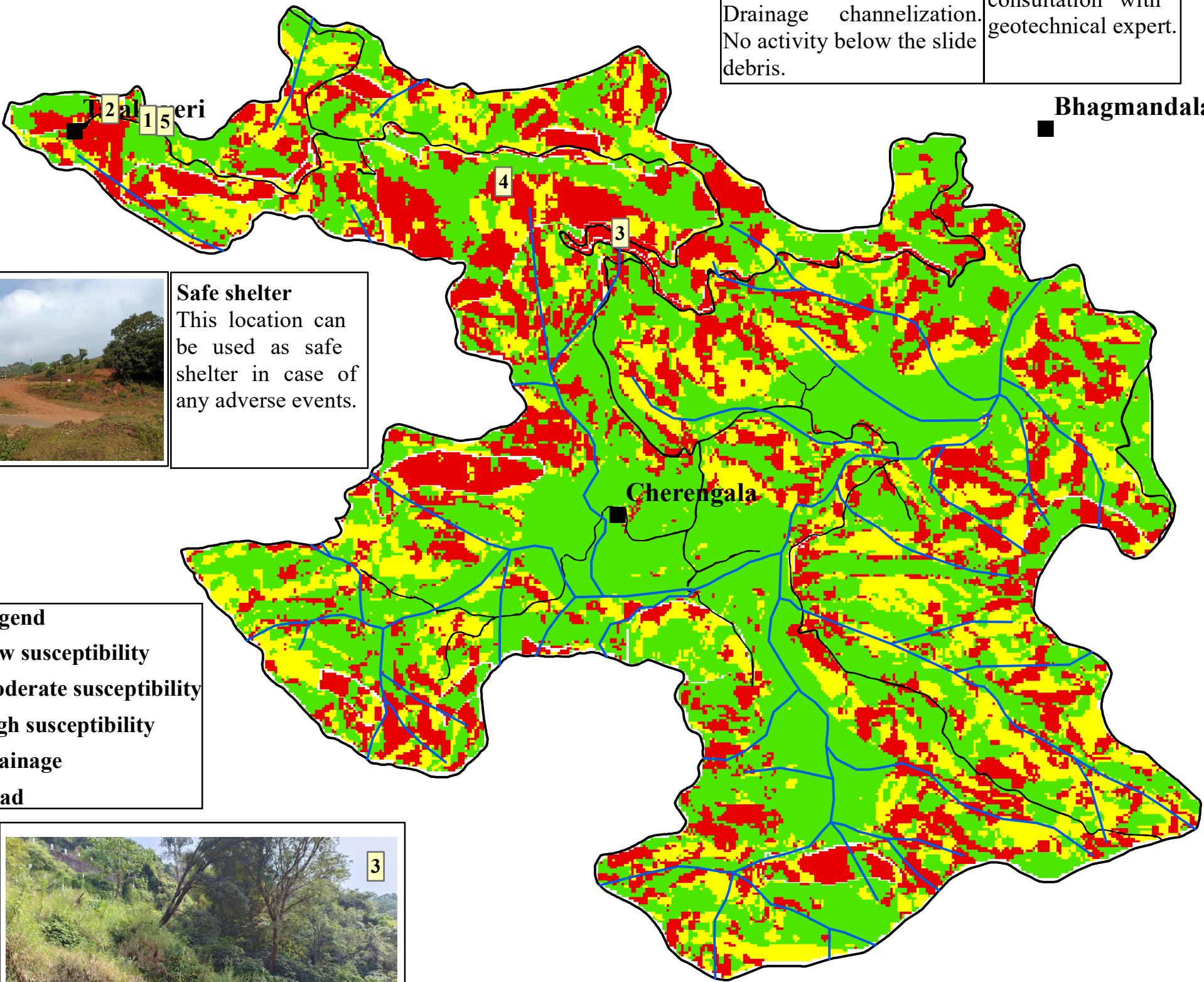
Removal of loose rock and debris material, Shotcrete with wire mesh. Drainage channelization. No activity below the slide debris.

Disclaimer

Shotcrete must be given after consultation with geotechnical expert.

