भारत सरकार

भारतीय भूवैज्ञानिक सर्वेक्षण

GOVERNMENT OF INDIA
GEOLOGICAL SURVEY OF INDIA

टोपोशीटस संख्या 48J/ 11 उत्तर कन्नड़ जिले, कर्नाटक, के कुछ हिस्सों में (1: 50,000), वृहद पैमाने पर भूस्खलन संवेदनशीलता मानचित्रण की रिपोर्ट ।

झेत्र सत्र-2014-16

(कोड सं: एल एस एम / एस आर / के.जी / 2014 / 93)

REPORT ON MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEET NO. 48J/11, UTTAR KANNADA DISTRICT, KARNATAKA

F.S-2014-16

(CODE NO : LSM/SR/K&G/2014/93)

By/द्वारा

Koushik Shukla, Senior Geologist/ कौशिक शुक्ला, वरिष्ठ भू-वैज्ञानिक

Ankur Kumar Srivastava, Senior Geologist/ अंकुर कुमार श्रीवास्तव, वरिष्ठ विज्ञानी

&/ और

Sahel.M.P, Geologist/ साहेल ऍम पी, भूविज्ञानी

PROJECT: NLSM / परियोजना : एन एल एस एम्

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

2016

REPORT ON MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEET NO. 48J/11, UTTAR KANNADA DISTRICT, KARNATAKA
F.S-2014-2016
(CODE NO : LSM/SR/K&G/2014/93)

By
Koushik Shukla, Senior Geologist,
Ankur Kumar Srivastava, Senior Geologist
&
Sahel.M.P, Geologist

CONTENTS

TITLE	**Page No.**
सारांश	
ABSTRACT	
CHAPTER-I	07-15
INTRODUCTION	
1.1 Background	07
1.2 Study Area	08
1.3 Present Work	09
1.4 Physiography	09
1.5 General Geology	10
1.6 Land Use and Land Cover	12
1.7 Methodology	13
1.8 Acknowledgements	15
CHAPTER-II	15-15
PREVIOUS WORK ON LANDSLIDE STUDIES	15
CHAPTER-III	16-17
LANDSLIDE INVENTORY	
3.1 Data Source	16
3.2 Inventory Mapping	16
3.3 Spatial Distribution of Landslides	17
CHAPTER-IV	18-27
LANDSLIDE SUSCEPTIBILITY ANALYSIS	
4.1 Background	18
4.2 Selection of Preparatory Factors	18
4.3 Geo-factor Themes	19
4.3.1 Slope Morphometry	19
4.3.2 Geomorphology	21

4.3.3 Land Use and Land Cover 24
4.3.4 Slope Forming Material (SFM) 26
4.3.5 Regolith Thickness 27

4.4 Landslide Susceptibility Analysis(AHP) 28-29
4.4.1 Methodology 29

LANDSLIDE SUSCEPTIBILITY MAP 34-34
5.1 Susceptibility Map 34

CONCLUSIONS AND RECOMMENDATIONS 35-37

REFERENCES
LOCALITY INDEX
ANNEXURE:
Annexure I- Slope Forming Material inventory data sheet.
Annexure II- Landslide inventory data sheet.

LIST OF PLATES:
Plate-1: Location map of the study area.
Plate-2: Geological map of parts of toposheet no 48J/11.
Plate- 3: Slope Gradient map for parts of toposheets no 48J/11.
Plate-4: Slope Curvature map for parts of toposheets no 48J/11.
Plate-5: Geomorphological map of parts of toposheet no 48J/11.
Plate-6: Land Use and Land Cover (LULC) map for parts of toposheets no 48J/11.
Plate-7: Slope Forming Material (SFM) map for parts of toposheets no 48J/11.
Plate-8: Regolith Thickness map for parts of toposheets no 48J/11.
Plate-9: Landslide susceptibility map.

LIST OF PHOTOGRAPHS:
Photo-1&2: Development of laterite (overburden) in study area (SH-144)
Photo-3: Wedge failure in Argillite, slide no. KAR/UK/48J11/2014/02
Photo-4: Slide due to extensive road cutting, slide no. KAR/UK/48J11/2014/07
Photo-5: Slide in overburden near Gundibail, slide no. KAR/UK/48J11/2014/10
Photo-6: Planar wedge failure in schist near Sasiguli, KAR/UK/48J11/2014/16
Photo-7: Development of cracks in road fill material near Sasiguli
Photo-8: Unstable road fill material without retaining wall near Sasiguli
Photo-9: A recactivated slide on SH 48, slide no. KAR/UK/48J11/2014/45
Photo-10: Planar wedge failure in schist near Sasiguli, KAR/UK/48J11/2014/16.
Photo-11: well section exposing laterite development near Shiroor
Photo-12: An example of landuse in study area, near Valki
Photo-13: Geomorphic feature “Ridge” near Sasiguli
Photo-14: Geomorphic feature “Scarp face” near NH206.
Photo-15: Geomorphic feature “Transportational Mid slope” and “Piedmont slope” near Malemane, NH-206

REPORT ON MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NO. 48J/11, UTTAR KANNADA DISTRICT, KARNATAKA
(CODE NO : LSM/SR/KG/2014/93)

By
Koushik Shukla, Senior Geologist,
Ankur Kumar Srivastava, Senior Geologist
&
Sahel.M.P, Geologist

ABSTRACT

Landslide Susceptibility Mapping in parts of Toposheets no. 48J/11 was carried out to prepare a seamless landslide susceptibility map and spatial (GIS-based) landslide database on 1:50000 scale using adequate remote sensing data and field inputs. Pre-field maps for Land use/ Land Cover (LU LC), Roads, Geomorphology, Slope Forming Material, Drainage, Slope gradient, Slope Curvature and Slope aspect were prepared in Arc GIS through visual interpretation of IRS LISS III data and multi-temporal Google Image

In field, checking of all thematic maps, field validation of landslide inventory and collection of recent/historic landslides and damage data as per geo-parametric data sheet was done, validation of landslide susceptibility maps was also done during field. During post field, Updation of all thematic and inventory maps was carried out using Arc GIS.

It was inferred that most of the slides are occurring in areas where there is overburden on slopes. Most of the slides occur along road sections (extensive cut slopes) where the slope stability has been disturbed. The causative factors for these landslide are mainly anthropogenic activity i.e. destabilisation of slopes by removal of toe, lack of proper drainage arrangement on the slopes causing water seepage leading to lack of shearing resistance leading to failure. The triggering factor for slides in the study area is mainly rainfall which has contributed in increase of the pore pressure in the weathered rock mass resulting in reduction of strength and subsequent failure.

Due to the lack of sufficient landslides in the study area falling in SOI T.S no 48J/11, AHP modelling has been done & resultant Landslide susceptibility map of the area was classified into high, medium & low susceptible areas. Prominent settlement locations like Hebbel, Morse, Nirgod, Mahime, Gonavati ,Tumboli & its surroundings are grouped in to high susceptible zones while rest of the area is under medium to low susceptible category. The road from Kumta to Siddapur is most affected by road construction activities & prone for landslides. Major drainages like Agnashini or Tadri, Sharavati & its tributaries are under low susceptible category & least prone for landslides.

टोपोशीटस संख्या 48J / 11 उत्तर कन्नड़ जिले, कर्नाटक, के कुछ हिस्सों में (1: 50,000), वृहद पैमाने पर भूस्खलन संवेदनशीलता मानचित्रण की रिपोर्ट । (कोड सं: एल एस एम / एस आर / के .जी / 2014 / 93)

द्वारा
कौशिक शुक्ला , वरिष्ठ भू-वैज्ञानिक
अंकुर कुमार श्रीवास्तव , वरिष्ठ भूविज्ञानी
और
साहेल ऍम पी, भूविज्ञानी

सारांश

भूस्थल मानचित्र संख्या 48J/11 में भूस्खलन संवेदनशीलता का मानचित्रण 1:50000 पैमाने पर पर्याप्त सुदूर संवेदन और फील्ड का उपयोग कर एक समेकित भूस्खलन नक्शा और स्थानिक भूस्खलन (जी .आई .स आधारित) डेटाबेस तैयार करने के लिए किया गया . भूमि उपयोग / भूमि कवर, सड़क, भू-आकृति विज्ञान , ढलान सामग्री , जल निकासी, ढाल , ढाल वक्रता और ढलान पहलू के पूर्व-क्षेत्र मानचित्र, आईआरएस लिस III डेटा और बहु लौकिक गूगल चित्रों के दृश्य व्याख्या के माध्यम से आर्क जीआईएस में तैयार किए गए ।

क्षेत्र में, सभी नक्शों की जाँच, भूस्खलन सूची का सत्यापन, भू- पैरामीट्रिक डाटा शीट के अनुसार, हाल ही में / ऐतिहासिक भूस्खलन के नुकसान के आंकड़ों का संग्रह क्षेत्र में किया गया, भूस्खलन संवेदनशीलता नक्शे का सत्यापन भी क्षेत्र सत्र के दौरान किया गया था। पोस्ट क्षेत्र के दौरान, सभी विषयगत और सूची नक्शे को अद्यतन आर्क जीआईएस में किया गया।

यह अनुमान लगाया गया कि अधिकांश क्षेत्रों में जहां ढलानों पर ओवेरबर्डन है स्लाइड उत्पन्न हो रही है। अधिकांश स्लाइड्स मुख्यतः उन सड़को के किनारे (व्यापक कटौती ढलानों), जहां ढलान स्थिरता को भंग कर दिया गया है साथ होते हैं । इन भूस्खलन के लिए प्रेरणा का कारण मानवीय गतिविधि जैसे की -टो डिस्टर्बेंस, जल निकासी व्यवस्था की कमी से प्रतिरोध विफलता इत्यादि मुख्य हैं। अध्ययन के क्षेत्र में स्लाइड्स के लिए ट्रिगर फैक्टर मुख्य रूप से वर्षा है- जिसकी वजह से पोरे दबाव में बृद्धि के कारण तथा प्रतिरोधकता में कमी आने के कारण भूस्खलन हुए है.

1: 50,000 मापदंड पर भूस्खलन संवेदनशीलता मानचित्रण हेतु मुख्यता भूस्खलन के आधार पर रास्टर आधारित जी. आई .अस मॉडलिंग का प्रयोग किया जाता है जिसमे सभी चयनित और भारित विषयगत नक्शो का प्रयोग होता है । ऐसे क्षेत्र हैं जहां भूस्खलन का पूर्व ज्ञान दुर्लभ या अपर्याप्त है के लिए, ए. एच .प मॉडलिंग किया जा सकता है । अध्ययन क्षेत्र में भूस्खलन की कमी के कारण टोपोशीट संख्या 48 J/11 में ए. एच .प मॉडलिंग किया गया है।क्षेत्र के भूस्खलन संवेदनशीलता नक्शा, उच्च मध्यम और कम संवेदनशील क्षेत्रों में वर्गीकृत किया गया । हेब्बेल , मोर्स, निर्गोड , महिमे , गोनावती जैसे प्रमुख स्थानों, तुम्बोली और उसके आसपास उच्च अतिसंवेदनशील क्षेत्रों में बांटा जा सकता है अन्य को मध्यम और कम संवेदनशील क्षेत्रों में वर्गीकृत किया जा सकता है । सिद्दपुर से कुमटा सड़क मार्ग सबसे अधिक सड़क निर्माण गतिविधियों और भूस्खलन के लिए संभावित है। अघनाशिनी या तदरी, शरावती और उसकी सहायक नदियों कम संवेदनशील क्षेत्र श्रेणी में है और भूस्खलन के लिए कम संवेदनशील हैं ।

REPORT ON MACRO-SCALE (1:50,000) LANDSLIDE SUSCEPTIBILITY MAPPING IN PARTS OF TOPOSHEETS NO. 48J/11, UTTAR KANNADA DISTRICT, KARNATAKA
(CODE NO : LSM/SR/KG/2014/93)

By
Koushik Shukla, Senior Geologist,
Ankur Kumar Srivastava, Senior Geologist
&
Sahel.M.P, Geologist

I. INTRODUCTION

1.1 Background

Geological Survey of India (GSI) has been carrying out landslide susceptibility Zonation/mapping on macro scale (1:50,000/ 25,000) since last 3 to 4 decades. However, compared to the available landslide-prone areas in India (~0.42 Million Km spreading over 1112 Survey of India 1:50,000 scale Topographic Sheets), the target achieved so far by GSI (~60,000 km2) is quite lesser. This warrants GSI, being the nodal agency for landslide studies in India, to impart maximum stress towards completion of this basic data generation work on landslides by aiming to complete the remaining task much at a faster pace than what has been followed by GSI so far.

Accordingly, since FS 2014-15, GSI undertook a national programme on landslide susceptibility mapping – **Macro scale (1:50,000) National Landslide Susceptibility Mapping (NLSM)** with an aim to cover the remaining targets expeditiously. This national programme was formally launched by Shri Dinsha Patel, Hon'ble Minister of Mines, Government of India on 5th February, 2014 at the 53rd Central Geological Programming Board Meeting, New Delhi.

The National Landslide Susceptibility mapping (NLSM) programme was launched by Geological Survey of India (GSI), with an objective to (i) prepare landslide inventory database using high resolution remote sensing data and field inputs, (ii) to prepare Toposheet-wise 1:50,000 scale spatial database for geofactors of landslides for use as input maps, (iii) to prepare landslide susceptibility map using multi-class index overlay method in a GIS platform.

Landslide susceptibility mapping on scale 1:50,000 covering 744.5 Sq. Km area is bounded by latitudes 14°16'00" to 14°30'00"N and longitudes 74°30'00" to 74°45'00"E which is falling in Survey of India Toposheet No.48 J/11 Uttar Kannada district, Karnataka, was carried out under the annual programme of Geological Survey of India, Southern Region, vide item code no: LSM/SR/K&G/2014/93 of field season 2014-16.

1.2 Study Area

Landslide Susceptibility Mapping in parts of Toposheet no. 48J/11 is a two year project, to be completed in the year 2016. Field checks were carried out in the proposed 744.5 sq. km. area (for F.S. 2014-16) to prepare a seamless landslide susceptibility map and spatial (GIS-based) landslide database on 1:50000 scale using adequate remote sensing and field inputs.

The study area forms the part of Karnataka State. The area extends from latitude 14°16'00" to 14°30'00"N and longitudes 74°30'00" to 74°45'00"E and falls in Uttar Kannada district, Karnataka. It is well connected to Bangalore, the state capital. Bangalore-Honnavar metalled road passes through the area in the southeastern and southwestern part via Kumbeshvar, Sulagod and Talageri. Siddapur-Kumta metalled road passes through the northern part via Biralamakki, Santeguli and Santagal. Talger-Ammenalli metalled road passes through the area in the northeastern part via Huggigadde and Nilkand. Interior places are connected by foot/cart tracks.

Plate-1

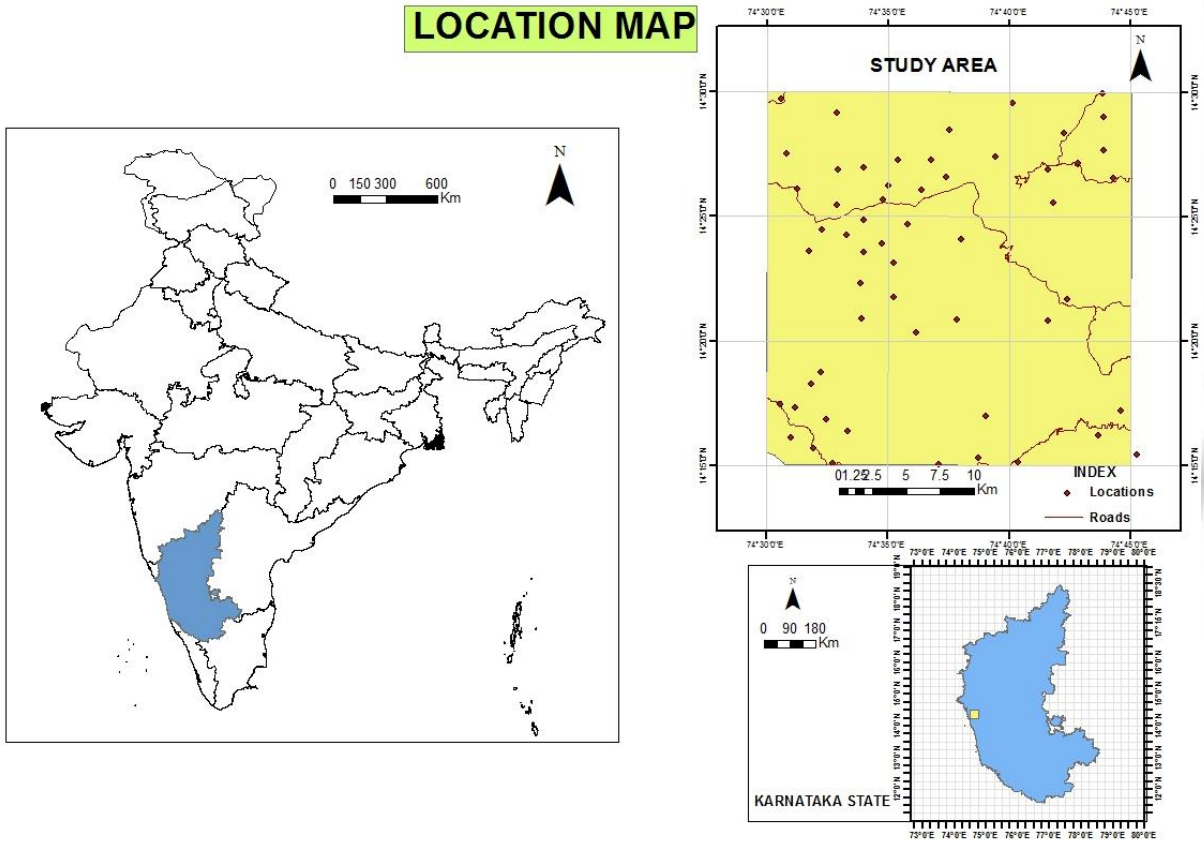


Figure 1-Location map of the study area

1.3 Present Work

The present work includes preparation of different thematic layers on 1:50,000 scale using google earth imageries. The thematic layers prepared during Prefield were validated in field and final correction in the maps was updated at headquarters. The nature and target of work envisaged for FSP of 2014-16 and achievements are given in table-1:

Table-1: Nature of work, quantum and achievements.

Nature of Work	Target	Achievements
Preparation of Thematic maps (in GIS on scale 1:50000)		
1. Slope forming material map	744.5 Sq.Km	744.5 Sq.Km
2. Geomorphology and lineament map	744.5 Sq.Km	744.5 Sq.Km
3. Slope morphometry (slope, aspect & curvature) map	744.5 Sq.Km	744.5 Sq.Km
4. Landuse / Landcover map	744.5 Sq.Km	744.5 Sq.Km
5. Drainage map	744.5 Sq.Km	744.5 Sq.Km
6. Regolith depth map	744.5 Sq.Km	744.5 Sq.Km
7. Preparation of landslide inventory map	744.5 Sq.Km	744.5 Sq.Km
Field based studies		
8. Field checking of all thematic maps	744.5 Sq.Km	744.5 Sq.Km
9. Field validation of landslide inventory and collection of recent and historic landslides	744.5 Sq.Km	744.5 Sq.Km
10. Collection of landslide inventory and damage data as per 41 point geo -parametric sheet	As necessary	47 Nos.
11. Validation of landslide susceptibility map at important locations	744.5 Sq.Km	744.5 Sq.Km
Post field studies and modelling		
12. Updation of thematic and inventory maps in GIS	744.5 Sq.Km	744.5 Sq.Km
13. Preparation of Landslide susceptibility map in GIS	744.5 Sq.Km	744.5 Sq.Km
Collection of rainfall data	As necessary	-

The report mainly consists of detailed description of the study area, area specific landslide issues, data sheet for Landslide Inventory, details of thematic Geofactors database for use as predictors.

