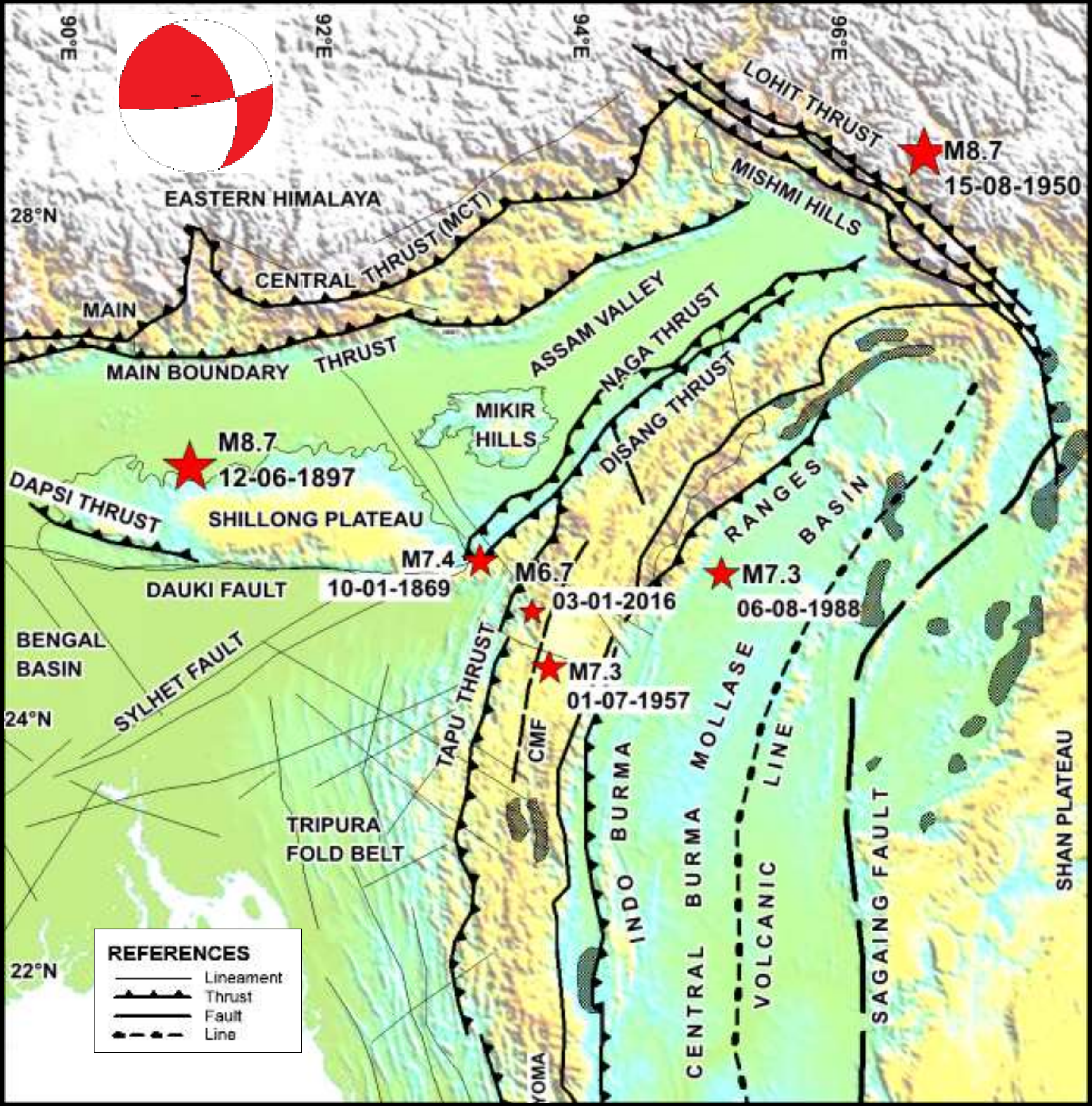
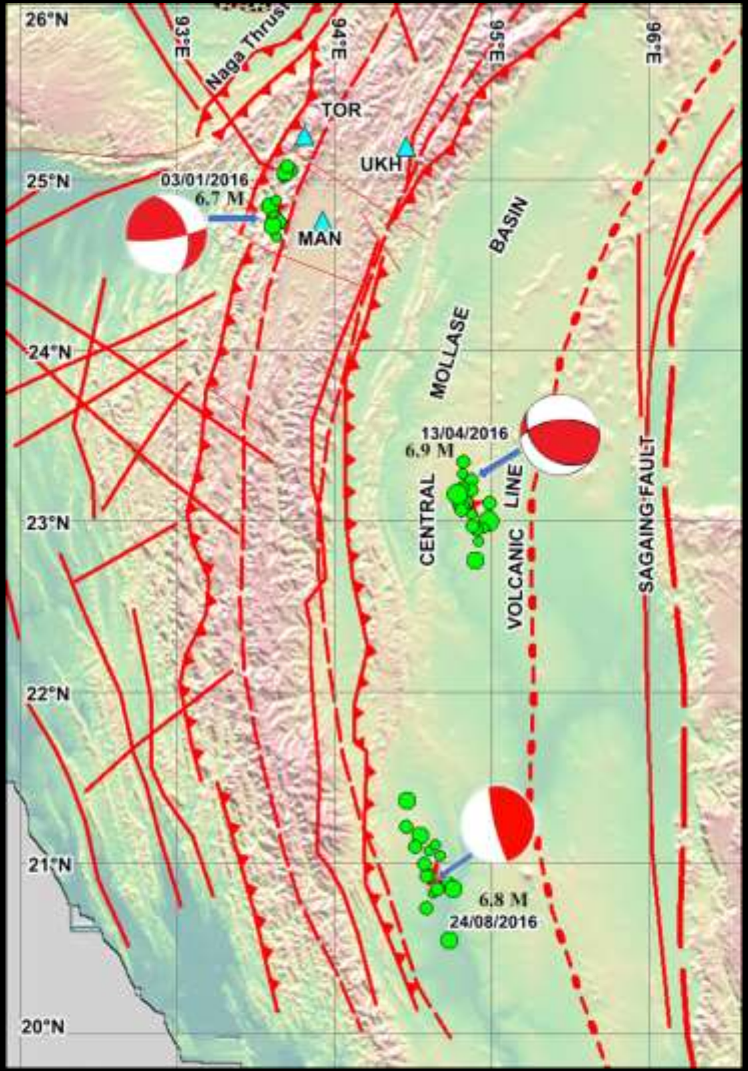
“R&D for Spatial Disaster Risk Reduction within the framework of National Disaster Management Plan”