12.383333° N

12.383333° N



Safe shelter

This location can be used as safe shelter in case of any adverse events.

Legend

- Low susceptibility
- Moderate susceptibility
- High susceptibility
- Drainage
- Road

12.366667° N

12.366667° N



Advisory

No further slope cut in the area. Lined drainage along the road, Regular monitoring of existing landslides.



Advisory

No further slope cut in the area. Construction, if any should be done only after sufficient slope protection. Provide drainage channels to prevent excess water percolation

12.35° N

12.35° N

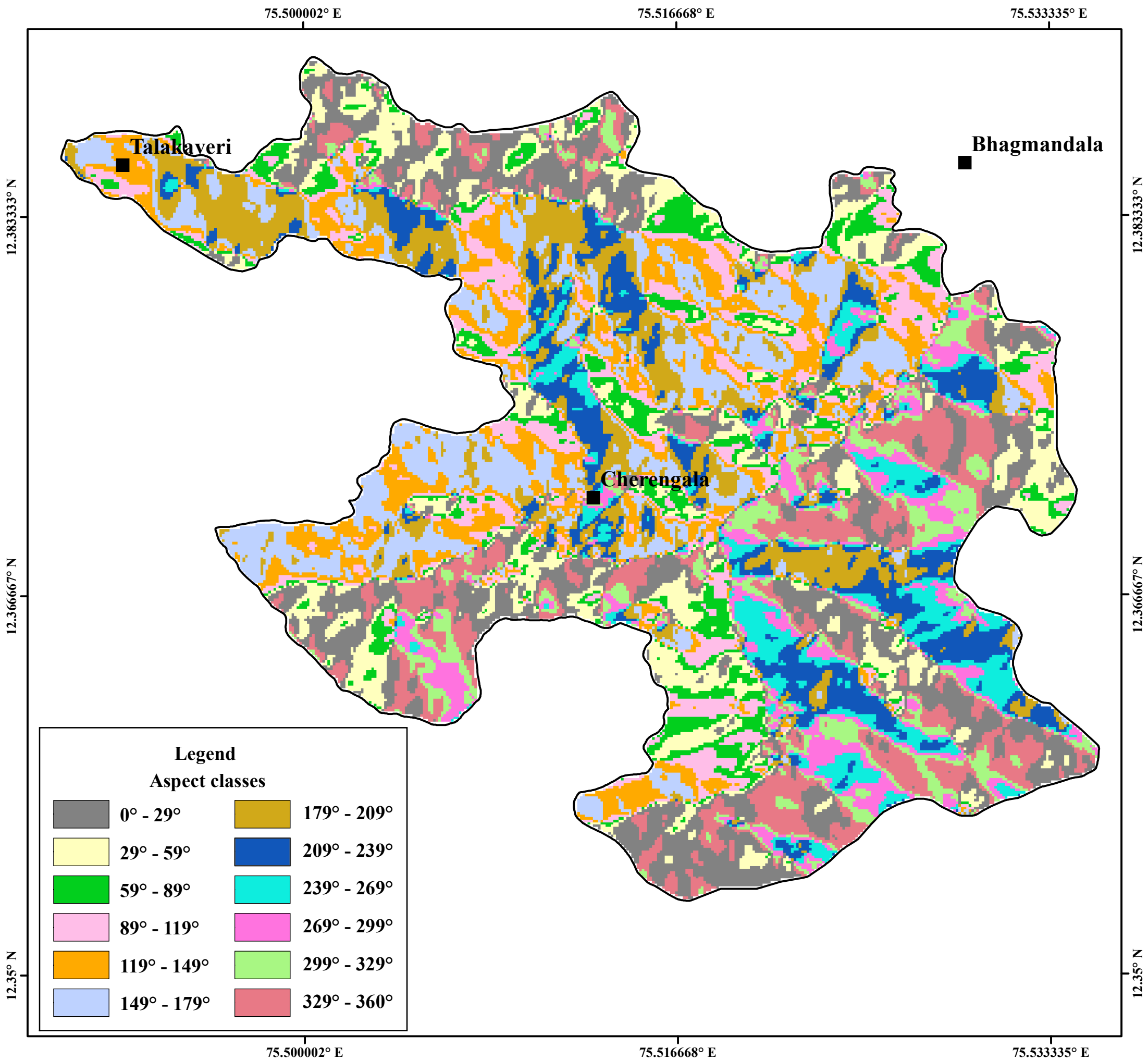
75.500002° E