1.4 Physiography

The area is an undulating highly rugged terrain comprising steep hills and valleys covered with dense forest. The highest elevation is 729 m above msl at 1.2 km southeast of Galamavu in the southeastern part of the area. Lowest elevation is 83 m above msl at 500 m northwest of Padukuli in the southwestern part of the area. Aghnashini or Tadri River flows from east to west in the northern part of the area. River Sharavati and its tributaries flows in the southern part,

besides few perennial nalas such as Bennihole in the northern part and Doddamane Halla in the southern part flows and drains the area. Dendritic type of drainage pattern is commonly noticed in the area.

1.5 General Geology

The area exposes rocks of Sargur Group, PGC, Bababudan group and Chitradurga Group of Dharwar Supegroup, mafic – ultramafic complex of Archaen age, quartz veins and dolerite dykes of Palaeo- Proterozoic age have intruded into these rocks. The Sargur Group of rocks represented by amphibolite are exposed as small lenticular enclaves within PGC. Peninsular Gneiss represented by granitic gneiss and migmatite gneiss and older granites (Karwar granite) are exposed in the north western part of the area. The rock is generally granitic, but shows faint gneissic bandings and are usually light grey in colour, medium to coarse grained, massive, hard and compact.

The PGC represented by migmatitic gneiss and granite gneiss are exposed in the southern and northern part of the area and forms basement. In the southern part augen gneiss and migmatite gneiss are exposed around Sharavati River, Mahime Gudda and Bailagadde. In the northern part, migmatite and granite gneiss are occurring prominently around Aghanashini (Tadri) River, Totagadde, Gaankarmule and Basalli. The migmatite shows ptygmatic folds and other migmatitic structures. Enclaves of amphibolite bodies are commonly seen within gneiss. Granite gneiss with well developed gneissic structure consists of quartz, orthoclase, plagioclase, biotite with lot of epidote with few specks of muscovite mica.

The older granitoid locally referred as Karwar Granite is exposed in the northwestern part at around Hosalli, west of Kandrakane, west of Taragoa, around Kadnir and Hadake Shirur. The granite is typically massive and non-foliated. It is generally coarse grained, equigranular and grey with rare pink variants. Its composition varies from granite to granodiorite with biotite as a chief mafic mineral. Vast stretch of intrusive granite intruding into PGC is seen in the northern and central part.

Bababudan Group of rocks represented by hornblende-actinolite-chlorite schist and quartzite of Kudremukh Formation are exposed in the southwest, northwest and northeastern part of the study area. Hornblende-actinolite-chlorite schist is exposed as lenses and bands in the southwestern part, around Kesuphal, Tulsani, Medanakeri in the northwestern part. It is exposed around Anegundi in the northeastern part, south of Halebail. The rock is highly fissile, with prominent foliation, soft, greenish and consists of mainly chlorite, actinolite and biotite. The quartzites are exposed as narrow linear bands in the southwestern, northwestern and northeastern part along with hornblende-actinolite-chlorite schist, white to pale yellow in colour, hard, compact and generally massive consisting of recrystallised quartz.

The Chitradurga Group of rocks represented by Lower Bisgod Formation and Upper Ranibennur Formation. The Lower Bisgod Formation consists of manganiferous phyllite and BMQ are exposed in the area in the northern part as narrow bands at 1 km east of Kesaragunikoppa. Mn phyllite and BMQ occur as interbanded sequence. Mn phyllite is black coloured, highly schistose consists of mainly manganese and chlorite. Banded magnetite quartzite is brownish to reddish, hard, compact, consists of alternate bands of magnetite and quartzite. The Upper Ranibennur Formation of Chitradurga Group consists of greywacke-argillite and banded ferruginous quartzites (BFQ) is well exposed in the area in the eastern part. Greywacke-argillite is the dominant rock unit, widely exposed in the entire eastern part. The rock is massive, fine grained, banded, slightly metamorphosed, grey to dark grey in colour, consists of angular to sub-angular grains of quartz, chlorite and sericite. BIF exposed as a narrow, linear bands in the northeastern and in the southeastern part. In the northeastern part, the BIF band is trending in NNE-SSW, whereas in the southeastern part, three parallel BIF bands are seen. It is trending in E-W direction. The BIF band is well bedded, hard, compact, dark brown to reddish brown.

The mafic-ultramafic complex represented by gabbro is exposed in the northwestern corner of the area, it is very smaller in dimension. It is intrusive into the hornblende-actinolite-chlorite schist of Kudremukh Formation.

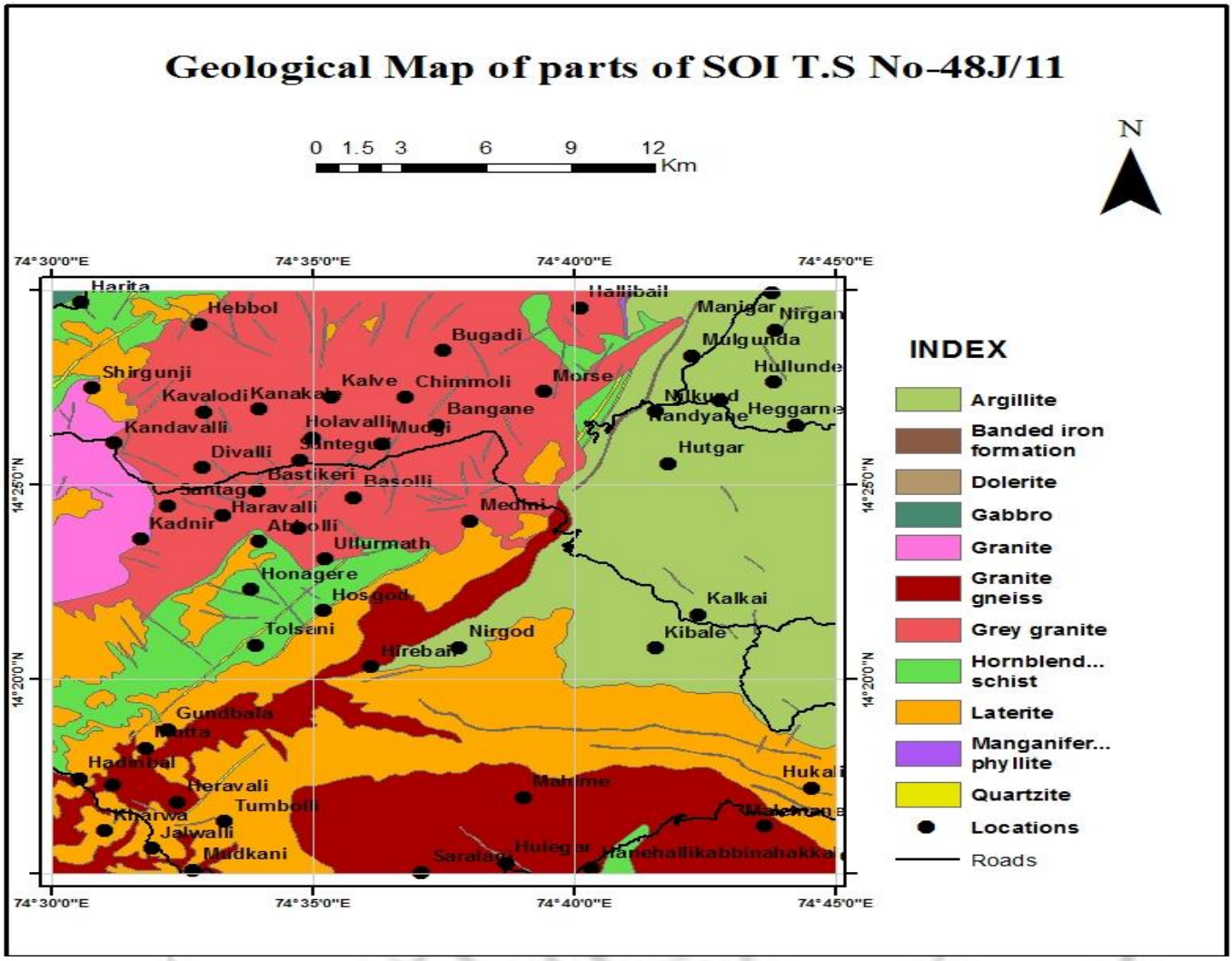
The younger basic intrusives like dolerite dyke of Paleo-Proterozoic age occur prominently as elongated, linear intrusive bodies, they are intruded into all rock types of the area. They are trending in N-S to NW-SE,NE-SW directions. They exhibit ophitic to sub-ophitic texture and consists of plagioclase (andesine, labrodorite) within mass of augite plates.

Laterite of Cenozoic age occupy the ridge portion. They are seen in the western, southern and central part of the area. In the northwestern part they are seen at the east of Anegundi around Santna, Bandivala in the western part at south of Hasad, around Kanakenammanagudda and also noticed in the south and central part of the area as a large/wide patches/lenses. In the southern and central part of the area. Laterite is seen on the Closepet Granite. In northwestern part, laterite is seen on the schistose rocks of Kudremukh Formation. The composition of laterite in the area is vary from aluminous to ferruginous.

Primary structures like beddings are noticed in the BIF and quartzite bands. They were trending in NE-SW to WNW-ESE with moderate to steep dip towards east as well as west at places. Foliation noticed in gneiss and schistose rocks are parallel to S_0. Joints are commonly noticed in granite gneiss of PGC in the northern and central part of the area. They are trending in NE-SW to NW-SE and dipping vertically.

The granite, gneisses, dolerite and laterite in the area are widely used for construction purpose as building stone and road materials.

Plate-2



1.6 Land Use and Land Cover

Land Use & Land Cover map was prepared in Arc GIS through visual interpretation of IRS LISS III data and multi-temporal Google Imageries of the area. The area in terms of LU/LC can be divided in to following classes: Barren, Cultivation, settlements, sparse vegetated areas, thick vegetated areas, river, swamps, plantation and Fallow land. The areas along river banks is covered with alluvial material and along low lying valleys is covered with overburden material and are being used for cultivation. Major part of the area is covered with thick vegetation/forest. In the study area slopes along the road corridors, are most affected by slope failures due to the construction activities.

1.7 Methodology

The method to be followed is primarily landslide dependent following a raster-based GIS modelling approach for integration of all selected and weighted thematic maps to prepare 1:50,000 scale landslide susceptibility maps. For areas where a-prior knowledge of landslide is missing or scarce and/or insufficient, any one of the following approaches may be adopted as per priority or terrain conditions and/or after due discussion with the local experts/workers.

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

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

Methodology adopted can be broadly grouped as follows:-

i) RS inputs and preparation of thematic maps using RS & GIS tools: Indian Space Research Organisation (ISRO) has a number of satellites having very high resolution (VHR) sensors. Out of them, the Multi-spectral optical sensors such as P-4 (LISS-IV) having 5 m resolution are useful RS tool, that can be utilised as source data for picking up spatial land-use/ cover and historic landslide incidence data. These digital images nowadays has larger scene coverage and cost-wise quite cheaper too, which should be used to prepare thematic maps like land use/cover and landslide incidences maps etc. For slope morphometric themes, the freely-downloadable 1-Arc (90 m resolution) Shuttle Radar Topographic Mission (SRTM) or 25 m resolution ASTER Digital Elevation Model (DEM) would be used.

Attempts will also be made to procure and use 10 m resolution Carto DEM, if the same is available from NRSC under the purview of a joint collaboration and/ or direct procurement from NRSC, whichever materializes in due course of time.

Using this DEM or elevation data, through simple GIS functionalities of Arc GIS (Spatial Analyst/ 3D Analyst) or ILWIS 3.X, slope and aspect maps would be generated and used as different thematic maps for slope morphometry. Excepting the above, simple GIS functionalities are also capable of doing many analytical operations through which buffer around drainage lines; lineament, road etc would be prepared and be used as thematic input maps for landslide susceptibility. Use of these tools and GIS techniques would immensely reduce the man-hours required for this type of spatial studies for preparation of analog maps. Generation and availability of such pre-field maps beforehand would facilitate better planning and focusing of field studies.

ii) Field studies & Landslide inventory: Field studies to be undertaken for this study can be divided into two parts – i) field checking/ updating of pre-field maps such as for the thematic maps like lithology, structure, geomorphology, overburden material type, thickness, land use/ cover and landslide incidences including collection of landslide inventory data for the new/ fresh landslides which are not recognizable in the RS source data used for this purpose because of its smaller dimensions or has only developed after the acquisition of that particular satellite data. Field studies in selected stretches in later phases of any such project may also be required for validation of final landslide susceptibility maps with actual ground situation.

Since the proposed methodology of 1:50,000 scale landslide susceptibility mapping (LSM) would be mainly landslide dependent unlike the existing BIS method, therefore, in the proposed exercise, one of the prime thrusts is to understand the landslides, its types, failure mechanisms and give maximum reliance to understand its dependence of prevalent geofactors. This exercise being an important part of the landslide susceptibility mapping would help in generating a good account of landslide inventory of the area simultaneously. Since, many places, within a Topographical Map Sheet in general is inaccessible, to augment the landslide incidence data prepared in field, use of high resolution RS data is extremely essential. As proposed, the IRS LISS-IV Multispectral imagery (5 m resolution) is an excellent optical product of relevant resolution from which, medium to large landslides in the landslide-prone areas can easily be picked-up/ mapped. However, understanding landslide types and failure mechanisms using only the RS data may not always be helpful for which later field validation later, even viewing the landslides from a greater distance would be quite useful. However, literature studies indicate that some basic and vital genetic parameters of any landslide such as material-involved, type etc, are determinable, if 3-D views of the terrain is observed using some advanced GIS functionality (such as anaglyph formation of high-resolution imagery using DEM background). Moreover, using digital and geo referenced imagery as input in a GIS, the location, dimension of any landslide to be mapped can be picked up in a more exact and accurate way than that identified and extrapolated at site during fieldwork. However, for 1:50,000 scale landslide susceptibility mapping, depicting a landslide by a point data in a GIS may also be sufficient as par as scale of work is concerned.

iii) Data integration, preparation of susceptibility map and validation: Use of GIS from the initial level of data acquisition, processing and preparation of thematic maps/ layers has always been helpful and worthy during integrating all the thematic maps with / without landslides in a GIS. Preparation of such spatial geo database in a GIS helps in easy updation and modification of geofactor maps at any point of the work. For integration, several simple bi-variate and multi-variate methods of data integration in a GIS are available and are accepted worldwide, not only in the field of landslide susceptibility mapping but also for the preparation of predictive maps of mineral prospectivity etc. These are robust and well-tested statistical/ mathematical techniques, which can be applied in Indian conditions too wherever, there are perennial and sufficient number of landslides.

However, GIS could also be equally helpful in processing and integrating thematic maps in situations where knowledge on a-prior landslides is scanty. In such cases, it is always advisable to apply ratings of geofactors developed in similar geo environment in nearby locations in those types of landslide-scarce study areas for application of more terrain-specific ratings/ weights. However, any predictive map of landslide susceptibility, prepared by whatsoever methods need validation, preferably quantitatively, not only by physically overlapping landslide incidence maps over the final landslide susceptibility maps but also through applying some internationally-accepted validation techniques followed elsewhere in case similar studies of predictive modelling. Formalization of this quantitative validation techniques following preparation of Success/ Prediction rate curves, Confusion matrix, creation of ROC curves etc using both calibrating and validating landslide data can easily be accomplished in a GIS using their normal functionalities, which, on an analog map format is almost impossible.

1.8 Acknowledgements

The author expresses his sincere gratitude to Shri B.D.Thapa, ADG & HOD, SRO, GSI, Hyderabad , Shri R.K.Agarwal, Dy. D.G & RMH-IV, GSI, Hyderabad. Our sincere thanks are to Shri T.Krishnappa Dy. D.G & Shri C.G.Hemantha Kumar, Dy. D.G, StateUnit: Karnataka and Goa for their support and guidance. The author is also thankful to Dr. H.S.M Prakash, Shri K.Basvaraj & Smt. Niharika Jha Director (TC) for their support. The author is grateful to Shri J.Srihari, Director ,Shri K. V. Maruthi, Superintending Geologist and supervisory officer for Project: NLSM , State Unit: Karnataka & Goa, GSI, Bangalore. The author is also grateful to Dr. Saibal Ghosh and Dr. Pankaj Jaiswal, Superintending Geologists, GHRM Cell, CHQ, Kolkata for their efficient guidance and technical help during pre-field work and field work.

II. PREVIOUS WORK ON LANDSLIDE STUDIES

Landslide studies in the area have been carried out only along transportation corridors (NH & SH) in the Western Ghats. Temporal data for these slides is not available as far as the study area is concerned. Landslides in the study area generally occur frequently from untreated cut slopes. These are usually small in size but pose considerable risk to life and property. Several landslides are reported along roads (Highways) every year during the monsoons indicating that the triggering factor for these slides may be rainfall along with anthropogenic activities.

Landslide Inventory work has been carried out in F.S. 2008-09 and 2010-12.19 landslides have been reported along the Jog – Honnavar road section (SH-50 and NH - 206). 11 landslides have been reported along SH-93 Sirsi- Siddapur road section. 38 landslides have been reported along SH-48 Kumta - Siddapur road section. Most of these slides are debris slides caused due to toe cutting of the slope for construction of roads.

III. LANDSLIDE INVENTORY

Landslides were identified, mapped and inventoried. Landslide inventories contain basic information about landslides such as location, classification, morphology, volume, run-out distance, activity and date of occurrence/activity etc. and can be prepared through various methods such as detailed geomorphologic fieldwork, mapping from remote sensing data and topographic maps, historical archive studies and interviews. In this study, satellite images are used as the main source for obtaining a multi-temporal landslide inventory.

3.1 Data Source: Landslides leave discernible signs on slopes, most of which can be recognized, classified and mapped in the field or from photo-interpretation (Varnes, 1978; Hansen, 1984). These signatures are mostly visible as morphological changes such as changes in slope type, breaks in slopes, hummocky surfaces, etc. These morphological signs are interpreted here to determine important landslide information such as type of failure, the surface area, cause and the run-out distance. Detailed and systematic field work was carried out to generate the 41-point attribute data for landslides.

Preparation of the landslide inventory commenced with the search of archival data sources, particularly published and unpublished reports of GSI. The SPOT images available as a base map in ESRI Arc GIS 10.2 (up to the resolution of 30cm), high resolution Google Earth data of different time periods (from 2002 to 2015) and LISS III data were used as the main data product for generating the multi-temporal landslide inventory.

3.2 Inventory Mapping: The following steps were used for mapping a landslide polygon in Arc GIS 10.2 and building its inventory attribute.

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

2. The mapped polygon is then saved as .kml file and later imported to Arc GIS using „conversion" function. In Arc GIS the kml to layer conversion is first done and then the layer data is exported as a polygon shape file or directly to the geodatabase. In this study the WGS 84 UTM projection (44N) is taken for analysis.

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

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

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

6. After identifying the landslides in the field, the morphological parameters viz landslide scar length, width and depth were noted carefully after measuring them in the field using a meter tape. Additional data such as landslide type, run-out distance, present land use, regolith thickness, probable cause, and damage details were also added to the inventory. The volume of mapped landslides was recalculated by multiplying the morphological parameters. Inventory of new landslides were plotted in the topographic maps and were digitized as polygons or points and entered in a geo-database of Arc GIS.

3.3 Spatial Distribution of Landslides: A total of 47 landslide incidences were identified in the area during pre-field work, including 46 slides reported earlier (K V Maruthi and K V Chandran, 2012; K.V. Maruthi et al., 2010). Most of the slides are occurring in the overburden. Landslides in the area are primarily caused due to extensive slope cuttings along roads. In the area major slides are observed along NH 206 (Bangalore - Honnavar). The slides occurring in the area are mostly shallow translational failure of debris type but at places rock falls are also present.

Several landslides are reported along roads (Highways) every year during the monsoons indicating that the triggering factor for these slides may be rainfall besides anthropogenic activities. The study area receives an annual rainfall of about 744.50 mm. This has resulted in high degree of weathering and laterisation causing good amount of overburden development. Slope failures in the area generally occur in this overburden part of the slope causing road blockage and sometimes damage to life and property. Details of past ten years rainfall is given below:

Table-2 : Past Ten years Annual Rainfall record for four Taluks namely Honnavar, Kumta, Siddapur and Sirsi falling in the study area.