GeoSmart India 3-5 December 2019, Hyderabad

Arun Kumar

Manipur University





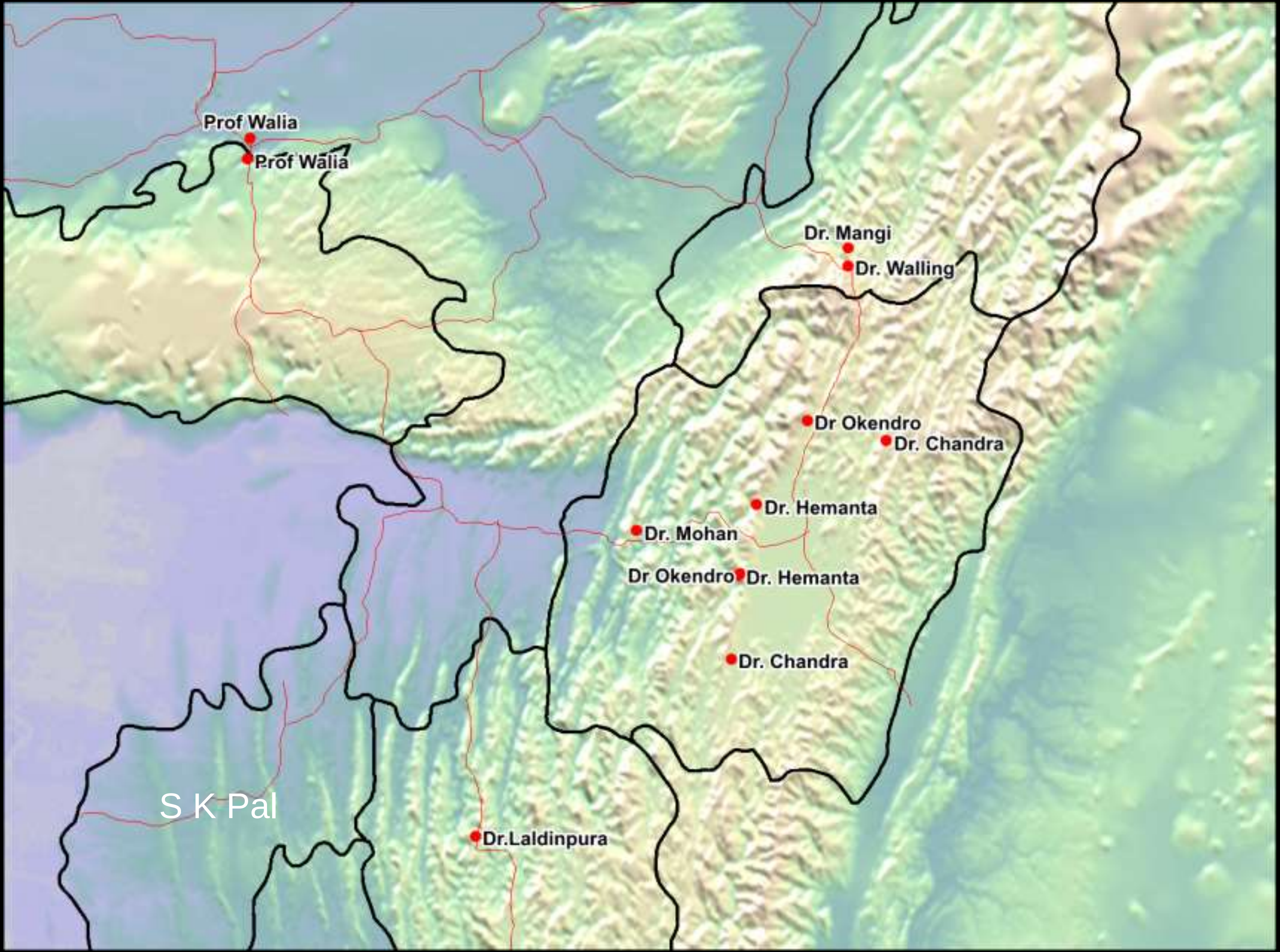
Tectonic map of NE India and past major earthquakes in NE region including recent event (Modified after GSI 2000)

DST INITIATIVES
Networking Programme on Landslide Hazard Mitigation for North Eastern States

Activities coordinated during first year of the coordinated project

- Takeoff Meeting 9-10 June 2018 at NEHU, Shillong
- Geotechnical Training Programme Feb 28 – 2 March 2019 at IIT Guwahati
- Large Scale Terrain mapping at Manipur University 13-14 September 2019

Networking Project in NE India
Locations of landslide sites



Take-Off Meeting 9-10 June 2018 at NEHU, Shillong

Geotechnical Training Programme Feb 28 – 2 March 2019 at IIT Guwahati

Large Scale Terrain Mapping at Manipur University 13-14 September 2019

Demonstration of Drone mapping MU Campus

Broad Objectives of the Networking projects in NE India

Broad Objectives

1. Large scale mapping (1:500) of the landslide sites
2. Geotechnical Study
3. Soil sample analysis (upto ~2 depth)
4. Direct shear of soil
5. RMR/SMR, Kinematic analysis
6. Monitoring of landslides in study area
7. Numerical modelling of both slides
8. Geomorphologic and structural mapping
9. Estimation of unconsolidated mass cover
10. Geo-hydrological studies.
11. To estimate the threshold levels of rain in triggering landslides in different sections of highways
12. In-Situ Hydrological Monitoring.
13. Numerical Modelling and Simulations – GeoStudio and TRIGRS

Outputs:

- Influence of geomorphologic parameters on slope stability
- Geotechnical Characterisation of Study Area
- Rainfall – Soil Moisture Variation Data of the Study area
- Rainfall Threshold for Landslide Initiation
- Interface with MSMDA and Survey of India IMD
- Rainfall – Soil Moisture Variation Data at two location of the Study area
- Landslide Hazard Maps and Risk Assessment
- Interface with GMDA, ASDMA
- Preparation of geological profiles and identification of role of structures in causing landslides
- Identification of role of unconsolidated mass cover in causing landslides
- Geotechnical properties of soil causing landslides
- Interface with the line department state PWD, BRO and state disaster management authority.
- Vulnerability and risk assessment
- Identification of slip surface and slope failure
- Mitigation/remedial measures.

Project and list of PI's/ Co PI's	Remarks
P1. Dr. R. K. Hemanta Singh, PI and Co-PI: Dr. Kh. Mohon Singh, Department of Geology, Imphal College	Large Scale Mapping and Geotechnical investigations - Completed
P2. Dr. M. Chandra Singh, PI and Co-PI: Prof. R.A.S. Kushwaha, Manipur University	Large Scale Mapping and Geotechnical investigations – Completed for one landslide site
P3. Dr. M. Okendro, PI and Co-PI: Prof. R.A.S. Kushwaha, Manipur University	Large Scale Mapping and Geotechnical investigations – Completed for one landslide site
P4. Dr. Laldinpuia, PI and Co.PI: Dr. Vanthangliana, Department of Geology, PUC, Aizawl	Large Scale Mapping and Geotechnical investigations – Completed for one landslide site; Monitoring suggested for longer period in order to arrive the numerical modelling and final conclusion
P5. Dr. Kh. Mohon Singh, PI and Co-P.I. Dr. M. Okendro, Imphal College	Large Scale Mapping and Geotechnical investigations – Completed for one landslide site and another site is
P6. Dr. Temsulemba Walling, PI and Co.PI: Prof. G. T Thong and Co PI- Dr. Ch. Mangi, Nagaland University.	**Large Scale Mapping and Geotechnical investigations – Completed for one landslide site; Monitoring of Landslide is recommended for slope stability analysis**