75.516668° E

75.533335° E

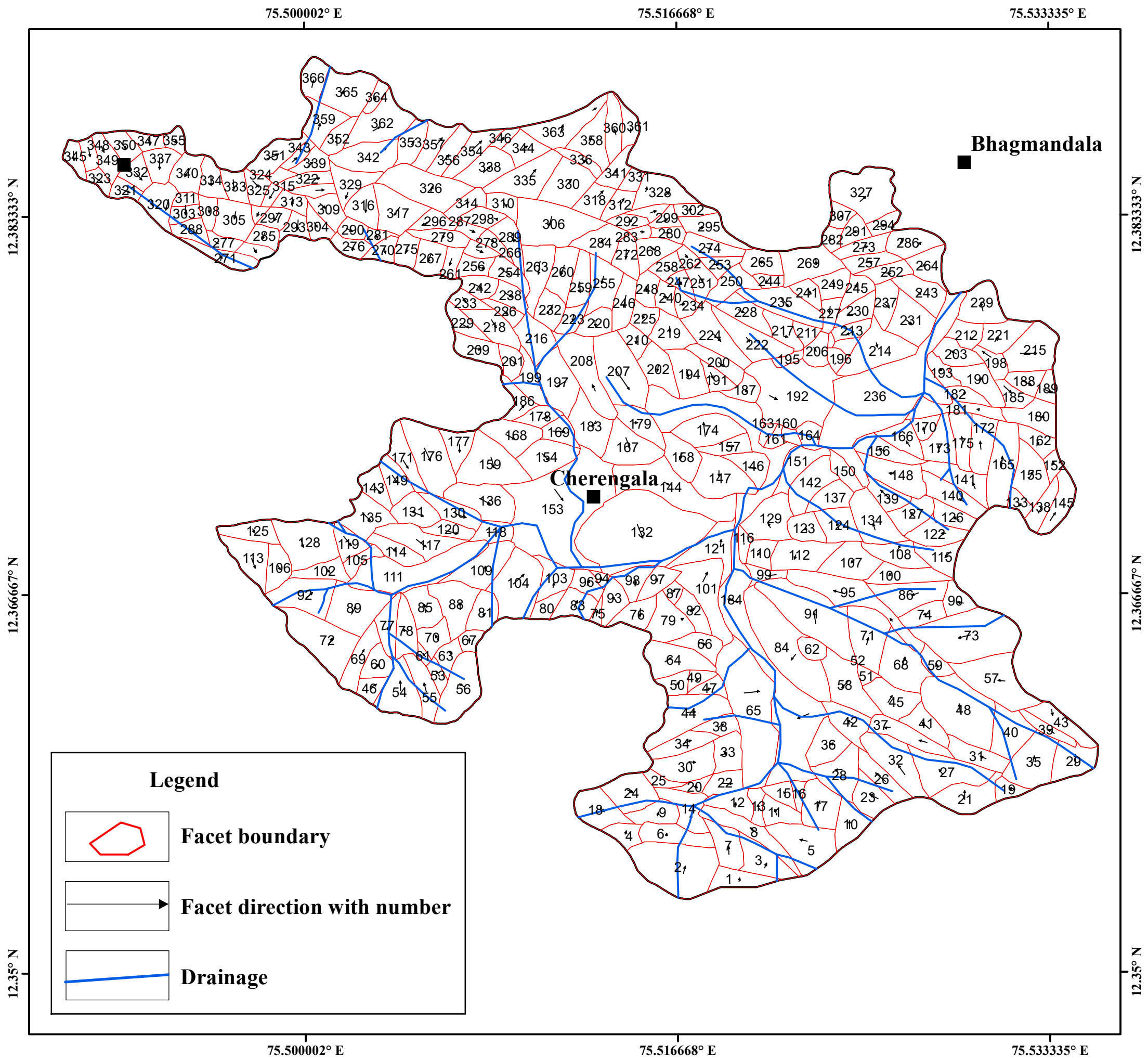


ASPECT MAP OF BHAGAMANDLA AND TALAKAVERI AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



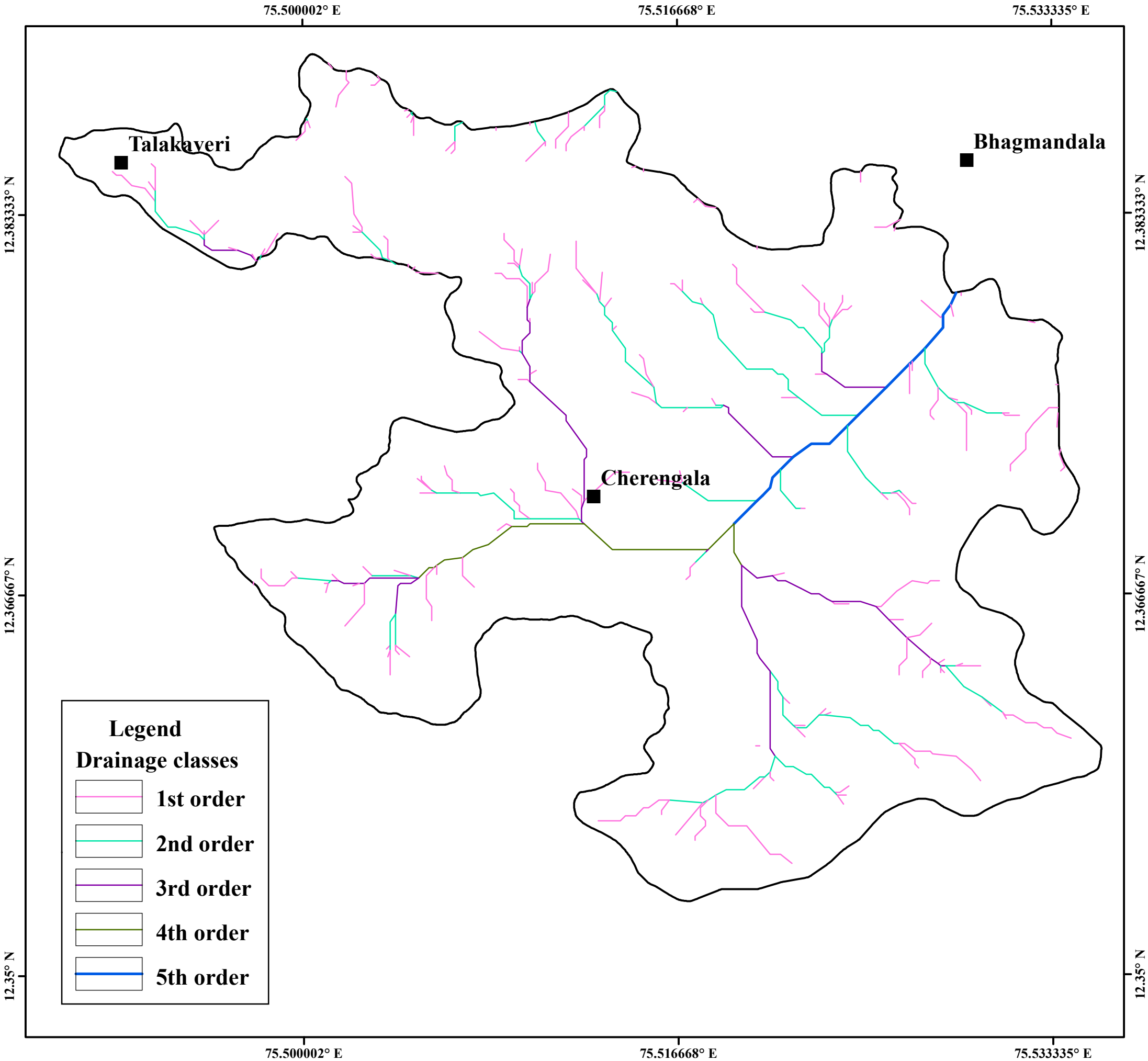


FACET MAP OF BHAGAMANDLA AND TALAKAVERI AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