Rainfall Data			(Rainfall in mm) Yearly Rainfall measured from Jan to Dec.									
S. No.	Name of the Taluk	Normal Rainfall	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Honnavar	3685.5	3821.9	3167.2	3561.1	3698.5	4716.4	393.4	4263.4	4459.8	4354.0	3641.2
2	Kumta	3753.5	3902.6	3345.2	3202.8	3427.8	4525.7	2995.5	3814.5	4430.2	4098.3	3348.1
3	Siddapur	2982.5	2033.6	2596.2	3581.1	3381.2	3821.5	3005.7	3377.4	3180.9	3684.4	2399.9
4	Sirsi	2534.6	1958.9	1897.4	2609.3	2865.4	2845.4	1893.5	3175.1	2604.4	3433.0	2400.1

During field at relevant and accessible locations data for landslides and damage for recent as well as old slides was collected as per geo-parametric data sheet (Annexure I). The slides occurring in the area are mostly translational failure of debris type. Validation of landslide inventory map was also done in field. (Photos-3,4,5,6,7,8,9,10)

Almost all landslides studied in the area appear to have caused due to the human interference in modifying the existing natural slopes. The specific causes of landslides in Western Ghat in general as well the study area in particular are 'toe cutting' of hill slopes for the construction of road, modification for human settlement, presence of weathered and loose rock mass, heavy and frequent rain etc. All slides are triggered by heavy rainfall mainly in rainy seasons extending for 4 months from May to August. The ubiquitous presence of water is favorable for intense weathering of rocks causing appreciable drop in their shearing resistance which lead to slope failure. The heavy rainfall during monsoon is the major trigger for all the slides. Due to lack of date of occurrence the landslides were grouped in to new, old and reactivated based on the morphological features observed on hill slopes with fresh surface having less plant growth on debris categorized as new slides and rest are grouped as old slides. As regard to reactivated ones the old slides wherein new slides are developed are considered along with the slides wherein authorities have provided some remedial measures but still then failed are also grouped under reactivated ones.

Most of the landslides in the area are grouped as Old and reactivated slides. Cut slope angle and height appear to have played a major role in slope failure. The Overburden thickness is around 1-4 m consisting of mostly soil and weathered rock in most of the cases.

IV. LANDSLIDE SUSCEPTIBILITY ANALYSIS

4.1 Background: The method to be followed is primarily landslide dependent following a raster-based GIS modelling approach for integration of all selected and weighted thematic maps to prepare 1:50,000 scale landslide susceptibility maps. As prior knowledge of landslide is missing in the area, AHP has to be applied for preparation of final susceptibility map.

4.2 Selection of Preparatory Factors: For susceptibility mapping, the selection of preparatory factors for landslides depends on the scale of analysis, the characteristics of the study area, the landslide type, the failure mechanisms and the priori knowledge of the main causes of landslides (Guzzetti et al., 1999;).

A systematic overview of the important preparatory factors required for susceptibility mapping in different scales is given in van Westen et al. (2008). A priori knowledge of the main causes of landslides in the area of interest is essential in selecting the most relevant factors out of the many known preparatory factors that can "theoretically" cause.

For areas where a-prior knowledge of landslide is missing or scarce and/or insufficient, any one of the following approaches may be adopted as per priority or terrain conditions and/or after due discussion with the local experts/workers.

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

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

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

4.3 Geo-factor Themes: Following geo-factor themes has been used for analysis:

4.3.1 Slope Morphometry: Mainly slope morphometry is defined by slope gradient (Plate-2) and curvature (Plate-3). The data for these factors was derived from DEM. For the slope gradient map as a derivative of DEM, the area was classified in to 05 classes ranging from 15 degree up to > 45 degrees. Curvature map is classified in to 3 classes' i.e convex, flatter and concave.

Plate-3

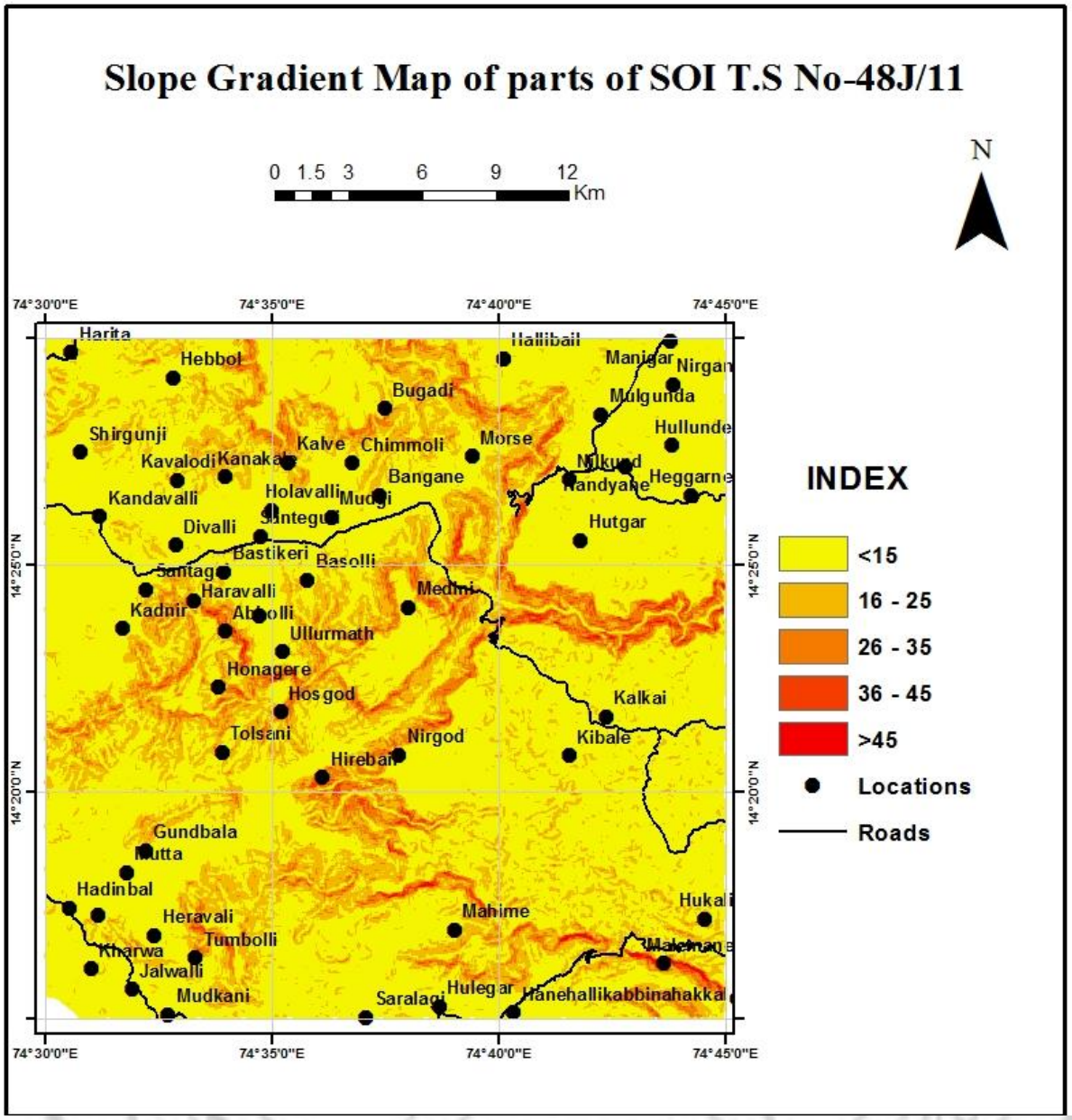
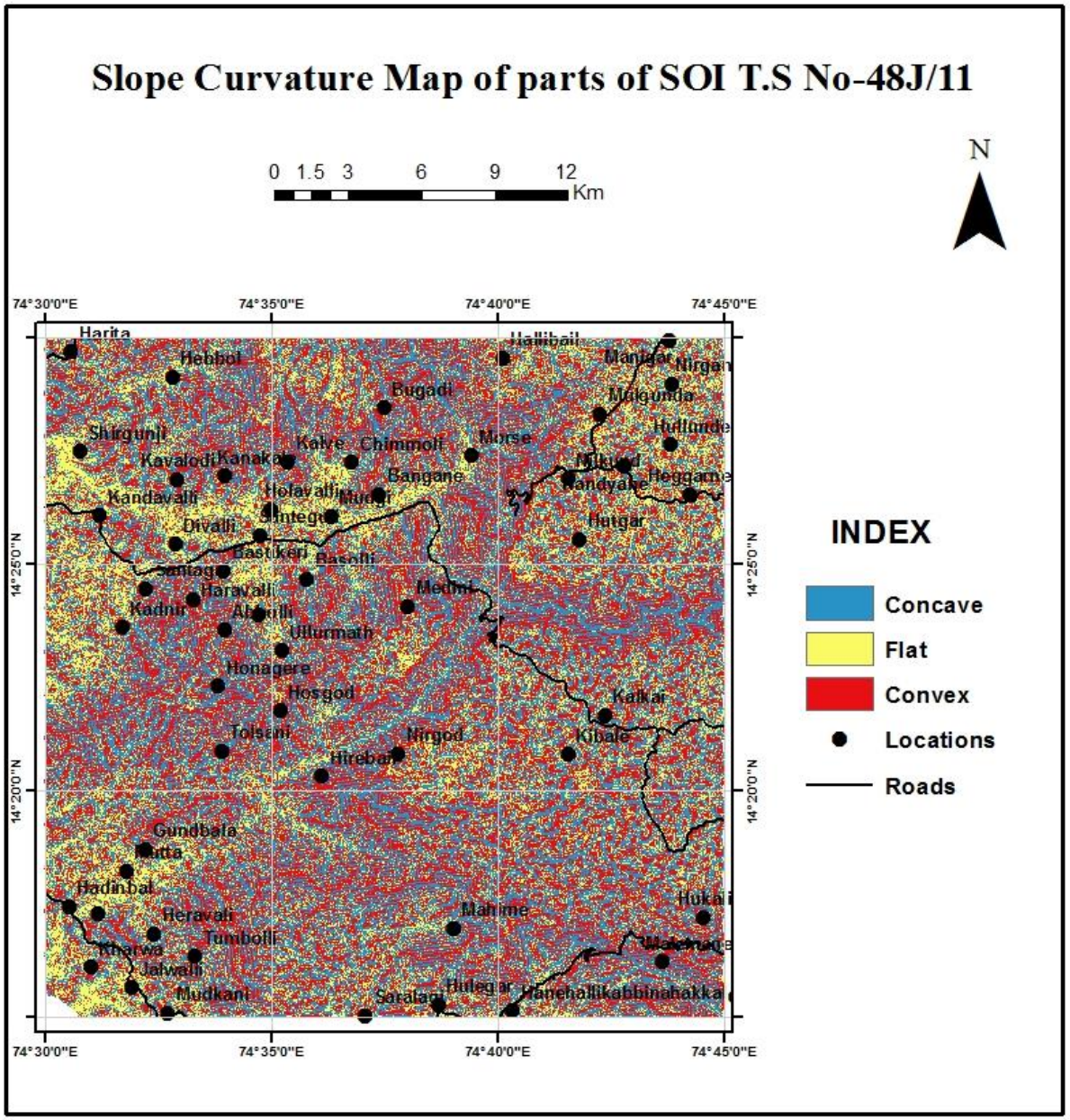

Slope Gradient Map of parts of SOI T.S No-48J/11
0 1.5 3 6 9 12
Km
N
74°30'0"E
74°35'0"E
74°40'0"E
74°45'0"E
14°25'0"N
14°20'0"N
Harita
Hebbol
Hallibail
Manigar
Nirgan
Bugadi
Mulgunda
Hullunde
Shirgunji
Kavalodi
Kanakal
Kalve
Chimmoli
Morse
Nilkund
Bangane
Nandyane
Heggarne
Kandavalli
Holavalli
Mudgi
Divalli
Hutgar
Bastikeri
Basolli
Haravalli
Kadnir
Medni
Ullurmath
Honagere
Hosgod
Kalkai
Tolsani
Nirgod
Kibale
Hirebail
Gundbala
Hadinbal
Heravali
Mahime
Tumbolli
Kharwa
Jalwalli
Mudkani
Huleg ar
INDEX
<15
16 - 25
26 - 35
36 - 45
>45
Locations
Roads

Plate-4



4.3.2 Geomorphology: Geomorphologically the area is an undulating highly rugged terrain comprising steep hills and valleys covered with dense forest. The highest elevation is 729 m above msl at 1.2 km southeast of Galamavu in the southeastern part of the area. Lowest elevation is 83 m above msl at 500 m northwest of Padukuli in the southwestern part of the area. Aghnashini or Tadri River flows from east to west in the northern part of the area. River Sharavati and its tributaries flows in the southern part, besides few perennial nalas such as Bennihole in the northern part and Doddamane Halla in the southern part flows and drains the area. Dendritic type of drainage pattern is commonly noticed in the area. Five major rivers viz.,

Kalinadi, Gangavali, Aghanashini, Sharavati and Venkatapura have their sources in the Sahyadris and flow west through the district into the Arabian Sea. Some of the magnificent waterfalls in the district such as the Jog, the Lushington (Unchalli) and Magod are associated with the rivers Sharavati, Aghanashini and Gangavali respectively. Deep gorges have been carved out by the perennial nalas and rivers which flow through the area. The area receives very heavy rainfall of about 4000 mm annually which decreases to 2500mm towards east. Due to very heavy rainfall the area is covered by wet-evergreen forest. The heavy rainfall has resulted in extensive weathering and lateritisation of the rocks which has led to thick capping of Laterite and soil cover in the area.

Western Ghats represent the edge of an upraised and disrupted continental block formed in early Miocene during which there was pronounced upwarp of the continent, subjected to fissuring and drifting apart from the western half. This is amplified by the absence of sediment older than the Miocene on western coast. Thus laterite on Western Ghats could have formed only during post-miocene period to quaternary.

Majority of the area is covered by highly dissected hills followed by peneplain – pediment complex and moderately to low dissected hills. The geomorphic expression of the area is governed by the following landforms: The development of hills and ridges depends, to a greater extent, on the lithology & structural elements. Bedding, joints, shear planes and fault zones have given rise to major lineaments in the area. The rugged topography is developed in the grey granites whereas the areas covered by incompetent rocks such as actinolite schist exhibit broad crested ridges and mature topography. At places the ridges are occupied by basic intrusives such as dolerite and gabbro dykes. The slopes in the toe part are characterised by laterite and saprolite development.

Geomorphological map (Plate-5) was prepared in Arc GIS through visual interpretation of IRS LISS III data and multi-temporal Google Imageries of the area. NGLM data supplied by GHRM cell was also taken into account while preparing the geomorphology map of the study area. Gemorphologically area can be divided in to ridges, highly/moderately/low dissected escarpments, transpotational mid slopes, pediment-peneplain complex and anthropogenic terrains (slope cuts, settlement, etc.).

Extensive road cuts are the main sites for slope failures in the study area, with rare occurrences of slides caused by toe erosion due to nalas and streams. The details of geomorphic features are given as follows :(Photos-13, 14, 15)

Ridge: This is the topmost part of the hills/mountains which is formed by the intersection of two escarpments from the opposite directions. (Photo-13)

Scarp (Escarpment): A long, more or less continuous cliff or relatively steep slope face facing in one general direction, breaking the general continuity of the land by separating two level or gently sloping surfaces, and produced by erosion or by faulting. Depending on the degree of dissection it can be classified in to highly/moderately/low dissected escarpments. (Photos-14)

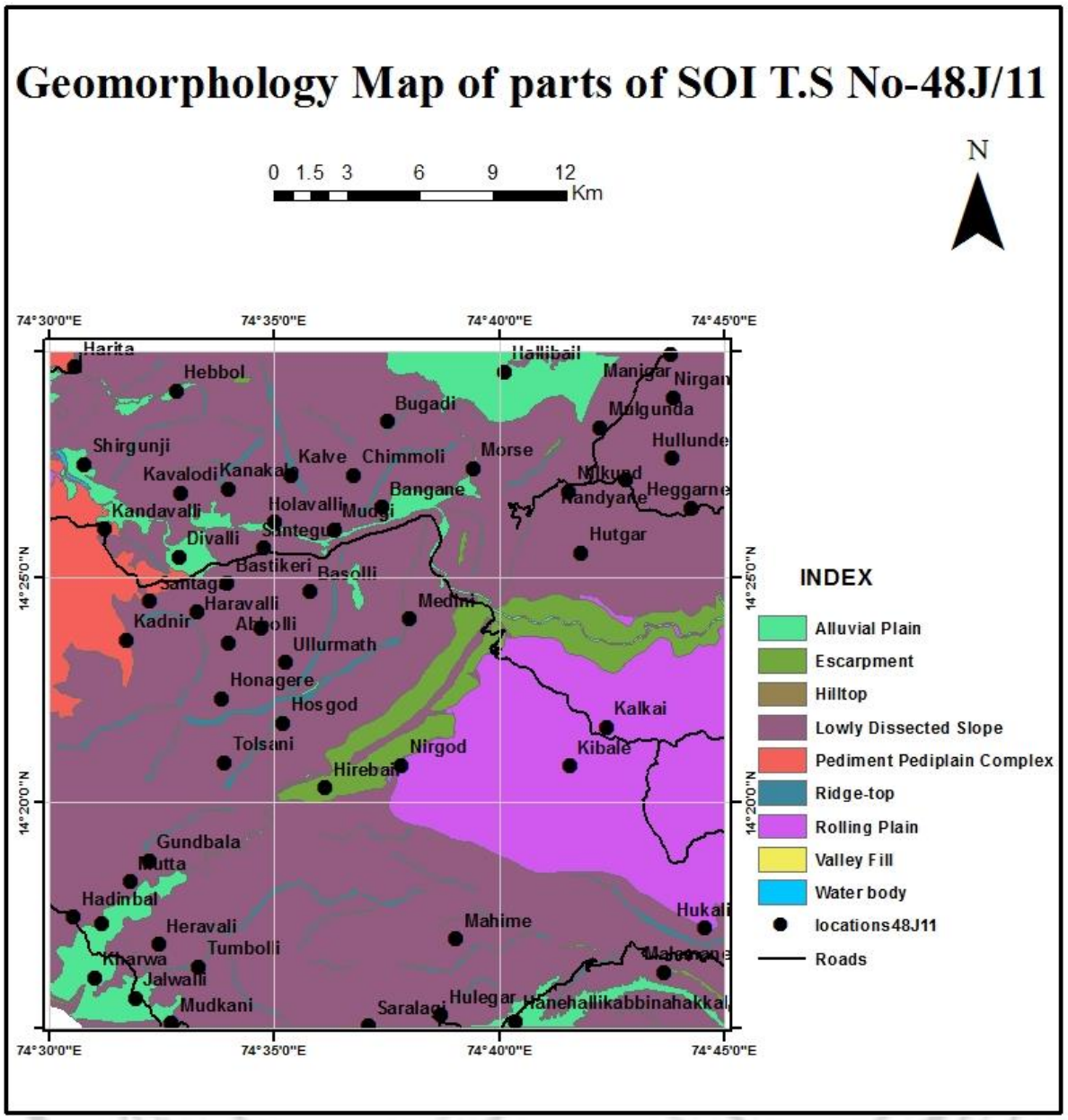
Transportational Mid Slopes: This is the part of the slopes which is in general having angle lesser than the escarpment but more than pediment zone, it generally occurs between escarpment and pediment zone. In general it has angle more than 45 degree (Photos-15).

Piedmont Slope : A broad, flat or gently sloping, rock floored erosion surface or plain of low relief, typically developed by sub aerial agents (including running water) in an arid or semiarid region at the base of an abrupt and receeding mountain front or plateau escarpment, and underlain by bedrock (occasionally by older alluvial deposits) that may be bare but more often partly mantled with a and discontinuous veneer of alluvium derived from the upland masses and in transit across the surface. (Photos-15)

Alluvial plain: A level or gently sloping tract or a slightly undulating land surface produced by extensive deposition of alluvium, usually adjacent to a river that periodically overflows its banks; it may be situated on a flood plain, a delta, or alluvial fan.