P7.Dr. S. K. Pal, PI, NIT, Agartala	**Soil samples from 22 sites are collected for geotechnical analysis– Completed; Recommended to estimate the factor of safety**
P8. Dr. Ch. Mangi Khuman, PI and Co-PI- Prof. Soibam Ibotombi, Manipur University and Co PI- Dr. Temsulemba Walling, NU	Recommended to take up two new landslide sites for Large Scale Mapping and Geotechnical investigations
P9. Dr. A Murali Krishna, PI and Co PI: Dr. Arindam Dey, IIT, Guwahati.	PI's could not come for presentation, submitted the progress report and committee noted the progress and found satisfactory
P10. Dr. Devesh Walia, PI and Co PI: Dr. Sunil Kumar De, Department of Geography NEHU, Shillong	Two sites are being investigated for establishing the relationship between rainfall and landslide occurrence; recommended for rainfall threshold development.
P11. Prof. Arun Kumar, PI and Co PI: Dr. M. Chandra, Imphal College, Manipur	Presented the progress for the active neotectonic signature and its relation with the landslide occurrences; recommended for 3D deformeter for active faults monitoring (CMT)
P12. Prof. Arun Kumar, Coordinator, Manipur University, Imphal Capacity building, overall coordination of various projects under Networking programme on Landslide Hazards Mitigation in NE India	Coordinator organised the training program for Geotechnical investigations and large scale mapping along with two review meetings. Recommended for the re appropriation of the budget head from the salary head of the JRF.

P-1

Geoscientific studies of Two Active Landslides, Manipur

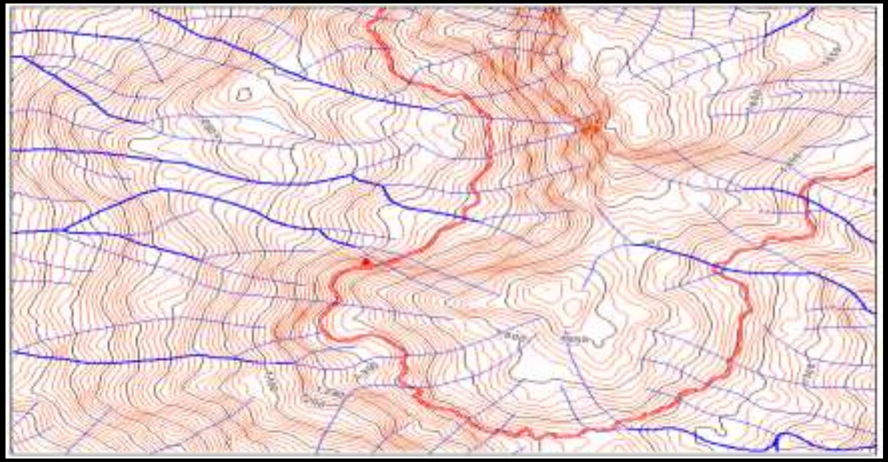
PI RK Hemanta Singh, Geology, United College, Chandel

1. Large scale mapping (1:500) of the study area.
2. Geotechnical Study

   a. Soil sample analysis (upto ~2 depth).

   b. Direct shear of soil.

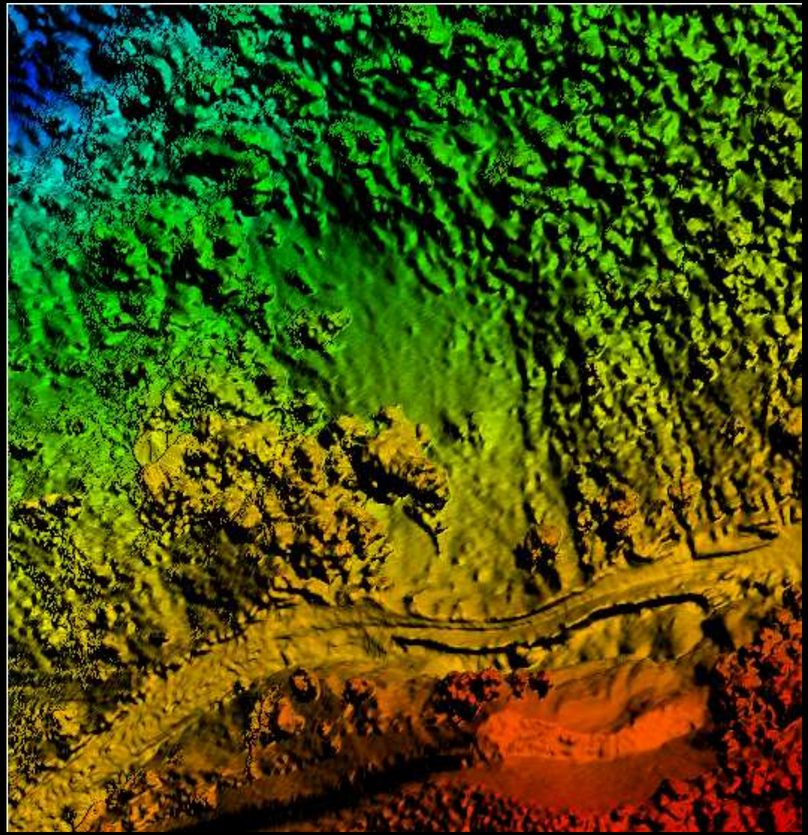
   c. Point load test for rock samples.

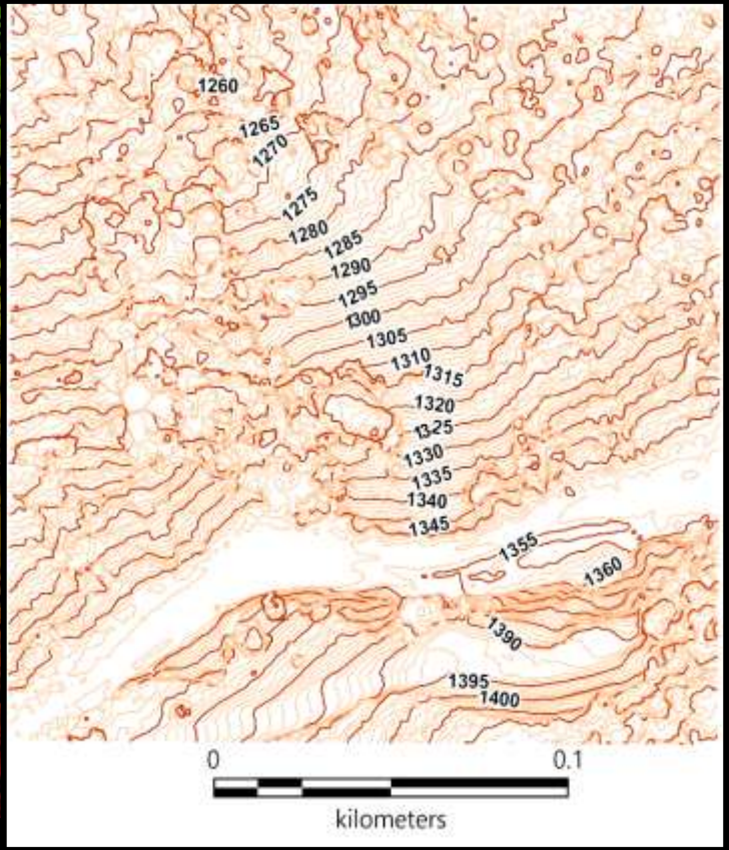


10 m contour intervals generated from ASTER DEM

P-1


Phantom IV Drone image processed with pix4D engine in ArcGIS


Digital Elevation Model (DEM)