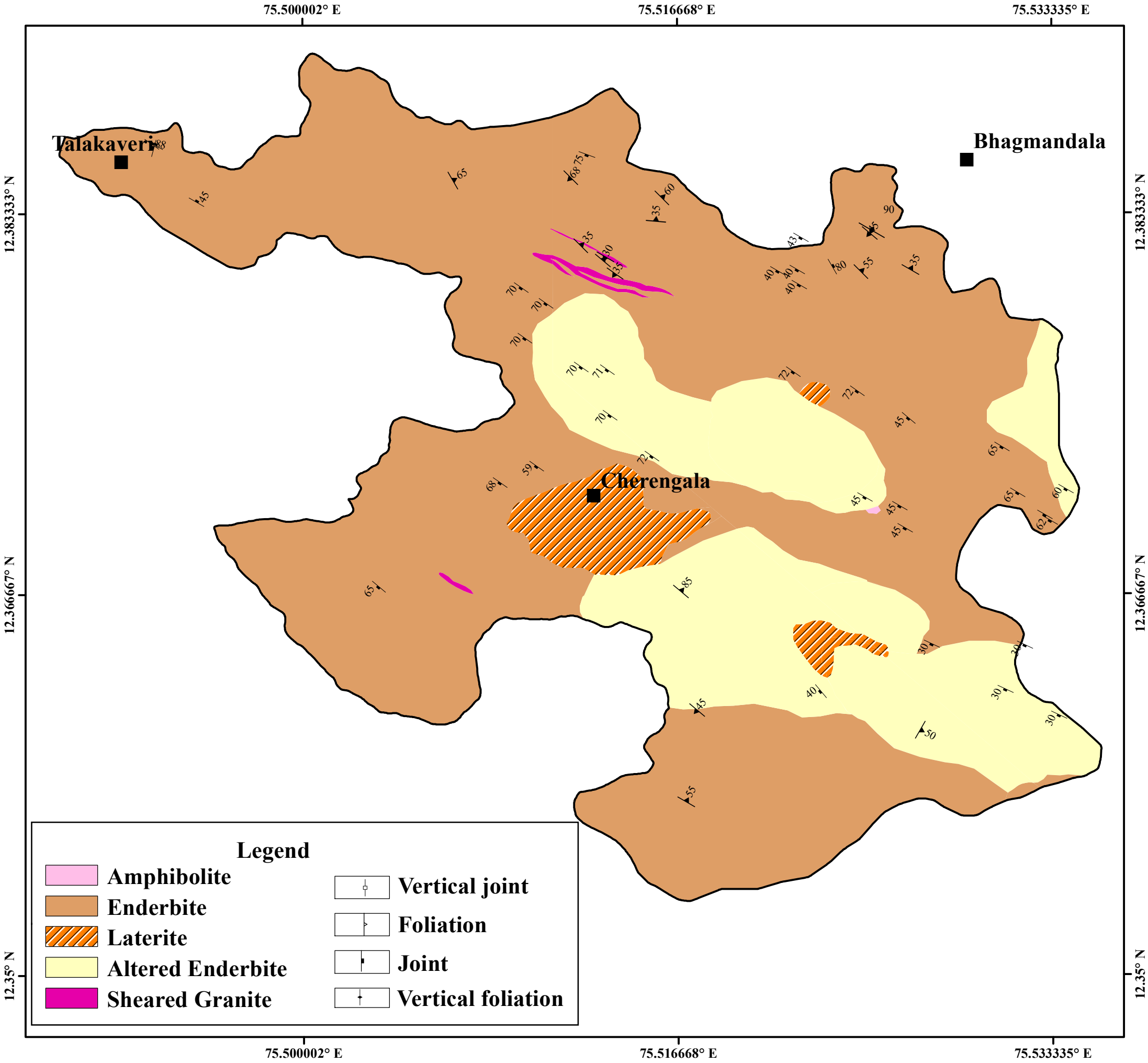


DRAINAGE MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



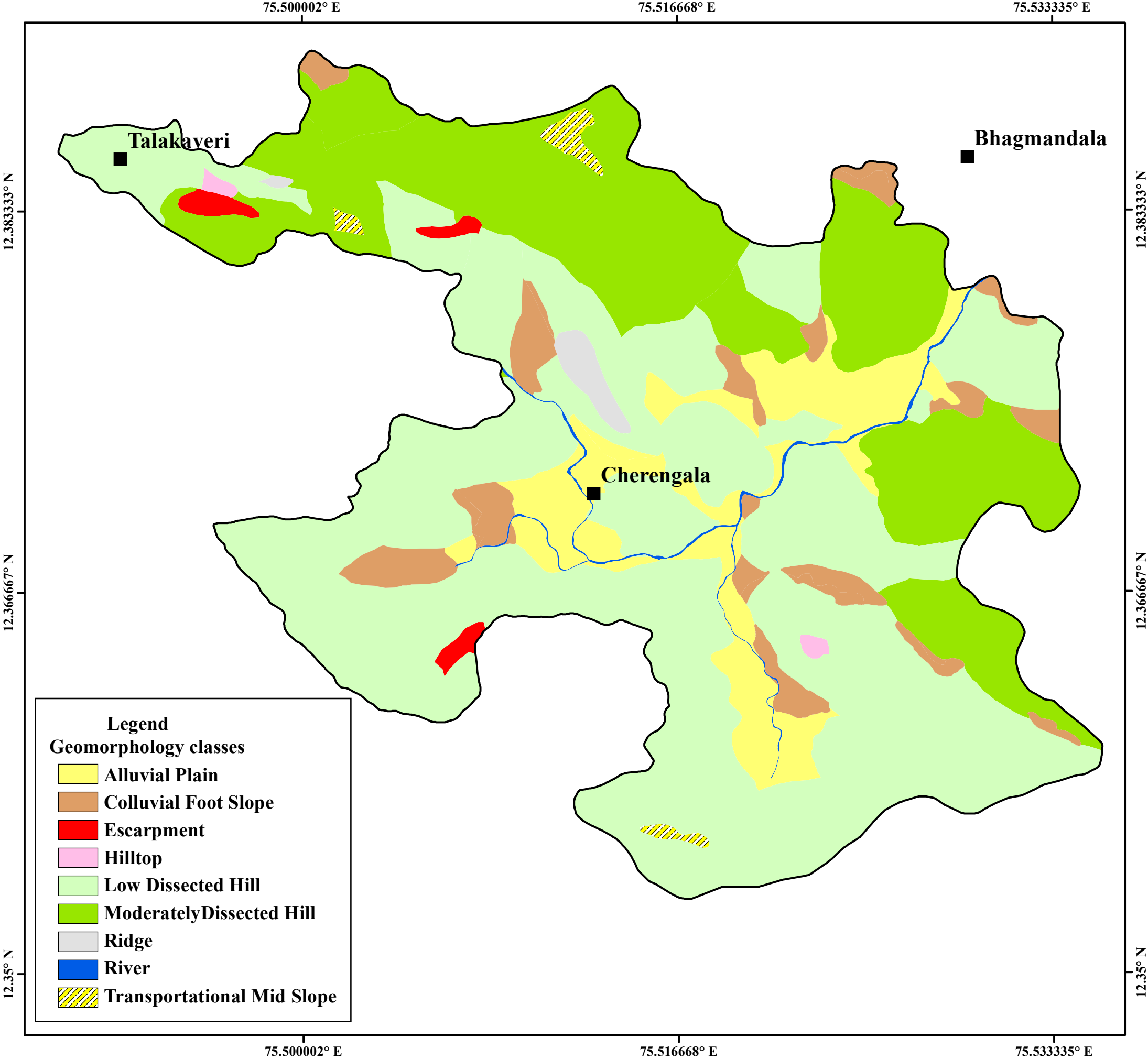