Alluvial Terrace: A stream terrace composed of unconsolidated alluvium (including gravel), produced by renewed down cutting of the flood plain or the valley floor by a rejuvenated stream, or by the later covering of a terrace with alluvium.

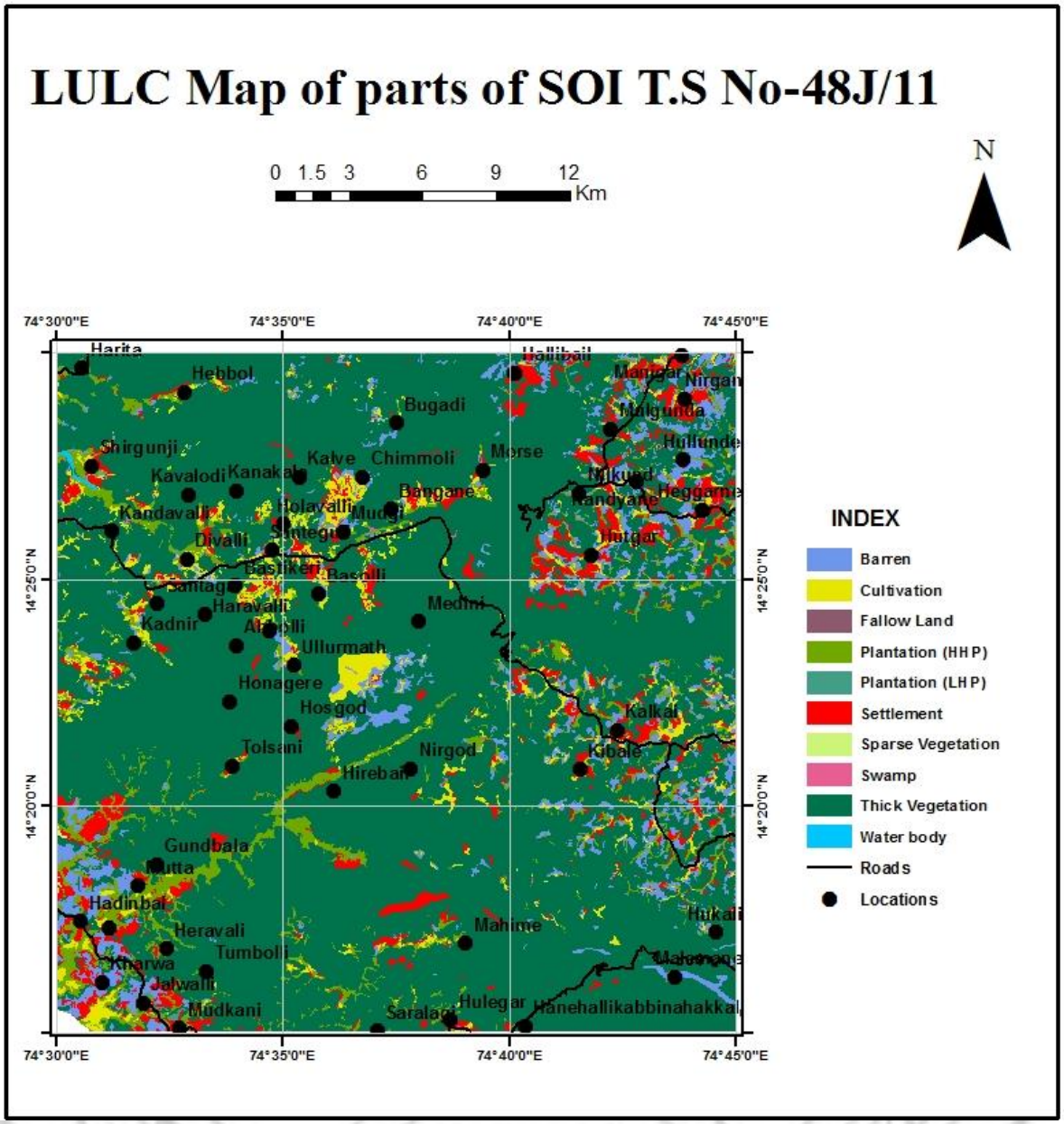
Plate-5



4.3.3 Land Use & Land Cover: Land Use & Land Cover map (Plate-6) was prepared in Arc GIS through visual interpretation of IRS LISS III data and multi-temporal Google Imageries of the area. The area in terms of LU/LC can be divided in to following classes: Barren, Cultivation, settlements, sparse vegetated areas, thick vegetated areas, river, swamps, plantation and Fallow land. The areas along river banks is covered with alluvial material and along low lying valleys is covered with overburden material and are being used for cultivation.

Major part of the area is covered with thick vegetation/forest. In the study area slopes along the road corridors, are most affected by slope failures due to the construction activities. (Photos-1,2, 11,12)

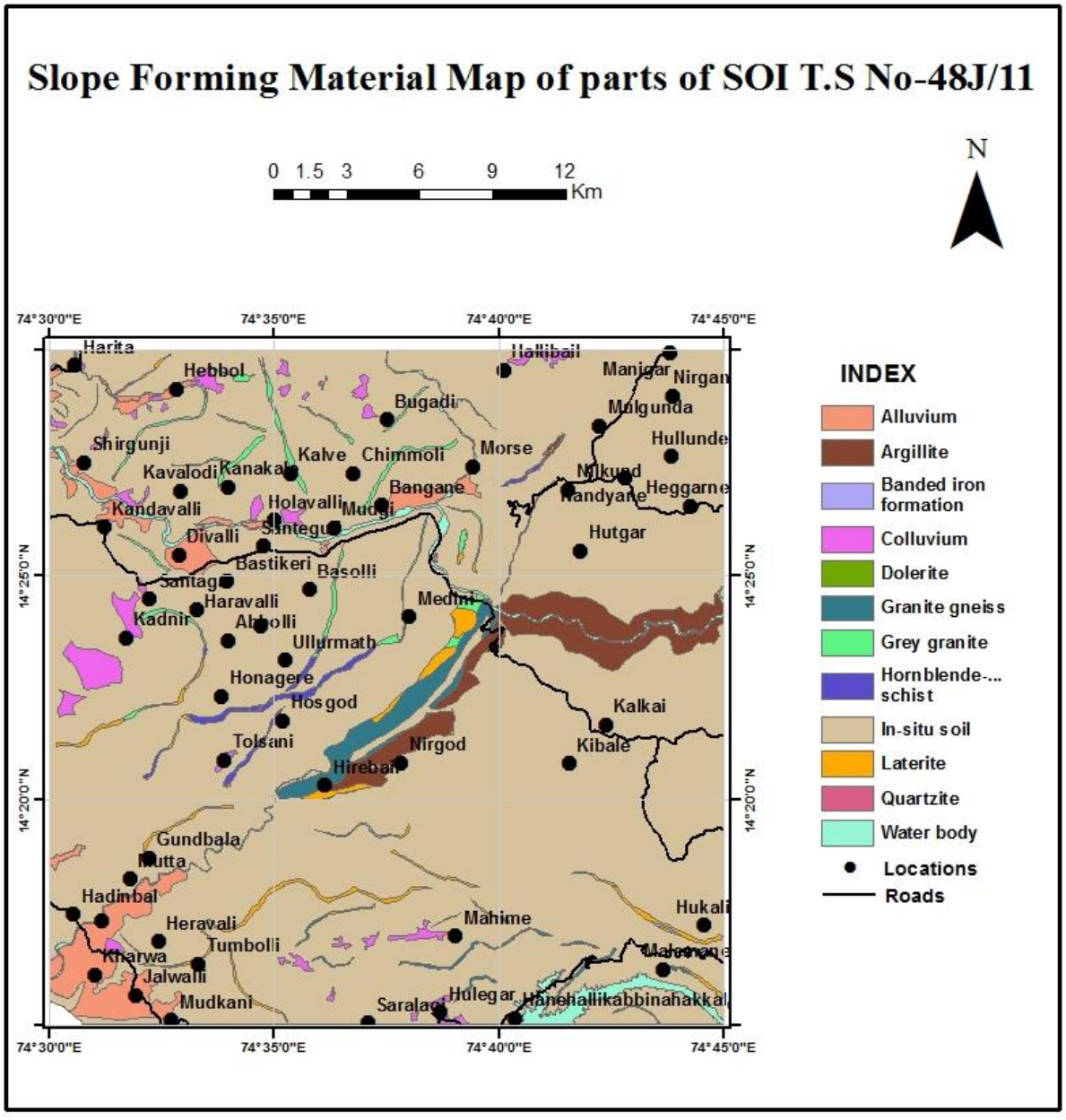
Plate-6


LULC Map of parts of SOI T.S No-48J/11
0 1.5 3 6 9 12
Km
N
74°30'0"E
74°35'0"E
74°40'0"E
74°45'0"E
14°25'0"N
14°20'0"N
Harita
Hebbol
Bugadi
Shirgunji
Kavalodi
Kanakal
Kalve
Chimmoli
Morse
Kandavalli
Holavalli
Mudgi
Divalli
Mulgunda
Hullunde
Hulgar
Medini
Kadnir
Ullurmath
Honagere
Hosgod
Tolsani
Nirgod
Hirebari
Kalkal
Gundbala
Hadinbal
Heravali
Tumboli
Kharwa
Jalwali
Mudkani
Mahime
Saralag
Hulegar
Hanehallikabbinahakkal
INDEX
Barren
Cultivation
Fallow Land
Plantation (HHP)
Plantation (LHP)
Settlement
Sparse Vegetation
Swamp
Thick Vegetation
Water body
Roads
Locations

4.3.4 Slope Forming Material (SFM): Slope Forming Material (SFM) map (Plate-7) was prepared in Arc GIS through visual interpretation of multi-temporal Google Imageries of the area and collection of data for material present on slopes. The area in terms of Slope Forming Material (SFM) can be divided in to following classes: Rock, Colluvium, Alluvium, In-situ soil & laterite.

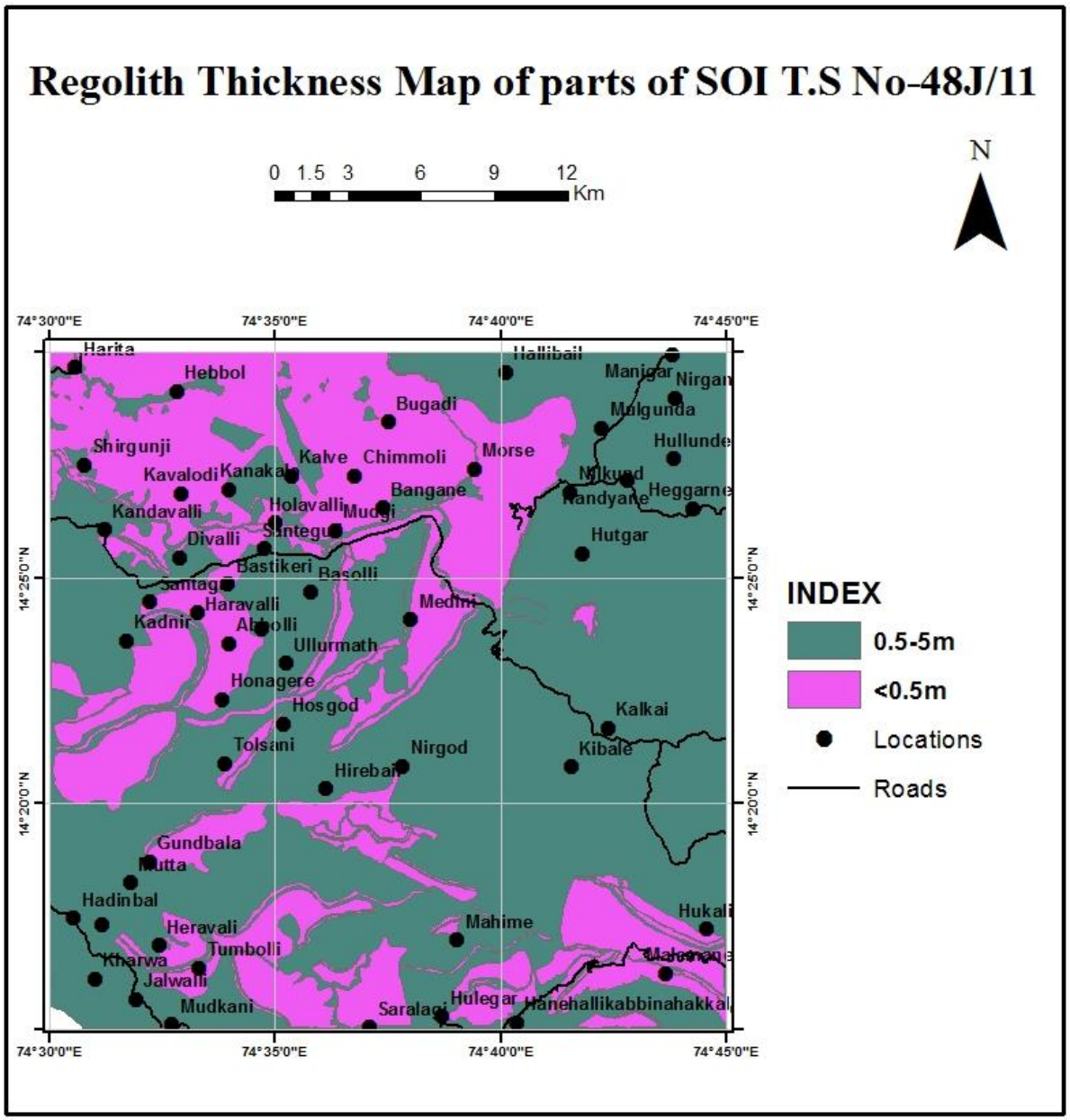
On slopes, rock is present at places where the slope angle in general is more than 35°, Colluvium is accumulated on the lower slopes due to gravitational action while alluvium is accumulated due to the fluvial action, In-situ soil is present at places where erosional activities are not too much in action & laterite is present in areas where weathered profiles are well developed.

Plate-7



4.3.5 Regolith Thickness: Depth of Overburden is directly controlled by Slope Forming Material (SFM), geomorphology, Land use & Land cover and slope gradient. In the study area it can be classified in to 2 classes: <0.5 m and 0.5-5 m. Along the moderate & steep slopes depth of overburden in general is less while along major weathered profiles regolith thickness is more, these areas are more prone for landslides.

Plate-8



4.4 Landslide Susceptibility Analysis (AHP)

Landslides or rather slope failures in the study area are concentrated mainly along roads and transportation corridors. Recording these slope failures which are as a result of anthropogenic activities and considering them for susceptibility zonation would be highly biased. Very few, almost negligible amount of slides are observed elsewhere in the area, the normal method of modeling cannot be used here. In this situation, ratings and inter-predictor weights can only be determined using expert or knowledge driven techniques by implementing one of the following alternatives or by combining knowledge derived from attempting all the alternatives.

Alternative 1: Finalisation of ratings and weights in a smaller neighbouring area-

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

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

In situation of complete non-availability of landslide inventory data, there is absolutely no remedy other than utilising complete expert or knowledge driven ratings and weights into susceptibility modeling despite its subjectivity. However, this knowledge-driven ratings/ weights in quantitative metrices can easily be determined mathematically using AHP, after preparing/ deciding on the qualitative pairwise importance matrix for different geofactor classes and amongst different geofactors for inter-predictor weights, obtained so far through discussion and comments received from local experts and landslide scientists engaged in landslide investigation of the area. The procedures of application of AHP through some examples are demonstrated through some illustration below.

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

and >45 and give semi-quantitative rating as 2, 4, 8, 6, 1 then it will be presumed that for land sliding, slope class 25-35 is the most important among all other classes.

4.4.1 Methodology: The Analytic Hierarchy Process (AHP), developed by Saaty (1981) is a method of structuring decision problems. The AHP consists of three levels of hierarchy. The first hierarchy level is the goal of the decision making, the second level involves how each of the existing criteria contributes to achievement of goal, and the third level is to find out how each of the alternatives contributes to each of the criteria.

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

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

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

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

The consistency ratio is then calculated as,

$CR= CI/ RI$ Eq-3

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

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

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

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

Example of LULC for calculation of LOFS is given below:

Example-Calculation of LOFS for LULC

CLASS	RATING
Barren (B)	1
Barrne Sand (BS)	0
Cultivation (CL)	2
Extensive Slope Cut (ESC)	9
Fallow Land (FL)	1
Moderate Vegetation (MV)	5
Plantation (HHP)	4
Plantation (LHP)	3
Quarry (QR)	5
Settlement (S)	1
Settlement on modified slope (SM)	7
Settlement with Cultivation (SC)	0
Settlement with Vegetation (SV)	0
Swamp (SW)	0
Thick Vegetation (TV)	4
Sparse Vegetation (SV)	7
Waterbody (WB)	0
Salt Pan (SP)	0

Table-3: Generic Table showing mutual comparison rank of LULC factor classes.

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

Table-4: Table showing matrix of mutual comparison ranks of LULC classes given rank >0.

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV	Sum rows	Frac rate	LOFS
B	0.020	0.013	0.037	0.020	0.013	0.012	0.011	0.013	0.020	0.021	0.012	0.021	0.213	0.018	0.063
CL	0.041	0.026	0.042	0.041	0.016	0.015	0.017	0.016	0.041	0.024	0.015	0.024	0.318	0.027	0.094
ESC	0.184	0.208	0.333	0.184	0.329	0.278	0.237	0.323	0.184	0.431	0.278	0.431	3.399	0.283	1.000
FL	0.020	0.013	0.037	0.020	0.013	0.012	0.011	0.013	0.020	0.021	0.012	0.021	0.213	0.018	0.063
MV	0.102	0.104	0.067	0.102	0.066	0.093	0.102	0.065	0.102	0.048	0.093	0.048	0.990	0.082	0.291
HHP	0.082	0.078	0.056	0.082	0.033	0.046	0.068	0.032	0.082	0.036	0.046	0.036	0.676	0.056	0.199
LHP	0.061	0.052	0.048	0.061	0.022	0.023	0.034	0.022	0.061	0.029	0.023	0.029	0.464	0.039	0.137
QR	0.102	0.104	0.067	0.102	0.066	0.093	0.102	0.065	0.102	0.048	0.093	0.048	0.990	0.082	0.291
S	0.020	0.013	0.037	0.020	0.013	0.012	0.011	0.032	0.020	0.021	0.012	0.021	0.232	0.019	0.068
SM	0.143	0.156	0.111	0.143	0.198	0.185	0.169	0.194	0.143	0.144	0.185	0.144	1.914	0.160	0.563
TV	0.082	0.078	0.056	0.082	0.033	0.046	0.068	0.032	0.082	0.036	0.046	0.036	0.676	0.056	0.199
SV	0.143	0.156	0.111	0.143	0.198	0.185	0.169	0.194	0.143	0.144	0.185	0.144	1.914	0.160	0.563
													Max		0.283

Table-5: Table Showing Fraction rate and LOFS values.