1 m contour intervals generated the DEM

Strength test results of Tombinoutek Landslide

Uniaxial compressive test data of sandstone of Tombinoutek Landslide

Sample No.	Rock type	Length (cm.)	Diameter (cm.)	Load P in KN	Remarks
1	**Sandstone**	**10.8**	**5.4**	**184**	
2	**Sandstone**	**10.8**	**5.4**	**223**	
3	**Sandstone**	**10.8**	**5.4**	**207**	

Calculation of Uniaxial Compressive Strength of sandstone of Tombinoutek Landslide

Sample No.	Load P in KN	Mean diameter cm	Mean radius, r cm	Compressive strength, Co = P/A ($P/\pi r^2$) in MPa
1	**184**	**5.4**	**2.7**	**80.3≈80 MPa**
2	**223**	**5.4**	**2.7**	**97.4≈97 MPa**
3	**207**	**5.4**	**2.7**	**90.4≈90 MPa**

Brazilian test data of sandstone of Tombinoutek Landsl

Sample No.	Rock type	Length (cm.)	Diameter (cm.)	Load P in KN	
1	**Sandstone**	**5.4**	**5.4**	**83**	
2	**Sandstone**	**5.4**	**5.4**	**78**	
3	**Sandstone**	**5.4**	**5.4**	**93**	

Table 9: Calculation of Cohesion (C) and Internal Friction Angle (ϕ) of sandstone Tombinoutek Landslide

Sample No.	Compressive MPa	Tensile MPa	Cohesion C	Internal friction angle (ϕ)°	Normal stress σn
1	80	18	20	39	32
2	97	17	21	43	36
3	90	20	22	38	36

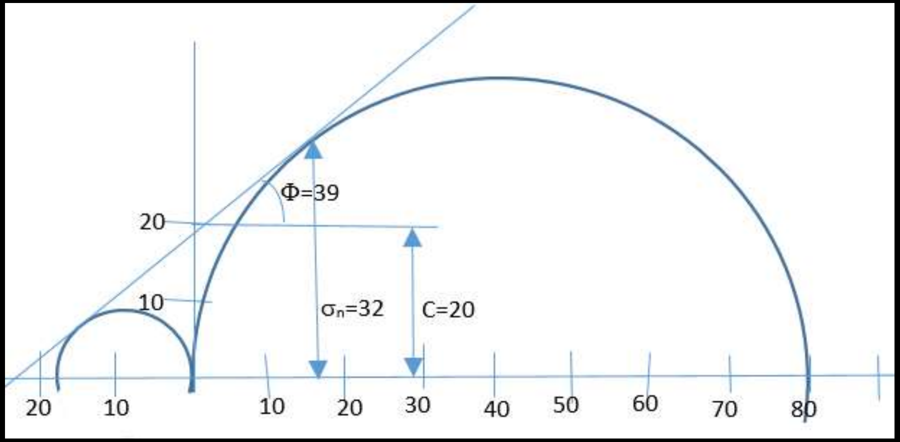


Fig. 11: Cohesion (C) and internal friction angle (ϕ) of sandstone sample 1 (Tombinoutek Landslide).

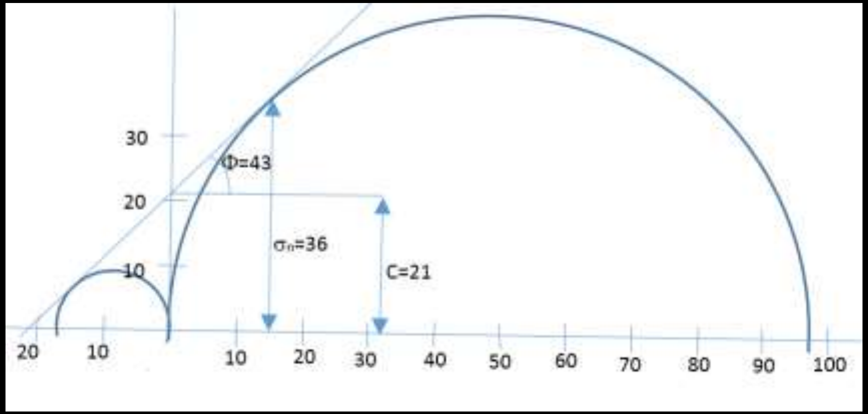
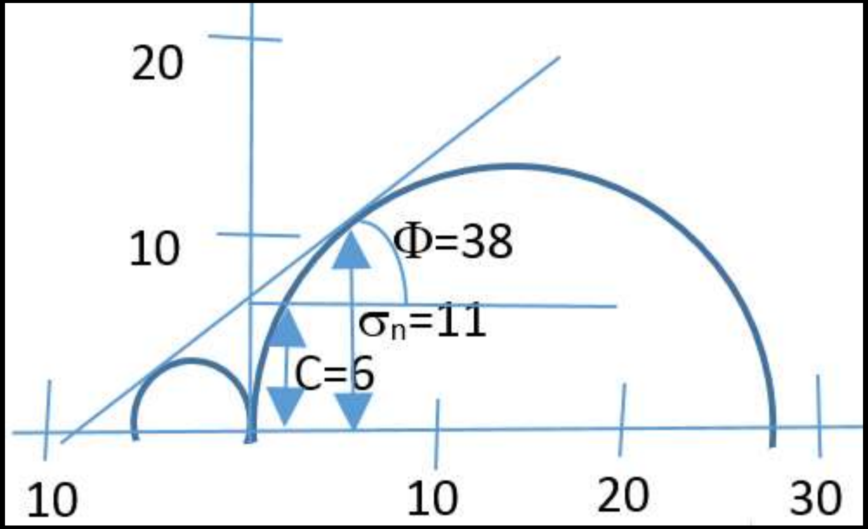


Fig. 12: Cohesion (C) and internal friction angle (ϕ) of sandstone sample 2 (Tombinoutek Landslide).

P-1

Sample No.	Compressive MPa	Tensile MPa	Cohesion C	Internal friction angle (ϕ)°	Normal stress σn
1	28	5	6	38	11
2	24	4	5.5	46	09
3	25	5	6.5	44	9.5



GEOSCIENTIFIC STUDIES - GEODETIC, GEOLOGICAL, GEOMORPHOLOGICAL & GEOTECHNICAL OF TWO ACTIVE LANDSLIDES-FORECASTING AND PREVENTION

(Lamva Lui Landslide along NH-150 , Churachandpur District and Sira- Rakhong Landslide along Tolloi Road , Ukhrul District, Manipur)

Landslide of Sera-Rakhong Village , Ukhrul Dist.