GEOLOGICAL MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11



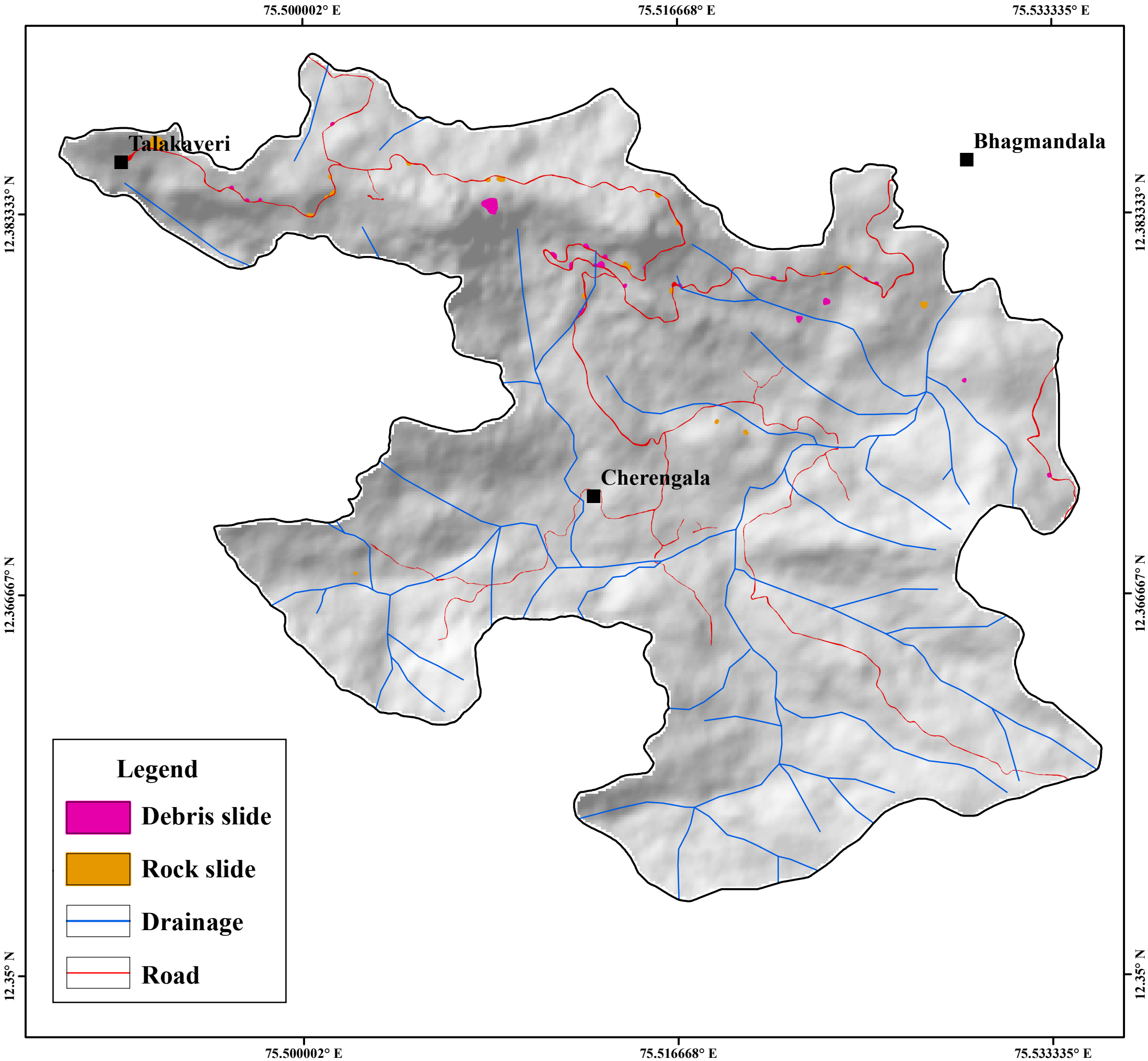


GEOMORPHOLOGY MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11





LANDSLIDE INCIDENCE MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11





ELEMENT AT RISK MAP OF BHAGAMANDLA AND TALAKAVERI
AREAS, IN PARTS OF TOPOSHEET NOS. 48P/07 & 48P/11