LULC	B	CL	ESC	FL	MV	HHP	LHP	QR	S	SM	TV	SV	Sum rows	CV
B	0.018	0.013	0.031	0.018	0.016	0.014	0.013	0.016	0.019	0.023	0.014	0.023	0.2191981	12.36
CL	0.035	0.027	0.035	0.035	0.021	0.019	0.019	0.021	0.039	0.027	0.019	0.027	0.3229031	12.17
ESC	0.16	0.212	0.283	0.16	0.412	0.338	0.271	0.412	0.174	0.479	0.338	0.479	3.7177267	13.12
FL	0.018	0.013	0.031	0.018	0.016	0.014	0.013	0.016	0.019	0.023	0.014	0.023	0.2191981	12.36
MV	0.089	0.106	0.057	0.089	0.082	0.113	0.116	0.082	0.097	0.053	0.113	0.053	1.0496105	12.72
HHP	0.071	0.08	0.047	0.071	0.041	0.056	0.077	0.041	0.077	0.04	0.056	0.04	0.698393	12.4
LHP	0.053	0.053	0.04	0.053	0.027	0.028	0.039	0.027	0.058	0.032	0.028	0.032	0.4718235	12.19
QR	0.089	0.106	0.057	0.089	0.082	0.113	0.116	0.082	0.097	0.053	0.113	0.053	1.0496105	12.72
S	0.018	0.013	0.031	0.018	0.016	0.014	0.013	0.041	0.019	0.023	0.014	0.023	0.2439453	12.61
SM	0.124	0.159	0.094	0.124	0.247	0.225	0.193	0.247	0.135	0.16	0.225	0.16	2.0954329	13.14
TV	0.071	0.08	0.047	0.071	0.041	0.056	0.077	0.041	0.077	0.04	0.056	0.04	0.698393	12.4
SV	0.124	0.159	0.094	0.124	0.247	0.225	0.193	0.247	0.135	0.16	0.225	0.16	2.0954329	13.14
													Sum CV	151.3

Table-6: Table showing estimation of consistency vector (CV).

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

Mean CV	**12.6**	
Consistency Index (CI) =		**(Mean CV-number of themes)/(No of themes -1)**
CI	0.06	
Consistency Ratio (CR) =		**CI/RI**
CR	0	
CR should never be more than 0.1		

Table-7: Table showing calculation of consistency index (CI) and consistency ratio (CR).

In the same manner for all the 6 factor maps calculation of LOFS and consistency ratio (CR) was done. After calculation of LOFS values for all the factor classes of all the factor maps, LOFS maps were prepared using Arc GIS by joining the LOFS tables to the individual maps respectively.

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

Factor	Slope	Curvature	SFM	LULC	Geom	RT
Slope	1.00	8.00	4.00	2.00	6.00	6.00
Curvature	0.13	1.00	0.20	0.14	0.33	0.33
SFM	0.25	5.00	1.00	0.33	3.00	3.00
LULC	0.50	7.00	3.00	1.00	5.00	5.00
Geom	0.17	3.00	0.33	0.20	1.00	1.00
RT	0.17	3.00	0.33	0.20	1.00	1.00
Sum Clmn	2.21	27.00	8.87	3.88	16.33	16.33

Factor	Slope	Curvature	SFM	LULC	Geom	RT	Sum rows	Frac rate	Weight	Weight W N
Slope	0.45283	0.296296	0.451128	0.515971	0.367347	0.367347	2.450919	0.408486	12.64217	13
Curvature	0.056604	0.037037	0.022556	0.036855	0.020408	0.020408	0.193869	0.032311	1	1
SFM	0.113208	0.185185	0.112782	0.085995	0.183673	0.183673	0.864517	0.144086	4.459293	4
LULC	0.226415	0.259259	0.338346	0.257985	0.306122	0.306122	1.69425	0.282375	8.73917	9
Geom	0.075472	0.111111	0.037594	0.051597	0.061224	0.061224	0.398223	0.06637	2.054087	2
RT	0.075472	0.111111	0.037594	0.051597	0.061224	0.061224	0.398223	0.06637	2.054087	2

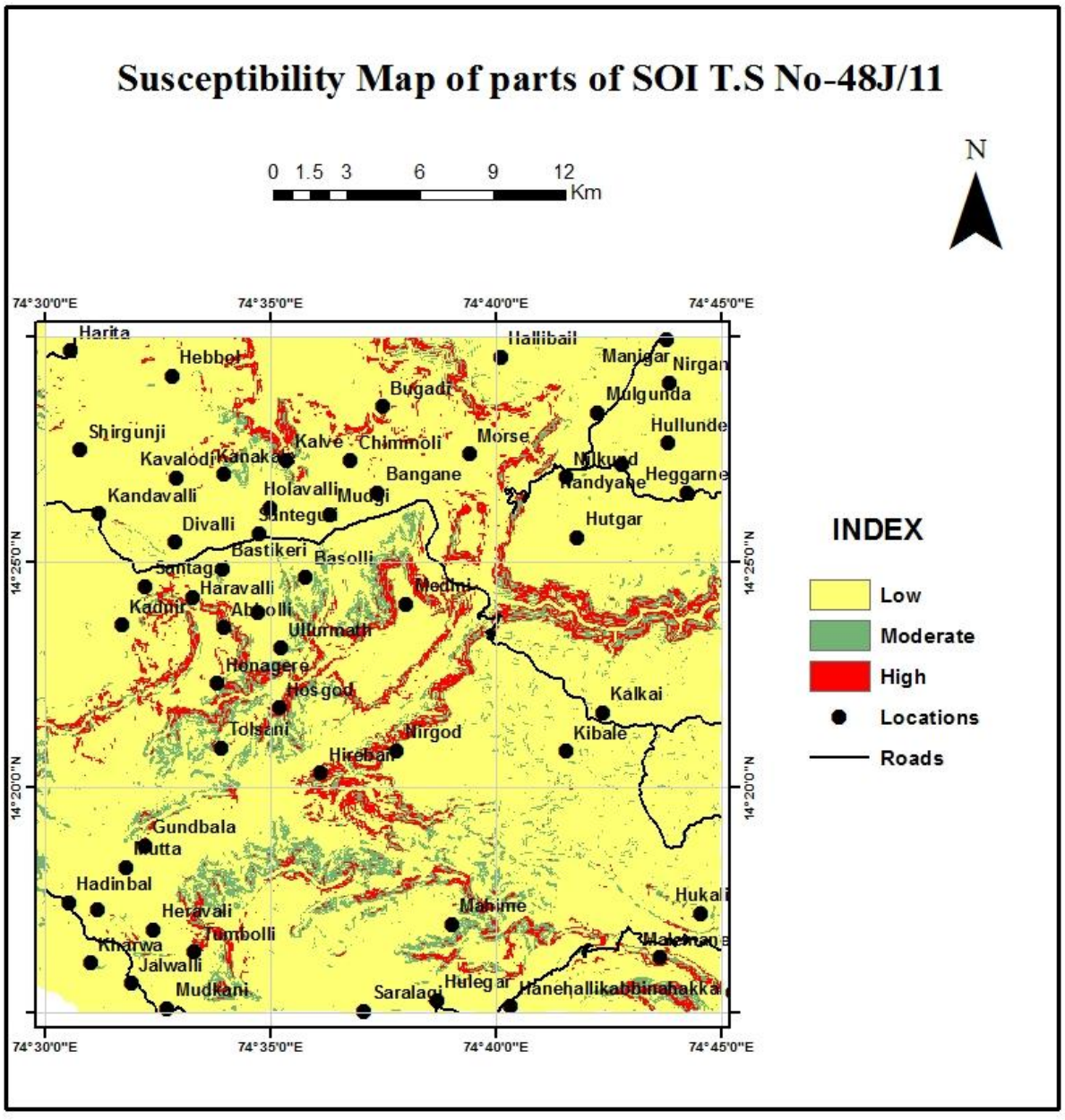
Table-8: Table showing mutual comparison of individual factor maps and weights.

The integer weight or rating and weights derived from AHP were used to obtain landslide susceptibility score map. The output map is then regrouped into three susceptibility class (high, moderate and low).

V. LANDSLIDE SUSCEPTIBILITY MAP

5.1 Susceptibility Map: The area can be classified in to high, medium & low susceptible areas, as per AHP analysis, Prominent settlement locations like Hebbel, Morse, Nirgod, Mahime, Gonavati ,Tumboli & its surroundings can be grouped in to high susceptible zones while rest of the area is under medium to low susceptible category. In the area route from Kumta-Siddapur is most affected by road construction activities & prone for landslides. Major drainages like Agnashini or Tadri , Sharavati & its tributaries are under medium to low susceptible category & least prone for landslides. In the area denudated hills & lowly dissected hills having extensive cut slopes are most prone for landslides.

Plate-9



VI. CONCLUSIONS AND RECOMMENDATIONS

Land use/ Land Cover (LU LC), Geomorphology, Slope Forming Material, Slope gradient, Slope Curvature and Regolith thickness are various thematic classes which has a direct or indirect control over landslide susceptibility. In the area denudated hills & lowly dissected hills having extensive cut slopes are most prone for landslides.

As per the AHP analysis ,the study area can be classified in to high, medium & low susceptible areas. Prominent settlement locations like Hebbel, Morse, Nirgod, Mahime, Gonavati ,Tumboli & its surroundings can be grouped in to high susceptible zones while rest of the area is under medium to low susceptible category. The road from Kumta-Siddapur is most affected by road construction activities & prone for landslides. Major drainages like Agnashini or Tadri, Sharavati & its tributaries are under low susceptible category & least prone for landslides.

These susceptibility zones has a direct influence on land use planning and development of land use regulations on the regional scale as it is obvious that zones or areas like Hebbel, Morse, Nirgod, Mahime, Gonavati ,Tumboli & its surroundings can be grouped in to high susceptible zones and not suitable for planners in comparison to the rest of the area which is under medium to low susceptible category and suitable for construction of structures like dams, tunnels and communication corridors .

The road from Kumta-Siddapur is most affected by road construction activities & prone for landslides, and is least suitable for development for planners; these areas need special attention from developers and administration for proper land use planning. Major drainages like Agnashini or Tadri, Sharavati & its tributaries are under low susceptible category & least prone for landslides but development along the banks of these drainages needs special post construction maintenance and monitoring.

1) The susceptibility map on 1:50,000 scale gives the qualitative estimation that the mapping unit will be affected by a future landslide source, but the “future” here is not connected to a time frame. It only indicates the stability status of a slope irrespective of a time of an event to occur.

2) The susceptibility model used to predict the spatial location of potential landslides is based on certain assumptions. It is assumed that landslides will occur in future under the same conditions and triggering factors that produced them in past.

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

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

5) The assessment of the landslide susceptibility is extremely important for high vulnerable areas because it gives basic construction standards for new roads or buildings, helps to assess the impact of future landslides and can also be used to locate key facilities like hospitals, fire stations, etc. As a general recommendation, if end users intend to use only the susceptibility map for land use planning, then no public or personal utility projects should be considered in highly susceptible areas, strict building safety regulations should be followed in moderate susceptible areas and constructions with simple slope stability measures be allowed in low susceptible areas. This is a general recommendation related to the landslide susceptibility based on the present land use condition; however the susceptibility values can be lowered if proper mitigation measures are adopted such that a high susceptible area can be made less vulnerable to land sliding. Therefore, it is recommended that the susceptibility map should be interpreted accordingly and the degree of susceptibility or hazard in response of mitigation measures should be worked out judiciously. In this regard cost-benefit analysis may be carried out for better planning.

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

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

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

9) In the event if a disaster strikes, then loss would be immense if buildings are not safely and properly located. The only economical way of reducing “at least‟ the loss of life is by making people aware of the inherent risk. Therefore, it is recommended that more priority should be given in increasing awareness amongst people through Community Based Disaster Management Programme (CBDMP).

10) The awareness should include information about the potential danger, its identification and its communication; the physical significance of hazard and inherent uncertainties; ways to reduce landslide risk and the available local mitigation options.

11) The villages or communities located in and around high hazard areas should be given priority in holding CBDMP.

REFERENCES

Bonham-Carter, G.F., 1994: Geographic Information Systems for Geoscientists: Modeling with GIS. Pergamon, Elsevier Science Ltd., 398 pp.

Chung, C.-J.F. and Fabbri, A.G., 2003: Validation of Spatial Prediction Models for Landslide Hazard Mapping. Natural Hazards, 30 (3): 451-472.

Fleiss, J.L., 1991: Statistical Methods for Rates and Proportions. John Wiley and Sons, Chichester.

Ghosh, S., Carranza, E.J.M., van Westen, C.J., Jetten, V.G. and Bhattacharya, D.N., 2011: Selecting and weighting spatial predictors for empirical modeling of landslide susceptibility in the Darjeeling Himalayas (India). Geomorphology, 131 (1–2): 35-56.

Guzzetti, F., Reichenbach, P., Cardinali, M., Galli, M. and Ardizzone, F., 2005: Probabilistic landslide hazard assessment at the basin scale. Geomorphology, 72 (1-4): 272-299.

Maruthi, K.V and Chandran K.V, 2012: Landslide Inventory along NH and SH of ghat roads in Uttar Kannada and Chikmagalur Districts, Karnataka, F.S 2010-12, Geol. Surv. Of India rep. (unpub.)

Maruthi, K.V, Pradhan, U.K and Mishra, A.K, 2010:A Report on Landslide Inventory along NH and SH of ghat roads in Chikmagalur, Coorg and Shimoga Districts, Karnataka, F.S 2008-09, Geol. Surv. Of India rep. (unpub.)

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

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

Yule, G.U., 1912: On the methods of measuring association between two attributes. Journal of the Royal Statistical Society, 75: 579-642.

LOCALITY INDEX

Locality	Latitude			Longitude		
	Deg.	Min.	Sec.	Deg.	Min.	Sec.
Hebbel	14	29	08	74	32	50
Mahime	14	16	57	74	39	02
Morse	14	27	24	74	39	25
Nirgod	14	20	49	74	37	49
Nikund	14	26	53	74	41	33
Santegal	14	24	28	74	32	14
Santeguli	14	25	38	74	34	45
Tumboli	14	16	21	74	33	19
Ullurmath	14	23	06	74	35	14

PHOTOS

Photo-1&2: Development of laterite (overburden) in study area (SH-144).

Photo-3: Wedge failure in Argillite, slide no. KAR/UK/48J11/2014/02.

Photo-4:Slide due to extensive road cutting, slide no. KAR/UK/48J11/2014/07.

Photo-5: Slide in overburden near Gundibail, slide no. KAR/UK/48J11/2014/10.

Photo-6: Planar wedge failure in schist near Sasiguli, KAR/UK/48J11/2014/16.

	
Photo-7: Development of cracks in road fill material near Sasiguli.	Photo-8: Unstable road fill material without retaining wall near Sasiguli.
	
Photo-9: A reactivated slide on SH 48, slide no. KAR/UK/48J11/2014/45.	Photo-10: Planar wedge failure in schist near Sasiguli, KAR/UK/48J11/2014/16.
	
Photo-11: well section exposing laterite development near Shiroor.	Photo-12: An example of landuse in study area, near Valki.

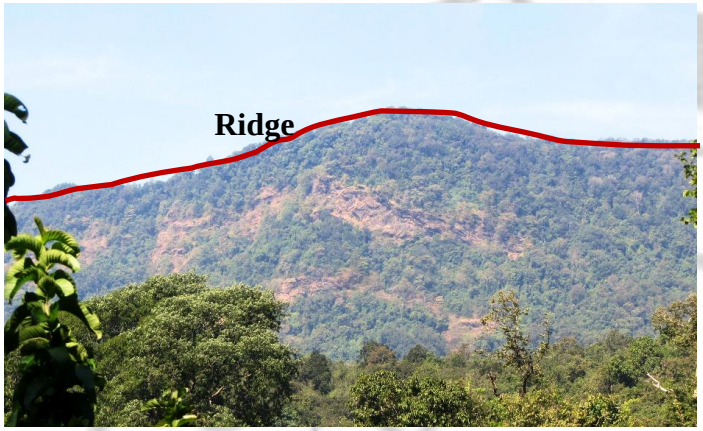


Photo-13: Geomorphic feature “Ridge” near Sasiguli.

Photo-14: Geomorphic feature “Scarp face” near NH-206.

Photo-15: Geomorphic feature “Transportational Mid slope” and “Piedmont slope” near Malemane, NH-206.

SYNOPSIS OF WORK DONE

1	**Title of the report**	Macro-scale (1:50000) Landslide susceptibility Mapping in parts of Toposheet nos. 48J/11 Uttar Kannada districts, Karnataka.
2	**FSP Code No**	LSM/SR/KG/2014/093
3	**Field Season**	2014 - 16
4	**Date of Commencement**	27th September, 2014
5	**Date of Completion**	3rd March 2016
6	**Officers associated with the investigation and no. of days spent in the field**	1.Koushik Shukla, Senior Geologist-20 Days 2. Sahel.M.P, Geologist-18 Days 3. Ankur Kumar Srivastava, Sr. Geologist(F.S-2014-15)-92 Days
7	**Quantum of work done**	

1. Pre-field preparation	
(i) Slope Forming Material map	744.5 sq. Km
(ii) Geomorphology & Lineament map	744.5 sq. Km
(iii) Slope Morphometry (slope, aspect & curvature) map	744.5 sq. Km
(iv) Landuse / Landcover map	744.5 sq. Km
(v) Drainage map	744.5 sq. Km
(vi) Regolith thickness map	744.5 sq. Km
(vii) Preparation of Landslide Inventory Map	744.5 sq. Km
2. Field-based studies	
(i) Field-checking of all thematic maps	744.5 sq. Km
(ii) Field validation of landslide inventory and collection of recent and historic landslides (using archives, old reports, road register etc.)	744.5 sq. Km
(iii) Collection of landslide inventory and damage data as per 41 point geo parametric data sheet	47 nos.
(iv) Validation of landslide susceptibility map at important locations	-
3. Post-field studies & modelling	
(i) Updation of thematic and inventory maps in GIS	744.5 sq. Km
(ii) Preparation of Landslide Susceptibility Map in GIS	744.5 sq. Km
4. Collection of rainfall data from available rain stations	Collected

8 **Expenditure**

Wages (Rs.)	39396.00
OC (Rs.)	155425.00*
POL(Rs.)	17027.25
Total (Rs.)	**6744.58.00**

* Expenditure including rent for Out Sourced vehicle for F.S-2014-15.

GEOLOGICAL SURVEY OF INDIA

Certificate of Quality of the report

Project/ Division: NLSM/EG **FSP No**.: LSM/SR/KG/2014/093 **Mission**:IV

Title of the report: "Macro-scale (1:50000) Landslide susceptibility Mapping in parts of Toposheet nos. 48J/11 Uttar Kannada districts, Karnataka".