Dr. M. Chandra Singh

P.I

Objectives

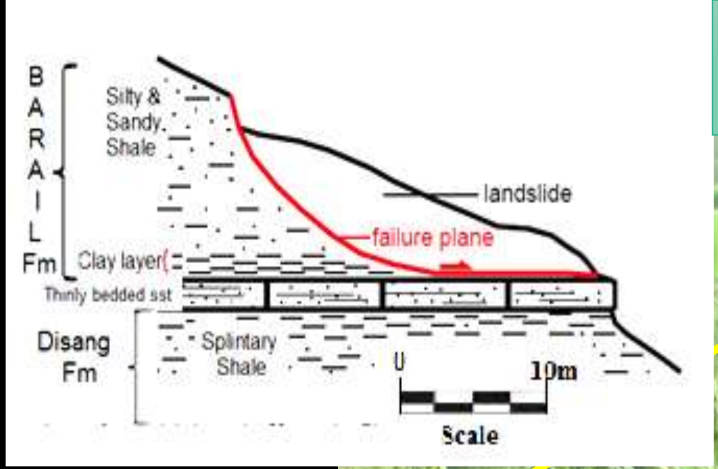
The approved objectives of the project are as follows

- To develop capacity building for Landslide monitoring system by using new advance Technique.
- *Preparation of DEM in and around the slide area generated from ASTER GDEM data*
- *Preparation of structural , drainage map in and around the slide area on 20 m contour interval and analysis*
- Preparation of DEM and base Map of the slide area on 1:500 scale with 50 cm contours interval, generated from Drone imaged augmented by total station and GIS technique
- Preparation and analysis of slope map, Slope Aspect Map, Lithological Map and *and plotting small scale slides over the above respective maps* by using base map and GIS technique.
- Geological and Geomorphological Studies by using new advance technique
- Geotechnical studies of active Landslide

  - Soil/Rock sample Analysis
- Forecasting /Prevention / Suggestive remedial / mitigation measures

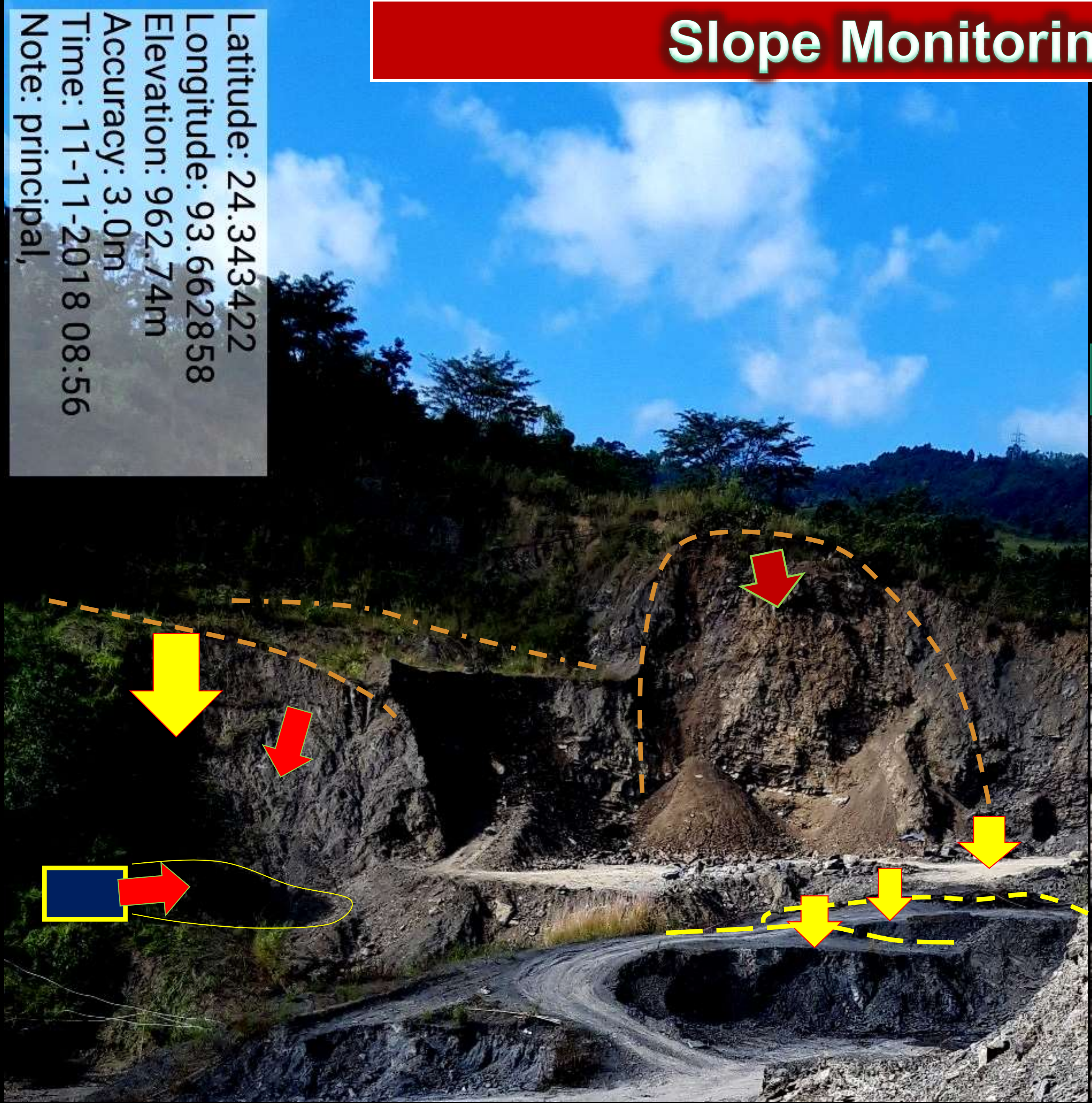
U-2
Translational
Sliding Phase

Earth Slide



Failure of soil slopes, both natural and manmade, during or shortly after rainfall is a commonly occurring phenomena in the area. In the residual soil (derived from the underlying rock) area infiltration of large volume water may lead to the soil fully Saturated, or an incre ased degree of saturation, where intense rainfall .It produced large fluid pressures.