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

Name and designation of the Officer	Total field stay during the FSP (No. of days)	Signature with date
1. Koushik Shukla, Sr.Geologist	20 days	
2. Sahel.M.P, Geologist	18 days	
3. Ankur Kumar Srivastava, Sr. Geologist(F.S-2014-15)	92 days	

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

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

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

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

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

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

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

Name(s) and designation of the Supervisory Officers	No. of inspection visits	Total No. of days spent on inspection visit	Signature with date
1. Shri. J. Srihari, Director	01	02	

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

Name and designation of the Regional Mission Head	Signature with date

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

Name and designation of the Regional HOD	Signature with date

SLOPE FORMING MATERIAL (SFM) DATA

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
1	74	30	19.4	74.51	14	17	31.4	14.29	Gravitational	pediment pediplain complex	Argillite	Moderate	Jointed moderate	J1N35°W/27°NE J2N20°W/74°S	YLM	5	Sparsely vegetated
3	74	31	31.4	74.53	14	16	33.7	14.28	Gravitational	pediment pediplain complex					YLM	5	Sparsely vegetated
4	74	40	22.4	74.67	14	14	50	14.25	Gravitational	Moderately dissected					Alluvium	5	Densely vegetated
5	74	42	5.3	74.70	14	16	25.8	14.27	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
6	74	28	37.1	74.48	14	18	55.7	14.32	Gravitational	Moderately dissected	Hornblende-Actinolite Chlorite schist	Moderate				0	Densely vegetated
7	74	30	32.2	74.51	14	20	54	14.35	Gravitational	Moderately dissected	Laterite					0	Densely vegetated
8	74	32	1.1	74.53	14	19	43.2	14.33	Gravitational	Moderately dissected		Moderate	Jointed moderate	J1N20°W/78°E J2 E-W/76°S J3N45°E/46°SE	Insitu -soil	5	Densely vegetated
9	74	32	29.1	74.54	14	19	54.2	14.33	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
11	74	33	5.6	74.55	14	20	12.4	14.34	Gravitational	Moderately dissected	Laterite				Insitu -soil	5	Densely vegetated
12	74	33	47.4	74.56	14	20	41.2	14.34	Gravitational		Laterite				Insitu -soil	5	Densely vegetated
13	74	33	42.3	74.56	14	20	33.2	14.34	Gravitational	pediment pediplain complex					Insitu -soil	5	Densely vegetated
15	74	35	55.9	74.60	14	20	23.2	14.34	Gravitational	Moderately dissected					Insitu -soil	5	HHP
16	74	36	6	74.60	14	20	26.1	14.34	Gravitational	Moderately dissected					Insitu -soil	5	agriculture

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
19	74	31	14.5	74.52	14	17	57.3	14.30	Gravitational	pediment pediplain complex					YLM	5	Waste land
20	74	29	21.8	74.49	14	19	45.3	14.33	Gravitational	pediment pediplain complex					Insitu -soil	10	Waste land
21	74	29	12.8	74.49	14	19	54.7	14.33	Gravitational	pediment pediplain complex	Hornblende-Actinolite Chlorite schist	High				0	Waste land
22	74	31	13.9	74.52	14	25	48.5	14.43	Gravitational	Lowly dissected	Laterite	High				0	Densely vegetated
23	74	32	52.8	74.55	14	24	52.5	14.41	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate	J1N45°W/85°NE J2 N40°E/73°NW		0	Densely vegetated
24	74	34	48.4	74.58	14	23	15.5	14.39	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
25	74	34	57	74.58	14	23	5.2	14.38	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
27	74	33	43.8	74.56	14	14	44.7	14.25	Gravitational	pediment pediplain complex	Granite gneiss	High	Jointed moderate	J1 N35°W/30°NE J2N25°W/72°W	Insitu -soil	5	Densely vegetated
29	74	36	56.6	74.62	14	14	21.3	14.24	Gravitational	Highly dissected					Insitu -soil	5	Densely vegetated
31	74	33	53.9	74.56	14	25	17.4	14.42	Gravitational	pediment pediplain complex					YLM	5	Settlement
32	74	35	21.4	74.59	14	25	29.8	14.42	Gravitational	Lowly dissected	Grey granite	Moderate	Jointed moderate			0	HHP

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
34	74	37	58	74.63	14	26	14.1	14.44	Gravitational	Lowly dissected	Laterite	High				0	Densely vegetated
37	74	30	30.6	74.51	14	21	0.7	14.35	Gravitational	Moderately dissected					YLM	5	Settlement
38	74	30	8.3	74.50	14	20	8	14.34	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
39	74	31	0.1	74.52	14	23	13.3	14.39	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
40	74	35	3.6	74.58	14	23	1.8	14.38	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
41	74	41	37.9	74.69	14	16	19.9	14.27	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate	J1 N55°W/85°S J2 N10°E/81°W		0	Densely vegetated
42	74	41	47.1	74.70	14	16	35.8	14.28	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
43	74	41	44.7	74.70	14	16	30.6	14.28	Gravitational	Lowly dissected					YLM	5	Waste land
44	74	41	38.9	74.69	14	16	22.6	14.27	Gravitational	pediment pediplain complex					YLM	5	Waste land
45	74	31	20.2	74.52	14	16	26.2	14.27	Gravitational	pediment pediplain complex					YLM	5	HHP
46	74	31	14.2	74.52	14	16	16.6	14.27	Gravitational	pediment pediplain complex					YLM	5	HHP
47	74	30	49.5	74.51	14	15	47	14.26	Gravitational	pediment pediplain complex					YLM	5	HHP
48	74	30	41.6	74.51	14	15	36.6	14.26	Gravitational	pediment pediplain complex					YLM	10	agriculture

SLOPE FORMING MATERIAL (SFM) DATA

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
50	74	30	0.1	74.50	14	15	13.9	14.25	Gravitational	Moderately dissected					Insitu -soil	10	Sparsely vegetated
51	74	30	34	74.51	14	16	35.7	14.28	Gravitational	pediment pediplain complex					Insitu -soil	10	agriculture
52	74	31	39.1	74.53	14	16	31.4	14.28	Gravitational	pediment pediplain complex	Laterite					0	agriculture
55	74	30	55.3	74.52	14	17	5.2	14.28	Gravitational	pediment pediplain complex	Granite gneiss					0	agriculture
58	74	31	54.3	74.53	14	17	34.9	14.29	Gravitational	pediment pediplain complex					Insitu -soil	5	Waste land
59	74	32	45.2	74.55	14	17	54.8	14.30	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
60	74	33	20.1	74.56	14	18	10.4	14.30	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
61	74	33	34.4	74.56	14	18	20.6	14.31	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
62	74	34	21.1	74.57	14	18	45.5	14.31	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
63	74	34	35.7	74.58	14	19	9.4	14.32	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
64	74	35	27.5	74.59	14	19	14.7	14.32	Gravitational	Moderately dissected					Insitu -soil	5	Settlement
65	74	35	25.8	74.59	14	19	17.5	14.32	Gravitational	Moderately dissected					Insitu -soil	5	Settlement
67	74	32	42	74.55	14	16	5.1	14.27	Gravitational	Lowly dissected	Laterite					0	Densely vegetated
68	74	32	48.3	74.55	14	16	9.6	14.27	Gravitational	Lowly dissected	Laterite					0	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
69	74	32	58.9	74.55	14	16	20.5	14.27	Gravitational	Moderately dissected	Laterite					0	Densely vegetated
70	74	32	26.5	74.54	14	17	29.2	14.29	Gravitational	Moderately dissected	Laterite					0	Densely vegetated
72	74	32	49.8	74.55	14	16	59	14.28	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
73	74	32	46.7	74.55	14	16	56	14.28	Gravitational	Lowly dissected	Laterite					0	Densely vegetated
74	74	32	53.6	74.55	14	16	48.7	14.28	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
75	74	33	4.1	74.55	14	16	49.4	14.28	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
76	74	35	54.4	74.60	14	18	57.4	14.32	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
77	74	36	14.7	74.60	14	18	39.6	14.31	Gravitational	Moderately dissected					Insitu -soil	10	Settlement
78	74	36	32.1	74.61	14	18	44.2	14.31	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
79	74	36	44.9	74.61	14	18	43.2	14.31	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
80	74	35	48.7	74.60	14	14	49.5	14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate	J1 N40°W/53°S J2 N73°E/32°N		0	Densely vegetated
81	74	35	48.7	74.60	14	15	13.5	14.25	Gravitational	Moderately dissected	Granite gneiss	Moderate	Jointed moderate	J1 E-W/60°N		0	Densely vegetated
82	74	36	18.9	74.61	14	15	50.6	14.26	Gravitational	Ridge	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
83	74	36	13.5	74.60	14	16	19.3	14.27	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
84	74	35	43.2	74.60	14	16	46	14.28	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
85	74	35	28.9	74.59	14	17	20.8	14.29	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
87	74	42	52.5	74.71	14	16	50.7	14.28	Gravitational	Highly dissected					Insitu -soil	10	Densely vegetated
88	74	42	41.4	74.71	14	16	59.4	14.28	Gravitational	Highly dissected	Granite gneiss	Moderate	Jointed moderate	J1 N65°W/88°N J2 N30°E/80°E		0	Densely vegetated
90	74	42	22.4	74.71	14	17	13	14.29	Gravitational	Highly dissected	Granite gneiss	Moderate	Jointed moderate	J1N65°W/73°N J2N15°W/Subv.		0	Densely vegetated
91	74	42	10.8	74.70	14	17	18.6	14.29	Gravitational	Highly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
93	74	41	44.9	74.70	14	17	33.8	14.29	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
94	74	37	4.1	74.62	14	14	58.1	14.25	Gravitational	Escarpment	Granite gneiss	High	Jointed moderate	J1 N65°W/85°N J2 N35°E/58°S J3 N45°E/73°W		0	Densely vegetated
95	74	37	8.7	74.62	14	15	13	14.25	Gravitational	Moderately dissected	Granite gneiss	High	Jointed moderate			0	Densely vegetated
96	74	37	39.3	74.63	14	16	17.4	14.27	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
97	74	37	55.7	74.63	14	16	33.8	14.28	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
98	74	38	13.9	74.64	14	16	47.2	14.28	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
99	74	38	24.8	74.64	14	16	43.1	14.28	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
100	74	38	50.1	74.65	14	16	49.4	14.28	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
101	74	38	57.8	74.65	14	16	56.5	14.28	Gravitational	Highly dissected	Quartzite	Low to fresh	Jointed moderate	J1 N70°E/Subv. J2 N50°W/Subv.		0	Densely vegetated
102	74	42	57.3	74.72	14	16	48.1	14.28	Gravitational	Highly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
105	74	40	50.3	74.68	14	17	13.3	14.29	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
112	74	38	59.8	74.65	14	15	41.6	14.26	Gravitational	Moderately dissected	Granite gneiss	Moderate	Jointed moderate	J1 N-S/54°E J2 N65°W/Subv.		0	Densely vegetated
113	74	39	7.4	74.65	14	15	40	14.26	Gravitational	Moderately dissected	Granite gneiss	High	Jointed moderate			0	Densely vegetated
114	74	39	6.1	74.65	14	15	55.8	14.27	Gravitational	pediment pediplain complex	Laterite					0	agriculture
115	74	38	50.7	74.65	14	15	35.1	14.26	Gravitational	pediment pediplain complex					Insitu -soil	5	Sparsely vegetated
116	74	33	12.2	74.55	14	14	51	14.25	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
116a	74	34	28.1	74.57	14	14	47.7	14.25	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
117	74	34	35.3	74.58	14	15	1.9	14.25	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
118	74	34	33.1	74.58	14	15	4	14.25	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
119	74	34	27.5	74.57	14	15	6.2	14.25	Gravitational	Moderately dissected	Laterite					0	Densely vegetated
120	74			74.58	14			14.25	Gravitational	Ridge	Laterite					0	Densely vegetated
121	74			74.58	14			14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
122	74			74.59	14			14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
123	74			74.62	14			14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
124	74			74.66	14			14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed high	J1 N50°E/88°S J2 N40°W/80°W J3 N80°W/20°N		0	Densely vegetated
125	74			74.66	14			14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
127	74			74.66	14			14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
128	74			74.67	14			14.25	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
130	74			74.67	14			14.26	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
136	74	41	26.5	74.69	14	16	10	14.27	Gravitational	Moderately dissected	Granite gneiss	Moderate	Jointed moderate	J1 E-W/85°S		0	Densely vegetated
137	74	41	34.9	74.69	14	16	7.2	14.27	Gravitational	Moderately dissected	Granite gneiss	Moderate	Jointed moderate	J1 E-W/78°S J2 N-S/83°W		0	Densely vegetated
139	74	41	55.5	74.70	14	16	24	14.27	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
140	74	42	28.3	74.71	14	16	28.5	14.27	Gravitational	Lowly dissected	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
158	74	43	38	74.73	14	16	52.5	14.28	Gravitational	Moderately dissected	Laterite					0	Densely vegetated
159	74	43	41.3	74.73	14	16	58.5	14.28	Gravitational	Ridge	Laterite					0	Densely vegetated
160	74	43	42	74.73	14	17	3.4	14.28	Gravitational	Ridge	Laterite					0	Densely vegetated
161	74	43	46.9	74.73	14	17	4.9	14.28	Gravitational	Lowly dissected	Laterite					0	Densely vegetated
163	74	43	59.7	74.73	14	17	11.3	14.29	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
164	74	44	4.9	74.73	14	17	18.5	14.29	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
165	74	44	15.1	74.74	14	17	18.3	14.29	Gravitational	pediment pediplain complex					Insitu -soil	5	Densely vegetated
166	74	30	18.7	74.51	14	22	25.1	14.37	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
167	74	30	20.6	74.51	14	22	19.8	14.37	Gravitational	Lowly dissected					Insitu -soil	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
169	74	30	36.8	74.51	14	22	19.8	14.37	Gravitational	Lowly dissected					Insitu -soil	5	Densely vegetated
171	74	30	53.4	74.51	14	22	22.3	14.37	Gravitational	Lowly dissected	Granitoid	Moderate	Fractured			0	agriculture
172	74	30	57.2	74.52	14	22	14	14.37	Gravitational	Lowly dissected	Granitoid	Moderate	Fractured			0	Densely vegetated
173	74	31	2	74.52	14	22	14.1	14.37	Gravitational	Lowly dissected	Granitoid	Moderate	Fractured			0	Densely vegetated
174	74	31	5.3	74.52	14	22	18.4	14.37	Gravitational	Lowly dissected	Granitoid	Moderate	Fractured		YLM	5	Densely vegetated
175	74	30	54.7	74.52	14	22	25	14.37	Gravitational	pediment pediplain complex	Granitoid	Moderate	Fractured		YLM	5	Settlement
176	74	30	52.2	74.51	14	22	42.2	14.38	Gravitational	pediment pediplain complex	Granitoid	Moderate	Fractured		YLM	5	Densely vegetated
177	74	30	51.6	74.51	14	22	47.7	14.38	Gravitational	pediment pediplain complex	Granitoid	Moderate	Fractured		YLM	5	agriculture
178	74	30	59.8	74.52	14	22	52.9	14.38	Gravitational	pediment pediplain complex	Granitoid	Moderate	Fractured		YLM	5	Settlement
179	74	31	11	74.52	14	22	56.6	14.38	Gravitational	pediment pediplain complex	Grey granite	Moderate	Fractured			0	agriculture
180	74	31	22.3	74.52	14	22	49.1	14.38	Gravitational	Lowly dissected	Grey granite	Moderate	Fractured			0	Densely vegetated
181	74	31	28	74.52	14	22	42.4	14.38	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
182	74	31	33.9	74.53	14	22	30.9	14.38	Gravitational	pediment pediplain complex					Insitu -soil	5	Densely vegetated

SLOPE FORMING MATERIAL (SFM) DATA

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
184	74	31	17.4	74.52	14	23	16.6	14.39	Gravitational	pediment pediplain complex					Insitu -soil	5	Densely vegetated
185	74	31	16.5	74.52	14	23	11.1	14.39	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
186	74	31	39.4	74.53	14	23	34.6	14.39	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate	J1 N40°E/59°W J2 E-W/64°N		0	Densely vegetated
187	74	31	49.9	74.53	14	23	35.8	14.39	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
188	74	31	56.8	74.53	14	23	40	14.39	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
189	74	31	54.5	74.53	14	23	31.8	14.39	Gravitational	pediment pediplain complex					YLM	5	agriculture
190	74	31	52.7	74.53	14	23	29.5	14.39	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
191	74	31	35.9	74.53	14	23	43	14.40	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
192	74	31	22.8	74.52	14	23	54.7	14.40	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
193	74	31	12.7	74.52	14	23	53.3	14.40	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
194	74	31	1.8	74.52	14	23	56.5	14.40	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
196	74	30	50	74.51	14	23	56.4	14.40	Gravitational	pediment pediplain complex					YLM	5	agriculture
197	74	31	3.3	74.52	14	24	5.5	14.40	Gravitational	pediment pediplain complex					YLM	5	agriculture
198	74	31	6.7	74.52	14	20	9.9	14.34	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
199	74	32	0.8	74.53	14	24	25.3	14.41	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
200	74	32	9.6	74.54	14	24	20.3	14.41	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
201	74	32	15.3	74.54	14	24	22.2	14.41	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
202	74	33	11.8	74.55	14	24	57.4	14.42	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
203	74	33	8.4	74.55	14	24	53.6	14.41	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
204	74	32	22.6	74.54	14	25	50.8	14.43	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate	J1 N25°W/78°W		0	Densely vegetated
205	74	32	18.9	74.54	14	25	57.3	14.43	Gravitational	Lowly dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
206	74	32	14.8	74.54	14	25	58.6	14.43	Gravitational	Lowly dissected					Alluvium	5	Densely vegetated
207	74	32	10.2	74.54	14	26	2.1	14.43	Gravitational	pediment pediplain complex	Grey granite	Moderate				0	plantation
208	74	32	19.8	74.54	14	26	15.8	14.44	Gravitational	Moderately dissected	Grey granite	Moderate				0	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
210	74	34	6.6	74.57	14	24	48.4	14.41	Gravitational	pediment pediplain complex					Insitu -soil	5	Densely vegetated
211	74	33	51.6	74.56	14	24	40.4	14.41	Gravitational	pediment pediplain complex					Insitu -soil	5	Densely vegetated
212	74	33	44.5	74.56	14	24	41.8	14.41	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
213	74	34	15.1	74.57	14	24	48.1	14.41	Gravitational	pediment pediplain complex					YLM	5	agriculture
214	74	34	22.5	74.57	14	24	46.4	14.41	Gravitational	pediment pediplain complex					YLM	5	Settlement
215	74	34	37.6	74.58	14	25	17.4	14.42	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
216	74	34	32.9	74.58	14	25	29.2	14.42	Gravitational	pediment pediplain complex					YLM	5	Moderately vegetated
217	74	34	41.4	74.58	14	24	35.2	14.41	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Moderately vegetated
218	74	34	34.8	74.58	14	24	17.5	14.40	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Moderately vegetated
219	74	34	24.4	74.57	14	24	4.8	14.40	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
221	74	34	44.3	74.58	14	24	40.2	14.41	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Quarry
222	74	34	53.4	74.58	14	24	41.5	14.41	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate	J1 N25°E/80°W		0	Densely vegetated
223	74			74.00	14			14.00	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate	J1 N70°W/83°S J2 N15°E/Subv.		0	Densely vegetated
224	74	34	51.5	74.58	14	24	22.6	14.41	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
225	74	34	20.7	74.57	14	23	54.4	14.40	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
226	74	35	10.7	74.59	14	25	18	14.42	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate	J1 N-S/54°E J2 N65°E/47°S		0	Densely vegetated
227	74	35	6.1	74.59	14	25	12.3	14.42	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
228	74	35	3.9	74.58	14	25	7.6	14.42	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
229	74	35	30.4	74.59	14	25	27.1	14.42	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
230	74	35	44.1	74.60	14	25	2.2	14.42	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
231	74	35	46.5	74.60	14	24	56.5	14.42	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
232	74	35	40.7	74.59	14	24	53.4	14.41	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
233	74	35	39.6	74.59	14	25	2.3	14.42	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated

SLOPE FORMING MATERIAL (SFM) DATA

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
235	74	35	31	74.59	14	25	4	14.42	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated
236	74	35	53.8	74.60	14	25	18.7	14.42	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate	J1 N10°W/Subv J2 N25°E/78°W		0	Densely vegetated
237	74	36	2.6	74.60	14	24	58.1	14.42	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
238	74	34	49.6	74.58	14	24	34	14.41	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
239	74	35	44.1	74.60	14	24	29.7	14.41	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate	J1 N20W/Subv. J2 N65E/Subv.		0	Densely vegetated
240	74	35	43.4	74.60	14	24	24.8	14.41	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
241	74	35	43.6	74.60	14	24	21.4	14.41	Gravitational	Moderately dissected	Grey granite	Moderate	Jointed moderate			0	agriculture
242	74	35	39.9	74.59	14	24	19.4	14.41	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
243	74	36	0	74.60	14	24	43.5	14.41	Gravitational	Highly dissected					Insitu -soil	5	Densely vegetated
244	74	37	53.9	74.63	14	26	19.6	14.44	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate	J1 N30W/Subv.		0	Densely vegetated
245	74	38	34.1	74.64	14	26	6.2	14.44	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate	J1 N65E/Subv.		0	agriculture
246	74	38	32.1	74.64	14	25	41.8	14.43	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate			0	agriculture
247	74			74.00	14			14.00	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate	J1 E-W/ Subv. J2 N5W/10°W		0	agriculture
248	74	38	50.8	74.65	14	24	43.3	14.41	Gravitational	Highly dissected	Grey granite	Moderate	Jointed moderate			0	agriculture
249	74	39	13.6	74.65	14	24	34.7	14.41	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
251	74	39	28.3	74.66	14	24	33.6	14.41	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
252	74	39	38.6	74.66	14	24	2.2	14.40	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
253	74	39	34.2	74.66	14	23	49.9	14.40	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
257	74	30	6.5	74.50	14	19	48.1	14.33	Gravitational	pediment pediplain complex					Insitu -soil	5	Sparsely vegetated
258	74	30	15.4	74.50	14	19	50.7	14.33	Gravitational	pediment pediplain complex					Insitu -soil	5	Sparsely vegetated
259	74	30	30.2	74.51	14	19	24.2	14.32	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
260	74	30	32.4	74.51	14	19	20	14.32	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
261	74	30	44.1	74.51	14	19	13.9	14.32	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
262	74	30	36.5	74.51	14	19	52.5	14.33	Gravitational	Moderately dissected	Granite gneiss	High	Jointed moderate	J1 N30°W/34°E		0	Densely vegetated
263	74	33	34.7	74.56	14	20	40.1	14.34	Gravitational	Moderately dissected	Granite gneiss	High	Jointed moderate			0	Densely vegetated
264	74	35	58.4	74.60	14	20	43.7	14.35	Gravitational	pediment pediplain complex	Granite gneiss	Moderate	Jointed moderate			0	Densely vegetated
265	74	35	59.1	74.60	14	20	55.7	14.35	Gravitational	Moderately dissected	Granite gneiss	Moderate	Jointed moderate		Insitu -soil	5	agriculture
266	74	36	5.4	74.60	14	21	6.1	14.35	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
267	74	36	8.3	74.60	14	21	20.9	14.36	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
269	74	39	48.9	74.66	14	23	34.6	14.39	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
270	74	39	44	74.66	14	23	31.1	14.39	Gravitational	pediment pediplain complex					YLM	5	agriculture
271	74	39	54.1	74.67	14	23	23.3	14.39	Gravitational	pediment pediplain complex	Grey granite	Moderate	Jointed moderate			0	Densely vegetated
272	74	39	46.3	74.66	14	23	21.1	14.39	Gravitational	pediment pediplain complex					YLM	5	Settlement
273	74	30	24.8	74.51	14	26	33.9	14.44	Gravitational	pediment pediplain complex	Grey granite	High	Jointed moderate			0	agriculture
274	74	31	10.7	74.52	14	26	14	14.44	Gravitational	pediment pediplain complex	Grey granite	High	Jointed moderate			0	agriculture
275	74	32	0.2	74.53	14	26	6.1	14.44	Gravitational	Lowly dissected					Alluvium	5	Settlement
276	74	31	30.7	74.53	14	24	45.6	14.41	Gravitational	Moderately dissected					Alluvium	5	Densely vegetated
277	74	30	18.9	74.51	14	24	25.3	14.41	Gravitational	Moderately dissected					Alluvium	5	Densely vegetated
278	74	32	53.6	74.55	14	25	42.6	14.43	Gravitational	Moderately dissected					Alluvium	5	Densely vegetated
279	74	36	15	74.60	14	21	39.9	14.36	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
282	74	36	24	74.61	14	22	7.4	14.37	Gravitational	pediment pediplain complex					YLM	5	agriculture
283	74	36	29.3	74.61	14	22	13.9	14.37	Gravitational	pediment pediplain complex					YLM	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
285	74	36	42.1	74.61	14	22	25.1	14.37	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
286	74	36	50.3	74.61	14	22	37.7	14.38	Gravitational	Moderately dissected					Insitu -soil	5	HHP
287	74	36	18.5	74.61	14	25	34.4	14.43	Gravitational	Moderately dissected					Insitu -soil	5	HHP
288	74	36	20.6	74.61	14	25	27.4	14.42	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
289	74	36	17.7	74.60	14	25	23.9	14.42	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
290	74	39	31.7	74.66	14	23	48.1	14.40	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
291	74	39	23.3	74.66	14	23	44.1	14.40	Gravitational	Moderately dissected	Laterite					0	Densely vegetated
292	74	39	7.6	74.65	14	23	39.1	14.39	Gravitational	Highly dissected	Laterite					0	Densely vegetated
293	74	38	56.2	74.65	14	23	36.3	14.39	Gravitational	Moderately dissected	Laterite					0	agriculture
294	74	38	35.8	74.64	14	23	17.5	14.39	Gravitational	Moderately dissected					YLM	5	agriculture
295	74	38	9.2	74.64	14	23	12.8	14.39	Gravitational	Lowly dissected	Grey granite	High	Jointed moderate			0	Densely vegetated
296	74	37	58.9	74.63	14	23	0.9	14.38	Gravitational	Lowly dissected	Grey granite	High	Jointed moderate			0	agriculture
297	74	37	39.5	74.63	14	23	2.9	14.38	Gravitational	Moderately dissected	Grey granite	High	Jointed moderate			0	agriculture
298	74	37	3.3	74.62	14	25	39.9	14.43	Gravitational	Moderately dissected	Grey granite	High	Jointed moderate			0	agriculture
299	74	36	57.4	74.62	14	25	27.2	14.42	Gravitational	Moderately dissected					Insitu -soil	5	agriculture

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
301	74	36	59.5	74.62	14	24	24.2	14.41	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
302	74	37	0.5	74.62	14	24	18	14.41	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
303	74	37	2.7	74.62	14	24	15.4	14.40	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
304	74	37	5.3	74.62	14	24	8.7	14.40	Gravitational	pediment pediplain complex					Insitu -soil	5	agriculture
305	74	37	4.8	74.62	14	23	55	14.40	Gravitational	pediment pediplain complex					Insitu -soil	5	Densely vegetated
306	74	37	3.1	74.62	14	23	50.8	14.40	Gravitational	Highly dissected	Laterite					0	Densely vegetated
307	74	30	37.9	74.51	14	19	56.5	14.33	Gravitational	Highly dissected	Laterite					0	Densely vegetated
308	74	30	33.8	74.51	14	20	2.9	14.33	Gravitational	Highly dissected	Laterite					0	agriculture
309	74	30	34.4	74.51	14	20	8.2	14.34	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
310	74	30	42.5	74.51	14	19	58.5	14.33	Gravitational	Moderately dissected					Insitu -soil	5	agriculture
311	74	36	7.7	74.60	14	20	31.1	14.34	Gravitational	Moderately dissected					Insitu -soil	5	HHP
312	74	36	10.8	74.60	14	20	31.2	14.34	Gravitational	Moderately dissected					Insitu -soil	5	HHP
313	74	36	13.3	74.60	14	20	31	14.34	Gravitational	Moderately dissected					Insitu -soil	5	HHP
314	74	36	19.1	74.61	14	20	35	14.34	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated

Lo no.	Longitude			Decimal	Latitude			Decimal	Geomorphological process	Geomorphological form	Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Overburden type	Overburden thickness	Landuse type
316	74	36	34.8	74.61	14	20	32.8	14.34	Gravitational	Lowly dissected					Insitu -soil	5	Densely vegetated
317	74	36	46.6	74.61	14	20	25.2	14.34	Gravitational	Lowly dissected					Insitu -soil	5	Densely vegetated
318	74	36	49.5	74.61	14	20	18	14.34	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
319	74	36	56.2	74.62	14	20	14.5	14.34	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
320	74	37	21.4	74.62	14	20	19.1	14.34	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
321	74	37	6.3	74.62	14	20	17.1	14.34	Gravitational	Rolling plain					Insitu -soil	5	Densely vegetated
322	74	37	0.2	74.62	14	20	14.5	14.34	Gravitational	Rolling plain					Insitu -soil	5	Densely vegetated
323	74	37	9.3	74.62	14	20	18.3	14.34	Gravitational	Rolling plain					Insitu -soil	5	Densely vegetated
324	74	37	58.6	74.63	14	20	21.4	14.34	Gravitational	Rolling plain					Insitu -soil	5	Densely vegetated
325	74	38	20.5	74.64	14	20	27.6	14.34	Gravitational	Rolling plain					Insitu -soil	5	Densely vegetated
326	74	38	59.2	74.65	14	20	34.7	14.34	Gravitational	Rolling plain					Insitu -soil	5	agriculture
327	74	39	22.3	74.66	14	20	50.9	14.35	Gravitational	Rolling plain					Insitu -soil	5	Densely vegetated
328	74	39	41.2	74.66	14	21	6.5	14.35	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
329	74	39	53.8	74.66	14	21	28.4	14.36	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
330	74	40	30.3	74.68	14	22	16	14.37	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated
331	74	32	24.3	74.54	14	20	11.2	14.34	Gravitational	Moderately dissected					Insitu -soil	5	Densely vegetated

Loc	X	Y	TS	Vill	Geomorphic Process	GeomForm	Rock	Weathering	RockCharter	DipJ3	Loc	Overburden Type	Thickness	Landuse
1a	14.41722222	74.54722222	48J/11	Devalli	Fluvial	Low Dissected Slope					1a	In-Situ Soil	0.5-5m	Densely Vegetated
2a	14.42305556	74.565	48J/11		Fluvial	Low Dissected Slope	Schist?	High	Sheared		2a			Densely Vegetated
2b	14.42305556	74.565	48J/11		Fluvial	Low Dissected Slope	Schist?	High	Sheared		2b			Densely Vegetated
3a	14.42833333	74.60416667	48J/11		Fluvial	Low Dissected Slope	Schist?	High	Sheared		3a			Densely Vegetated
3b	14.43055556	74.60861111	48J/11		Fluvial	Low Dissected Slope	Schist?	Low			3b			Densely Vegetated
4a	14.44	74.63472222	48J/11		Fluvial	Low Dissected Slope	Schist?	Moderate	Sheared		4a			Densely Vegetated
5a	14.42277778	74.64	48J/11		Fluvial	Low Dissected Slope	Granite	Low			5a			Densely Vegetated
5b	14.42277778	74.64	48J/11		Fluvial	Low Dissected Slope					5b	In-Situ Soil	0.5-5m	Moderately Vegetated
6a	14.41	74.65166667	48J/11		Fluvial	moderately dissected slope	schist?	Low	Sheared		6a			Densely Vegetated
7a	14.39708333	74.66433333	48J/11		Fluvial	moderately dissected slope					7a	In-Situ Soil	5-10m	Densely Vegetated
8a	14.38388889	74.675	48J/11	Hosalli	Fluvial	Low Dissected Slope	Schist?	High	Sheared		8a			Densely Vegetated
9a	14.36	74.70055556	48J/11	Kible	Fluvial	Low Dissected Slope					9a	In-Situ Soil	5-10m	Densely Vegetated
9b	14.37111111	74.69194444	48J/11		Fluvial	Low Dissected Slope					9b	In-Situ Soil	0.5-5m	Densely Vegetated
10a	14.35666667	74.71277778	48J/11	Madlamana	Fluvial	Low Dissected Slope	Schist?	Moderate	Sheared		10a			Densely Vegetated
11a	14.35694444	74.72861111	48J/11		Fluvial	Low Dissected Slope					11a	In-Situ Soil	0.5-5m	Densely Vegetated
12a	14.36055556	74.74083333	48J/11		Fluvial	moderately dissected slope					12a	In-Situ Soil	5-10m	Densely Vegetated
13a	14.37444444	74.73722222	48J/11		Fluvial	moderately dissected slope					13a	In-Situ Soil	0.5-5m	Densely Vegetated
14a	14.49305556	74.72277778	48J/11	Shiragim	Fluvial	Low Dissected Slope					14a	In-Situ Soil	0.5-5m	Densely Vegetated
15	14.47833333	74.71194444	48J/11		Fluvial	Low Dissected Slope					15	In-Situ Soil	0.5-5m	Densely Vegetated
16	14.45805556	74.70016667	48J/11		Fluvial	Low Dissected Slope					16	In-Situ Soil	0.5-5m	Densely Vegetated
17	14.45055556	74.71472222	48J/11		Fluvial	Low Dissected Slope					17	In-Situ Soil	0.5-5m	Densely Vegetated
18	14.44027778	74.73	48J/11	Vajagara	Fluvial	Low Dissected Slope					18	In-Situ Soil	0.5-5m	Densely Vegetated
19	14.41361111	74.74555556	48J/11		Fluvial	Low Dissected Slope					19	In-Situ Soil	5-10m	Densely Vegetated
20	14.42472222	74.74222222	48J/11		Fluvial	Low Dissected Slope					20	In-Situ Soil	5-10m	Densely Vegetated
21	14.48833333	74.73722222	48J/11		Fluvial	Low Dissected Slope					21	In-Situ Soil	0.5-5m	Densely Vegetated
22	14.47583333	74.73916667	48J/11		Fluvial	Low Dissected Slope					22	In-Situ Soil	5-10m	Densely Vegetated
23	14.46277778	74.73444444	48J/11		Fluvial	Low Dissected Slope					23	In-Situ Soil	0.5-5m	Densely Vegetated
24	14.42138889	74.72	48J/11		Fluvial	Low Dissected Slope					24	In-Situ Soil	0.5-5m	Densely Vegetated
25	14.43277778	74.71472222	48J/11		Fluvial	Low Dissected Slope					25	In-Situ Soil	0.5-5m	Densely Vegetated
26	14.42916667	74.69805556	48J/11		Fluvial	Low Dissected Slope					26	In-Situ Soil	0.5-5m	Densely Vegetated
27	14.42583333	74.68527778	48J/11		Fluvial	Low Dissected Slope					27	In-Situ Soil	0.5-5m	Densely Vegetated
28	14.44083333	74.70611111	48J/11		Fluvial	Low Dissected Slope					28	In-Situ Soil	0.5-5m	Densely Vegetated
29	14.49333333	74.70305556	48J/11		Fluvial	Low Dissected Slope					29	In-Situ Soil	5-10m	Densely Vegetated
30	14.49472222	74.67472222	48J/11		Fluvial	Low Dissected Slope					30	In-Situ Soil	0.5-5m	Densely Vegetated
31	14.44861111	74.60555556	48J/11		Fluvial	Low Dissected Slope	Granite	Low	Massive		31			Densely Vegetated

Hydrology	Erosion	Susceptibility	Risk
wet	Toe Erosion by nala	Meta-Stable	Absent
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Absent
Damp	Toe Erosion by nala	Stable	Absent
Damp	Toe Erosion by nala	Meta-Stable	Absent
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Absent
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Damp	Toe Erosion by nala	Meta-Stable	Moderate
Dry		Stable	Absent
Damp	Toe Erosion by nala	Stable	Absent
Damp	Toe Erosion by nala	Stable	Absent
Damp	Toe Erosion by nala	Stable	Absent
Damp		Stable	Absent
Damp		Meta-Stable	Moderate
Damp		Meta-Stable	Moderate
Damp		Stable	Absent
Damp		Meta-Stable	Moderate
Damp		Stable	Absent
Damp		Meta-Stable	Moderate
Damp		Stable	Absent
Damp		Meta-Stable	Moderate
Damp		Meta-Stable	Moderate
Damp		Meta-Stable	Moderate
Damp		Meta-Stable	Moderate
Damp		Meta-Stable	Moderate
Damp		Meta-Stable	Moderate

Location No.	Toposheet No.	Slide No.	Locality/Village Name/NH/SH	Latitude			Longitude			Length (m)	width (m)	Height(m)	Run out distance(m)	Location No.	Geomorphological process	Geomorphological form
AKS/UK/2014/10	48J/11	KAR/UK/48J/11/2014/01	Darbejeddi	14	19	55.4	74	32	45.1	15	5	1.5	2	AKS/UK/2014/10	Gravitational	Transportational mid slope
AKS/UK/2014/14	48J/11	KAR/UK/48J/11/2014/02	Chikkoli	14	20	16.5	74	34	1.3	15	4	1	2	AKS/UK/2014/14	Gravitational	Transportational mid slope
AKS/UK/2014/26	48J/11	KAR/UK/48J/11/2014/03	Hadinbail	14	17	10.4	74	30	40.6	60	10	2		AKS/UK/2014/26	Gravitational	Piedmont slope
AKS/UK/2014/28	48J/11	KAR/UK/48J/11/2014/04	NH206	14	14	43.6	74	34	37.6	5	12	1	1	AKS/UK/2014/28	Gravitational	Transportational mid slope
AKS/UK/2014/30	48J/11	KAR/UK/48J/11/2014/05	NH206	14	16	34.5	74	43	14.4	5	12	1	1	AKS/UK/2014/30	Gravitational	Transportational mid slope
AKS/UK/2014/35	48J/11	KAR/UK/48J/11/2014/06	near Karikan Parmeshwari temple	14	20	59.8	74	30	30.1	10.5	30	0.5	1	AKS/UK/2014/35	Gravitational	Transportational mid slope
AKS/UK/2014/36	48J/11	KAR/UK/48J/11/2014/07	Karikan Parmeshwari temple	14	21	0.7	74	30	26.1	15	25	0.5		AKS/UK/2014/36	Gravitational	Transportational mid slope
AKS/UK/2014/53	48J/11	KAR/UK/48J/11/2014/08	NH206	14	16	31.4	74	31	39.1	15	59	0.5		AKS/UK/2014/53	Gravitational	Transportational mid slope
AKS/UK/2014/54	48J/11	KAR/UK/48J/11/2014/09	NH206	14	14	53.3	74	39	11.4	7	19.6	0.5		AKS/UK/2014/54	Gravitational	Transportational mid slope
AKS/UK/2014/56	48J/11	KAR/UK/48J/11/2014/10	Road section near Gundibail	14	17	1.8	74	31	14.8	15	38.3	1	1	AKS/UK/2014/56	Gravitational	Transportational mid slope
AKS/UK/2014/66	48J/11	KAR/UK/48J/11/2014/11	Katchha road near Dibbangal	14	15	50.8	74	32	24.4	7	8.9	0.5		AKS/UK/2014/66	Gravitational	Denudational hill slope
AKS/UK/2014/71	48J/11	KAR/UK/48J/11/2014/12	Road section near Heravalli	14	17	19.4	74	32	32.2	7	7	0.5		AKS/UK/2014/71	Gravitational	Transportational mid slope
AKS/UK/2014/92	48J/11	KAR/UK/48J/11/2014/13	Road section near Mettinagadde	14	17	26.6	74	42	3.7	5	60	0.5		AKS/UK/2014/92	Gravitational	Transportational mid slope
AKS/UK/2014/103	48J/11	KAR/UK/48J/11/2014/14	road section near Sasiguli	14	17	19.8	74	41	35.9	10	17.8	1		AKS/UK/2014/103	Gravitational	Transportational mid slope
AKS/UK/2014/104	48J/11	KAR/UK/48J/11/2014/15	road section near Sasiguli	14	17	17.6	74	41	29.4	12	47.1	1		AKS/UK/2014/104	Gravitational	Transportational mid slope
AKS/UK/2014/106	48J/11	KAR/UK/48J/11/2014/16	Sasiguli village	14	17	35.2	74	41	47.6	10	52	1	2	AKS/UK/2014/106	Gravitational	Transportational mid slope
AKS/UK/2014/107	48J/11	KAR/UK/48J/11/2014/17	Hulgibail	14	17	30.4	74	41	42.3	8	61.5	0.5	2	AKS/UK/2014/107	Gravitational	Transportational mid slope
AKS/UK/2014/108	48J/11	KAR/UK/48J/11/2014/18	Hulgibail	14	17	17.7	74	41	32.9	9	42.7	0.5	2	AKS/UK/2014/108	Gravitational	Transportational mid slope
AKS/UK/2014/109	48J/11	KAR/UK/48J/11/2014/19	Sasiguli village	14	17	14.1	74	41	10.7	10	22.6	1	2	AKS/UK/2014/109	Gravitational	Transportational mid slope
AKS/UK/2014/110	48J/11	KAR/UK/48J/11/2014/20	Gerusoppa	14	15	23.3	74	40	16.4	12.3	35	1		AKS/UK/2014/110	Gravitational	Transportational mid slope