Slope Monitoring



Northern Side

P-3

GEOSCIENTIFIC STUDIES –GEODETIC, GEOLOGICAL , GEOMORPHOLOGICAL AND GEOTECHNICAL OF ACTIVE LANDSLIDE

- Acquisition of Project equipment
- Preparation of Landslide Susceptibility Maps
- Collection of Rock and Soil Samples along with Discontinuities and geological data
- Preparation of core samples of rock for determination of UCS and tensile strength
- Testing of collected soil and rock samples
- Geodetic Survey by Total Station and supplemented by Drone survey of a site at Jouzangtek, Old Cachar Road.
- Find out the relation between structural data and slope geometry in rock dominated site.
- Determination of the factor of safety

PI: DR. M. OKENDRO
DEPARTMENT OF GEOLOGY
IMPHAL COLLEGE

P-3

Table 4: Consistency limits of soil samples **(Sept, 2018)**

Location	Liquid limit (W_L) %	Plastic limit (W_P) %	Plasticity Index (I_P)	Liquidity Index (I_L)	Consistency Index (I_C)
Toribari 1	53.5	32.59	20.90 (Highly Plastic)	-0.27 (Stiff)	1.27 (Stiff)
Toribari 2	47.8	36.3	11.49 (Moderately Plastic)	-0.77 (Stiff)	1.77 (Stiff)

Table 5: Results of calculation of **FOS** from the Chart Numbers, Hoek and Bray (1981)

Location	Slope angle	Slope height (m)	Cohesion C (N/m^2)	Internal friction angle (ϕ)	Unit weight (γ), N/m^3 (ρ_t X 9.81)	FOS
Toribari 1	15^0	175.0	7600	17^0	18088.7	1.38
Toribari 2	9^0	92.00	7500	9^0	15470.3	0.65

Table 6: Slice parameters of Toribari (Kalikhola) Landslide (June, 2018)

Slices	Angle, α (◦)	Vertical stress , γ_h (MN/m²)	Uplift pressure,$\gamma_w h_w$ (MN/m²)	Slice width Δx (m)	Friction angle, ϕ (◦)	Cohesion, C (MN/m²)	Vertical distance, a (m)	Radius of failure, R (m)
1	-10	0.834	0.259	100	16.5	0.00945	867.5	1108.8
2	-7	1.660	0.711	100	16.5	0.00945	867.5	1108.8
3	-4	2.244	1.030	100	16.5	0.00945	867.5	1108.8
4	19	2.378	1.103	100	16.5	0.00945	867.5	1108.8
5	21	2.513	1.128	100	16.5	0.00945	867.5	1108.8
6	25	2.244	0.981	100	16.5	0.00945	867.5	1108.8
7	27	1.974	0.931	100	16.5	0.00945	867.5	1108.8
8	35	1.436	0.735	100	16.5	0.00945	867.5	1108.8
9	40	0.646	0.147	100	16.5	0.00945	867.5	1108.8
10	50	0.089	0.000	025	16.5	0.00945	867.5	1108.8

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9	40	0.646	0.147	100	16.5	0.00945	867.5	1108.8
10	50	0.089	0.000	025	16.5	0.00945	867.5	1108.8

Table 19: Calculation of Factor of Safety (Bishop's method) from slice's parameters (June, 2018)

P-3

Slices	X	Y	F (assume)	X/(1+Y/F)	Z	Q	Z + Q	$F = \frac{X/(1+\frac{Y}{F})}{Z+Q}$
1	18.249	-0.052	1	19.254	-14.495			1st iteration = 0.63801
2	29.284	-0.036	1	30.389	-20.237			2nd iteration = 0.61317
3	36.995	-0.020	1	37.777	-15.653			3rd iteration = 0.61065
4	40.944	0.101	1	37.186	77.442			4th iteration = 0.61039
5	44.962	0.113	1	40.371	90.069			5th iteration = 0.61036
6	42.323	0.138	1	37.186	94.837			6th iteration = 0.61036
7	35.728	0.150	1	31.043	89.651			
8	26.48	0.207	1	21.932	82.376			
9	20.534	0.248	1	16.446	41.542			
10	1.401	0.353	1	1.035	1.719			
				∑272.593	∑427.25	0.0026	∑427.254	

P-3

Table 3: Results of Brazilian Tests

Samples	Cylindrical Sample No.	Length (in cm)	Diameter (in cm)	Load (in kN)	Average load (in kN)
A	T1	5.5	5.4	47	49.33
	T2	5.5	5.4	49	
			5.4	52	

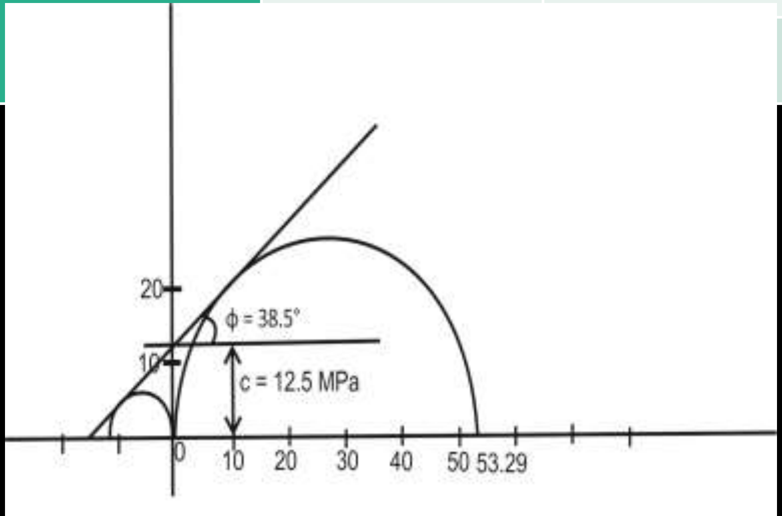


Figure: Failure envelope

Table 4: Calculation of tensile strength of the study area

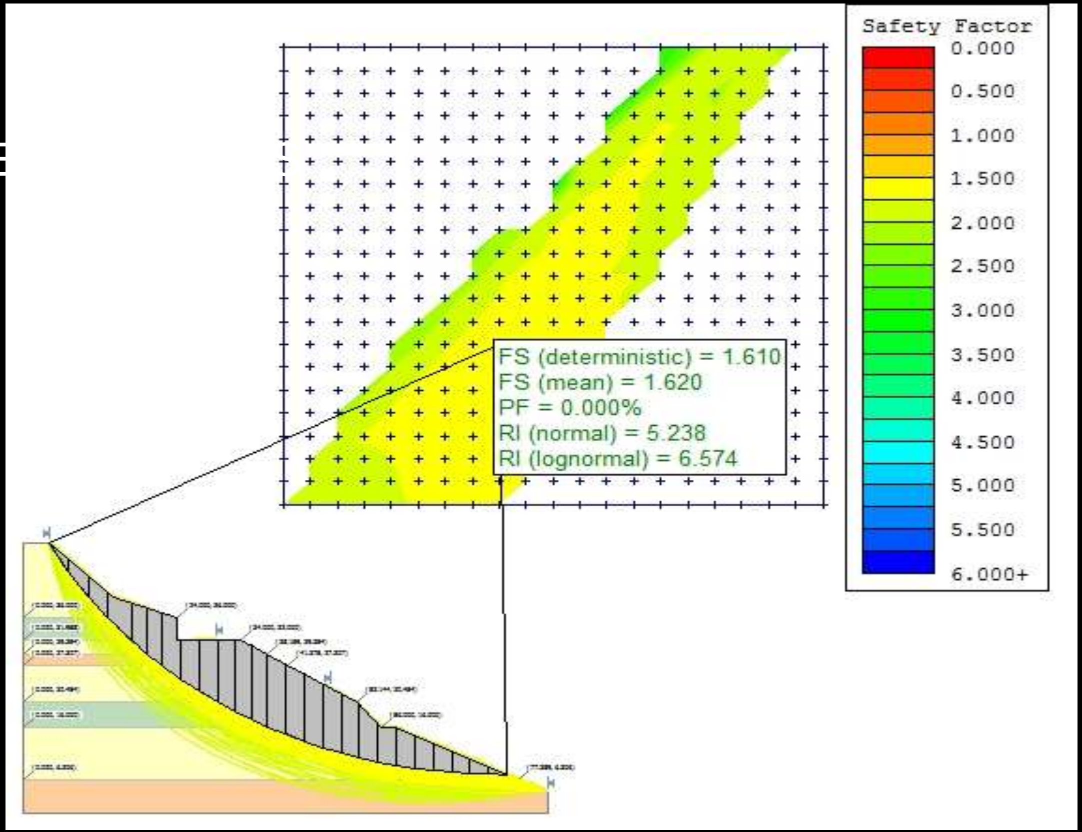
Rock Samples	Cohesion c	Frictional Angle Φ	Normal Stress σ_n	Failure Envelope $T=C+\sigma_n \tan\varphi$
A	12.5 MPa	38.5	10	22.8147

MONITORING OF LANDSLIDE BY INSTRUMENTATION AND PARTICIPATORY MAPPING

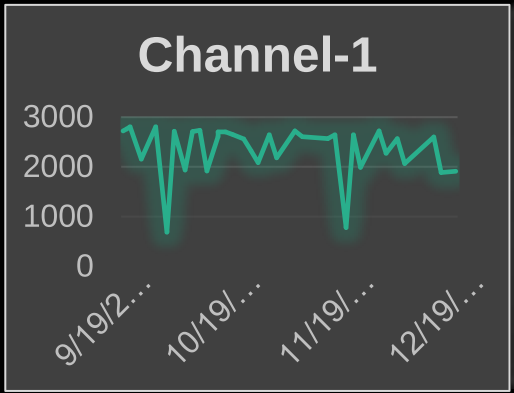
Principal Investigator; Dr. LALDINPUIA, Department of Geology, PUC, Aizawl

P-4

LE



- Organized Three Days Workshop on '*Monitoring of landslide using Total Station*' in collaboration with Dept. of Civil Engineering, MZU under '*Overhead*' during 14-16 May, 2018.
- Supported One Day International Workshop on '*Geological Research in Indo- Burma ranges*' on 12 November 2018.
- JRF & Field Assistant appointed on **17th May, 2018**.
- *One research paper* presented at 2nd Mizoram Science Congress on 5th October, 2018.
- Zuangtui 132kV station monitoring is permitted by C.E., P&E, Govt. of Mizoram, and start monitoring on June, 2018.
- 10 months TS monitoring data is generated **(27 campaigns)**, and it shows that movement rate is in inch level.
- JRF was send to CSIR- CIMFR, Dhanbad for one week training (28th Mar- 9th Apr, 2019).
- Abstract regarding the project was accepted for oral presentation in the *36th IGC, New Delhi, March 2020*.



Borehole Extensometer chart

ZUANGTUI 132 KV STATION

Slumping monitoring using TS, Crackmeter & B/W Extensometer

Future work plan (for ongoing project):-

1. Soil sampling using core cutter sampler, and Direct shear/ Triaxial test for software analysis; for both sites.
2. Publication & presentation (s)
3. 2nd study area, Hunthar slumping site monitoring start on August, 2019.

P-5 # "Numerical Modeling of Nungkao Landslide, NH-37, Manipur"

Dr Kh Mohon Singh, PI, Department of Geology Imphal College

OBJECTIVES

i) Large scale mapping(1:500) of the study area

ii) Geological and Geotechnical study

iii) Numerical modeling of the landslide

OUTPUTS

Strength parameters for samples

Rock sample	Cohesion, C in (MPa)	Internal friction angle, ϕ	Normal stress, σ_n in (MPa)	Shear strength in (MPa) $\tau = C + \sigma_n \tan\phi$
Perp	12.625	55.75	5.25	23.14
Parallel	9	53.875	6.375	17.72
Mean	10.81	54.81	5.81	20.43

P-5 **Rock Mass Rating (RMR):**

Structural discontinuities data along with slope orientation are used to plot in the stereonet for the determination of RMR.

Six parameters are employed to obtain the numerical values of RMR.

i Uniaxial Compressive Strength of rock material,

ii Rock Quality Designation,

iii Spacing of Discontinuities,

iv Condition of Discontinuities,

v Groundwater conditions and

vi Orientation of Discontinuities

- All the ratings are algebraically summarized and can be adjusted with discontinuity orientation as shown in the following equations
- $RMR = RMR_{basic}$ + adjustment of discontinuity orientation
- $RMR_{basic} = \Sigma$ parameters (i+ii+iii+iv+v)

Table 4: Slope characteristics and Strength Parameters of the Landslide area.

Table 4: Slope characteristics and Strength Parameters of the Landslide area.

Station	Location	Attitude of slope	Type of Rock	Attitude of Disconti- nuities (°)	Degree of Weatherig	Strength Qc (MPa)
Nungkao	24º46´8.2˝N 93º18´51.3˝E	65º/081º	Massive to thickly bedded sandstone.	66/057 80/163	Low	77.25

Table 5: Orientation of discontinuities and slopes

Station	aj	Bj	as	Bs	aj - as	Bj - Bs	Probable failure
Nungkao	98	81	81	65	17	16	Wedge sliding

aj=joint dip direction, Bj=joint dip angle, a_s=slope direction, B_s=slope angle

Table 6: RMR Determination

Station	Strength	RQD	Spacing	jL	jR	jA	jC	Ground water	RMR
Nungkao	7	17	15	2	2	1	4	15	58

jL = joint continuity or length, **jR =** joint roughness, **jA =** joint alteration, **jC** = joint condition factor