Location No.	Toposheet No.	Slide No.	Locality/Village Name/NH/SH	Latitude			Longitude			Length (m)	width (m)	Height(m)	Run out distance(m)	Location No.	Geomorphological process	Geomorphological form
AKS/UK/2014/131	48J/11	KAR/UK/48J/11/2014/21	Gerusoppa	14	15	32.3	74	40	17.3	10.5	19	0.5		AKS/UK/2014/131	Gravitational	Transportational mid slope
AKS/UK/2014/132	48J/11	KAR/UK/48J/11/2014/22	Nh206	14	16	3.3	74	40	48.2	12	45.7	1		AKS/UK/2014/132	Gravitational	Transportational mid slope
AKS/UK/2014/133	48J/11	KAR/UK/48J/11/2014/23	Nh206	14	16	15.5	74	41	15.7	15	33.9	1		AKS/UK/2014/133	Gravitational	Transportational mid slope
AKS/UK/2014/134	48J/11	KAR/UK/48J/11/2014/24	NH206 Mastimane	14	16	9	74	41	1.8	9.7	27	0.5	1	AKS/UK/2014/134	Gravitational	Transportational mid slope
AKS/UK/2014/135	48J/11	KAR/UK/48J/11/2014/25	NH206 Mastimane	14	16	27.5	74	41	56.6	9.5	68.7	1		AKS/UK/2014/135	Gravitational	Transportational mid slope
AKS/UK/2014/138	48J/11	KAR/UK/48J/11/2014/26	NH206	14	16	28.9	74	42	30.6	10.7	22.1	0.5		AKS/UK/2014/138	Gravitational	Transportational mid slope
AKS/UK/2014/141	48J/11	KAR/UK/48J/11/2014/27	NH 206 Shiva temple	14	16	28.9	74	42	30.6	8.3	17.3	0.5		AKS/UK/2014/141	Gravitational	Transportational mid slope
AKS/UK/2014/142	48J/11	KAR/UK/48J/11/2014/28	NH206	14	16	7.5	74	41	3.2	10	22.1	0.5		AKS/UK/2014/142	Gravitational	Transportational mid slope
AKS/UK/2014/143	48J/11	KAR/UK/48J/11/2014/29	NH206	14	16	16.3	74	41	28.4	10.4	36.8	1		AKS/UK/2014/143	Gravitational	Transportational mid slope
AKS/UK/2014/144	48J/11	KAR/UK/48J/11/2014/30	NH206	14	16	26.4	74	41	52.6	8.9	27.6	0.5		AKS/UK/2014/144	Gravitational	Transportational mid slope
AKS/UK/2014/145	48J/11	KAR/UK/48J/11/2014/31	NH206	14	16	45.6	74	42	56.1	8.8	16.3	0.5		AKS/UK/2014/145	Gravitational	Transportational mid slope
AKS/UK/2014/147	48J/11	KAR/UK/48J/11/2014/32	NH206	14	16	37.6	74	43	11.4	9.7	24.7	0.5		AKS/UK/2014/147	Gravitational	Transportational mid slope
AKS/UK/2014/148	48J/11	KAR/UK/48J/11/2014/33	NH206	14	16	31.6	74	43	38.1	10.3	25	0.5		AKS/UK/2014/148	Gravitational	Transportational mid slope
AKS/UK/2014/149	48J/11	KAR/UK/48J/11/2014/34	NH206	14	16	37.6	74	43	47.7	11	16.9	0.5		AKS/UK/2014/149	Gravitational	Transportational mid slope
AKS/UK/2014/150	48J/11	KAR/UK/48J/11/2014/35	NH206	14	16	24.0	74	42	9.8	16.7	51	0.5		AKS/UK/2014/150	Gravitational	Transportational mid slope
AKS/UK/2014/151	48J/11	KAR/UK/48J/11/2014/36	NH206	14	16	47.7	74	43	0.9	11.2	12	0.5		AKS/UK/2014/151	Gravitational	Transportational mid slope
AKS/UK/2014/152	48J/11	KAR/UK/48J/11/2014/37	NH206	14	16	32.6	74	43	18.7	11.3	37.3	0.5		AKS/UK/2014/152	Gravitational	Transportational mid slope

Location No.	Toposheet No.	Slide No.	Locality/Village Name/NH/SH	Latitude			Longitude			Length (m)	width (m)	Height(m)	Run out distance(m)	Location No.	Geomorphological process	Geomorphological form
AKS/UK/2014/153	48J/11	KAR/UK/48J/11/2014/38	NH206	14	16	30.4	74	43	55.3	14.7	62.5	1		AKS/UK/2014/153	Gravitational	Transportational mid slope
AKS/UK/2014/154	48J/11	KAR/UK/48J/11/2014/39	NH206	14	16	40.5	74	44	3.4	14	10	0.5		AKS/UK/2014/154	Gravitational	Transportational mid slope
AKS/UK/2014/155	48J/11	KAR/UK/48J/11/2014/40	NH206	14	16	39.4	74	44	13.7	12	15.7	1		AKS/UK/2014/155	Gravitational	Transportational mid slope
AKS/UK/2014/156	48J/11	KAR/UK/48J/11/2014/41	NH206	14	16	37.6	74	44	16.2	8	10	0.5		AKS/UK/2014/156	Gravitational	Transportational mid slope
AKS/UK/2014/161	48J/11	KAR/UK/48J/11/2014/42	NH206	14	17	4.9	74	43	46.9	8	4	0.5		AKS/UK/2014/161	Gravitational	Transportational mid slope
AKS/UK/2014/254	48J/11	KAR/UK/48J/11/2014/43	SH48	14	23	48.8	74	39	51.2	13	41.8	0.5		AKS/UK/2014/254	Gravitational	Transportational mid slope
AKS/UK/2014/255	48J/11	KAR/UK/48J/11/2014/44	SH48	14	23	50.4	74	39	57.0	8.8	21.2	0.5		AKS/UK/2014/255	Gravitational	Transportational mid slope
AKS/UK/2014/266	48J/11	KAR/UK/48J/11/2014/45	SH48	14	23	49.7	74	39	59.3	70	34.2	1		AKS/UK/2014/266	Gravitational	Transportational mid slope
AKS/UK/2014/280	48J/11	KAR/UK/48J/11/2014/47	SH48	14	23	31.1	74	39	44.0	15	80	0.5		AKS/UK/2014/280	Gravitational	Transportational mid slope
AKS/UK/2014/281	48J/11	KAR/UK/48J/11/2014/48	SH48	14	23	23.3	74	39	54.1	11	20	0.5		AKS/UK/2014/281	Gravitational	Transportational mid slope

Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Fault, lineament etc., its nature & continuity	Location No.	Overburden type	Overburden thickness	Landuse type	Erosion	Susceptibility assessment of slope	Qualitative risk assessment	Type of material	Type of movement
Actinolite Chlorite Schist	Moderate	Jointed moderate	J1 N20W/78E J2 E-W/76S		AKS/UK/2014/10	Insitu -soil	1-2m	Moderately vegetated	Toe erosion by nala & River	Unstable	Moderate	Rock	Slide
Actinolite Chlorite Schist	Moderate	Jointed moderate	J1 N15E/50W J2N-S/40E J3 E-W/76S		AKS/UK/2014/14	Insitu -soil	2-5m	Densely vegetated		Meta stable	Moderate	Rock	Slide
Granite gneiss	Moderate	Jointed moderate	J1N35W/30NE J2 N25W/72W		AKS/UK/2014/26	Insitu -soil	1-2m	Moderately vegetated		Meta stable	Moderate	Rock	Fall
Laterite	High				AKS/UK/2014/28	Insitu -soil	2-5m	Sparsely vegetated	Rill erosion	Meta stable	Moderate	Soil	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/30	Insitu -soil	1-2m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Granite	Moderate	Jointed moderate	J1 N55W/85E J2 N40W/18E		AKS/UK/2014/35	Insitu -soil	1-2m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Granite	High	Jointed moderate	J1 N60W/67W J2 N55E/76S		AKS/UK/2014/36	Insitu -soil	0-1m	Densely vegetated		Unstable	Low	Debris	Slide
Argillite	Moderate	Jointed moderate			AKS/UK/2014/53	Insitu -soil				Meta stable	Low	Debris	Slide
Argillite	Moderate	Jointed moderate			AKS/UK/2014/54	Insitu -soil	2-5m	Densely vegetated		Meta stable	Low	Debris	Slide
Saprolite	Moderate	Jointed moderate			AKS/UK/2014/56	Insitu -soil	2-5m	Moderately vegetated		Meta stable	Moderate	Debris	Slide
Argillite	High				AKS/UK/2014/66	Insitu -soil	>5m	Moderately vegetated		Meta stable	Moderate	Soil	Slide
Argillite	Moderate	Jointed moderate	J1 N15E/81E J2 E-W/subv.		AKS/UK/2014/71	Insitu -soil	1-2m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Argillite	Moderate	Jointed moderate	J1 E-W/40N J2 N25W/65S		AKS/UK/2014/92	Insitu -soil	1-2m	Densely vegetated		Meta stable	Low	Debris	Slide
Quartz-Mica schist	Moderate	Jointed moderate			AKS/UK/2014/103	Insitu -soil	0-1m	Densely vegetated		Unstable	High	Debris	Slide
Quartz-Mica schist	Moderate	Jointed moderate	J1 N45W/84E J2 N50E/85W		AKS/UK/2014/104	Insitu -soil	0-1m	Densely vegetated		Unstable	High	Debris	Slide
Quartzite	High	Jointed high	J1 E-W/54N J2 N30E/80N		AKS/UK/2014/106	Insitu -soil	0-1m	Densely vegetated		Unstable	Moderate	Debris	Slide
Quartzite	High	Jointed moderate	J1 N60E/83S J2 N30W/85E		AKS/UK/2014/107	Insitu -soil	0-1m	Settlement		Meta stable	Moderate	Debris	Slide
Quartz-Mica schist	High	Jointed high	J1 N70E/71S		AKS/UK/2014/108	Insitu -soil	0-1m	Densely vegetated		Meta stable	High	Debris	Slide
Quartzite	High	Jointed moderate	N35E/32W J1 N15E/30 S J2 N45W/88N		AKS/UK/2014/109	Insitu -soil	0-1m	Sparsely vegetated		Meta stable	Moderate	Rock	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/110	Insitu -soil	0-1m	Moderately vegetated		Meta stable	Low	Debris	Slide

Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Fault, lineament etc., its nature & continuity	Location No.	Overburden type	Overburden thickness	Landuse type	Erosion	Susceptibility assessment of slope	Qualitative risk assessment	Type of material	Type of movement
Laterite	Moderate				AKS/UK/2014/131	Insitu -soil	1-2m	Moderately vegetated		Stable	Low	Debris	Slide
Quartzite	Moderate	Jointed high	J1 N50W/Subvertical J2 N40E/70NW		AKS/UK/2014/132	Insitu -soil	1-2m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Quartzite	High	Jointed moderate	J1 N55W/78S E-W/35N bedding		AKS/UK/2014/133	Insitu -soil	1-2m	Densely vegetated		Meta stable	Low	Debris	Slide
Laterite	High				AKS/UK/2014/134	Insitu -soil	0-1m	Moderately vegetated		Meta stable	Moderate	Debris	Slide
Laterite	Moderate				AKS/UK/2014/135	Insitu -soil	0-1m	Moderately vegetated		Unstable	High	Debris	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/138	Insitu -soil	0-1m	Densely vegetated		Meta stable	Moderate	Rock	Fall
Laterite	High				AKS/UK/2014/141	Insitu -soil	0-1m	Densely vegetated		Unstable	Moderate	Debris	Slide
Laterite	Moderate				AKS/UK/2014/142	Insitu -soil	0-1m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/143	Insitu -soil	0-1m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Quartzite	Moderate				AKS/UK/2014/144	Insitu -soil	0-1m	Densely vegetated		Meta stable	Low	Debris	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/145	Insitu -soil	0-1m	Densely vegetated		Stable	Low	Debris	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/147	Insitu -soil	0-1m	Densely vegetated		Meta stable	Low	Debris	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/148	Insitu -soil	0-1m	Densely vegetated		Stable	Low	Debris	Slide
Laterite	Moderate				AKS/UK/2014/149	Insitu -soil	1-2m	Moderately vegetated		Unstable	Moderate	Debris	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/150	Insitu -soil	0-1m	Moderately vegetated		Meta stable	Low	Debris	Slide
Quartzite	Moderate	Jointed moderate			AKS/UK/2014/151	Insitu -soil		Moderately vegetated		Stable	Low	Debris	Slide
Quartzite	High	jointed low			AKS/UK/2014/152	Insitu -soil	0-1m	Moderately vegetated		Meta stable	Low	Debris	Slide

Rock type	Weathering	Rock characteristics	Structural data (Dip/Dip direction of planar fabrics	Fault, lineament etc., its nature & continuity	Location No.	Overburden type	Overburden thickness	Landuse type	Erosion	Susceptibility assessment of slope	Qualitative risk assessment	Type of material	Type of movement
Quartzite	Moderate	jointed low			AKS/UK/2014/153	Insitu -soil	1-2m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Quartzite	High	Jointed moderate			AKS/UK/2014/154	Insitu -soil	1-2m	Densely vegetated		Unstable	Moderate	Debris	Slide
Laterite	High				AKS/UK/2014/155	Insitu -soil	2-5m	Moderately vegetated		Meta stable	Moderate	Debris	Slide
Laterite	High				AKS/UK/2014/156	Insitu -soil	1-2m	Moderately vegetated		Meta stable	Low	Debris	Slide
Laterite	High				AKS/UK/2014/161	Insitu -soil	1-2m	Moderately vegetated		Meta stable	Moderate	Debris	Slide
Argillite	Moderate				AKS/UK/2014/254	Insitu -soil	1-2m	Moderately vegetated		Unstable	Moderate	Debris	Slide
Phyllite, Metabasalt	Low to fresh	Jointed moderate	J1 N55W/54S J2 N75E/51N		AKS/UK/2014/255	Insitu -soil	1-2m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Phyllite, Argillite	Moderate	Jointed moderate	J1 N50W/41E J2 N80W/38S		AKS/UK/2014/266	Insitu -soil	0-1m	Densely vegetated		Unstable	High	Debris	Slide
Argillite	Moderate	Jointed moderate	J1 N10W/subv J2 N65E/50N		AKS/UK/2014/280	Insitu -soil	0-1m	Densely vegetated		Meta stable	Moderate	Debris	Slide
Argillite	Moderate	Jointed moderate			AKS/UK/2014/281	Insitu -soil	0-1m	Densely vegetated		Meta stable	Moderate	Debris	Slide

Failure plane	Activity	Location No.	Distribution	Style	Failure mechanism	History	Triggering factor	Geo scientific causes	Remedial measures
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/10	Widening	Composite	Shallow translational failure		Rainfall	Toe erosion by stream	Retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/14	Widening	Composite	Shallow translational failure		Rainfall	Reduction of strength on saturation, anthropogenic activity	Retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/26	Widening	Multiple	Shallow translational failure		Rainfall	Reduction of strength on saturation, anthropogenic activity	
Shallow (<= 5 m)	Active	AKS/UK/2014/28	Widening	Single	Shallow translational failure	Recent	Rainfall	Increase in pore pressure, anthropogenic activity	Terraced slopes
Shallow (<= 5 m)	Active	AKS/UK/2014/30	Widening	Single	Shallow translational failure	Recent	Rainfall	Increase in pore pressure, Reduction of strength on saturation,	Terraced slopes
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/35	Widening	Single	Shallow translational failure		Rainfall	Increase in pore pressure, Reduction of strength on saturation,	Slope gradation, proper drainage at toe
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/36	Widening	Single	Shallow translational failure		Rainfall	Increase in pore pressure, Reduction of strength on saturation,	slope gradation
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/53	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure, anthropogenic activity	slope gradation
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/54	Widening	Single	Shallow translational failure		Rainfall	Increase in pore pressure, anthropogenic activity	slope gradation
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/56	Widening	Single	Shallow translational failure		Rainfall	Increase in pore pressure, anthropogenic activity	slope gradation
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/66	Widening	Single	Shallow translational failure	Old	Rainfall	Slope disturbance	Terraced slopes
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/71	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure, anthropogenic activity	Retaining wall
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/92	Widening	Single	Shallow translational failure		Rainfall	Slope disturbance	Retaining wall
Shallow (<= 5 m)	Active	AKS/UK/2014/103	Enlarging	Single	Shallow translational failure	Recent	Rainfall	Increase in pore pressure, anthropogenic activity	Retaining wall
Shallow (<= 5 m)	Active	AKS/UK/2014/104	Widening	Single	Shallow translational failure	Recent	Rainfall	Improper slope cutting, wedge failure	Proper drainage, removal of loose material, retaining wall
Shallow (<= 5 m)	Active	AKS/UK/2014/106	Widening	Single	Shallow translational failure		Rainfall	Increase in pore pressure, Reduction of strength on saturation,	Slope gradation, proper drainage at toe
Shallow (<= 5 m)	Active	AKS/UK/2014/107	Widening	Single	Shallow translational failure	Recent	Anthropogenic	Increase in pore pressure, Reduction of strength on saturation,	Terraced slopes
Shallow (<= 5 m)	Active	AKS/UK/2014/108	Widening	Single	Shallow translational failure	Recent	Rainfall	Reduction of strength on saturation, anthropogenic activity, removal of vegetation	Retaining wall
Shallow (<= 5 m)	Active	AKS/UK/2014/109	Widening	Single	Shallow translational failure	Recent	Rainfall	Increase in pore pressure, Reduction of strength on saturation,	
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/110	Widening	Single	Shallow translational failure		Rainfall	Increase in por pressure, toe removal	

Failure plane	Activity	Location No.	Distribution	Style	Failure mechanism	History	Triggering factor	Geo scientific causes	Remedial measures
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/131	Widening	Single	Shallow translational failure		Rainfall	Improper slope cutting	slope terracing
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/132	Widening	Composite	Shallow translational failure		Rainfall	Improper slope cutting	
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/133	Widening	Single	Shallow translational failure		Rainfall	Increase in por pressure, toe removal	
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/134	Widening	Single	Shallow translational failure		Rainfall	Increase in por pressure, toe removal	slope terracing
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/135	Widening	Composite	Shallow translational failure		Rainfall	Increase in pore pressure	Proper drainage, removal od loose material
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/138	Widening	Composite	Shallow translational failure		Rainfall	Increase in pore pressure and loosenig of overburden due to tree roots	Proper drainage, removal od loose material
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/141	Widening	Composite	Shallow translational failure		Rainfall	Increase in pore pressure and loosenig of overburden due to tree roots	proper drainage
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/142	Widening	Single	Shallow translational failure		Rainfall	Increase in pore pressure	proper drainage
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/143	Widening	Single	Shallow translational failure		Rainfall	Increase in pore pressure	proper drainage
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/144	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure	Proper drainage, removal of loose material, retaining
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/145	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure	proper drainage
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/147	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure	proper drainage
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/148	Widening	Single	Shallow translational failure	Old	Rainfall	Slope disturbance	Retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/149	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure	Retaining wall
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/150	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure	proper drainage
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/151	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure	proper drainage
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/152	Widening	Single	Shallow translational failure	Old	Rainfall	Slope disturbance	proper drainage

Failure plane	Activity	Location No.	Distribution	Style	Failure mechanism	History	Triggering factor	Geo scientific causes	Remedial measures
Shallow (<= 5 m)	Inactive	AKS/UK/2014/153	Widening	Single	Shallow translational failure	Old	Rainfall	Slope disturbance	
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/154	Widening	Single	Shallow translational failure	Recent	Rainfall	Increase in pore pressure	Retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/155	Advancing	Single	Shallow translational failure	Recent	Rainfall	Increase in pore pressure	Retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/156	Widening	Single	Shallow translational failure	Old	Rainfall	Slope disturbance	Retaining wall
Shallow (<= 5 m)	Active	AKS/UK/2014/161	Widening	Single	Shallow translational failure	Recent	Rainfall	Toe cutting by Stream	Retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/254	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure ,Slope disturbance	Proper drainage, retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/255	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure ,Slope disturbance	Proper drainage, retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/266	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure ,Slope disturbance	Proper drainage, retaining wall
Shallow (<= 5 m)	Reactivated	AKS/UK/2014/280	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure ,Slope disturbance	Stone pitching
Shallow (<= 5 m)	Stabilised	AKS/UK/2014/281	Widening	Single	Shallow translational failure	Old	Rainfall	Increase in pore pressure ,Slope disturbance	Proper drainage