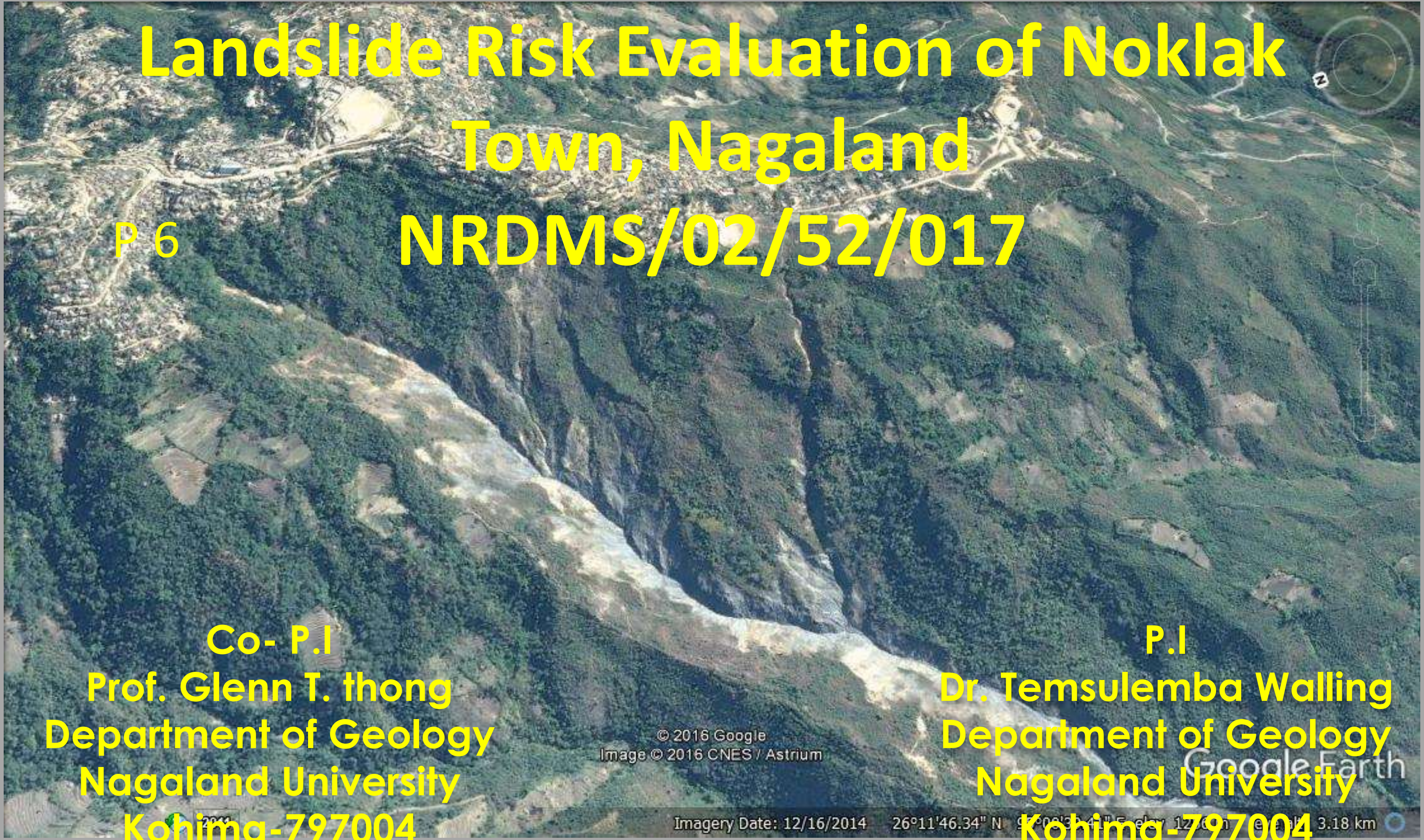
Numerical Modeling :Finite Element Method

- The finite element method(FEM) is the dominant discretization technique in structural mechanics.
- The basic concept in the physical interpretation of the FEM is the subdivision of the mathematical model into disjoint(non–overlapping) components of simple geometry called finite elements or elements for short.
- Each element is associated with the actual behaviour of the body.

Landslide Risk Evaluation of Noklak Town, Nagaland

P 6

NRDMS/02/52/017

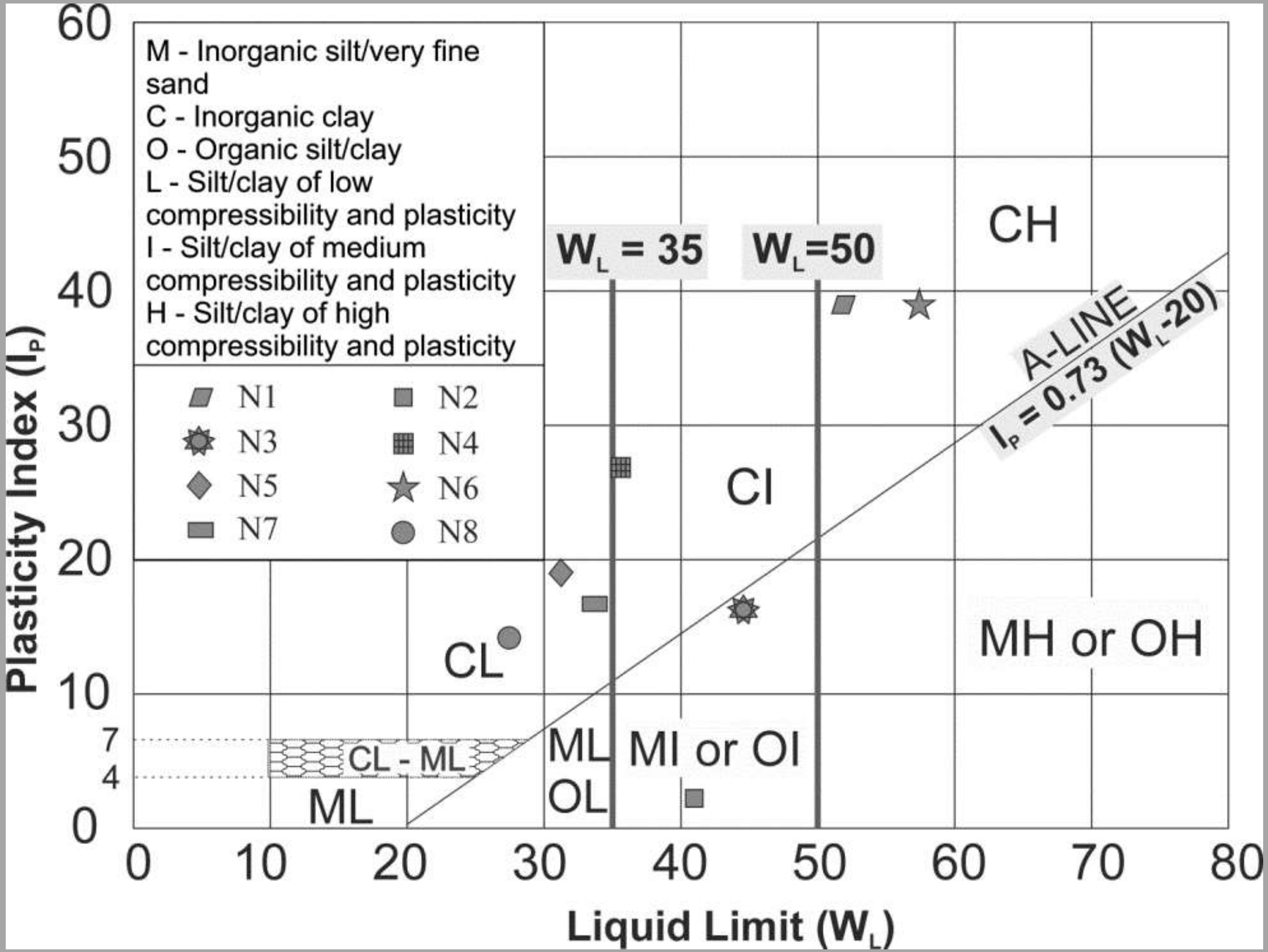


Co- P.I
Prof. Glenn T. thong
Department of Geology
Nagaland University
Kohima-797004

P.I
Dr. Temsulemba Walling
Department of Geology
Nagaland University
Kohima-797004




Results

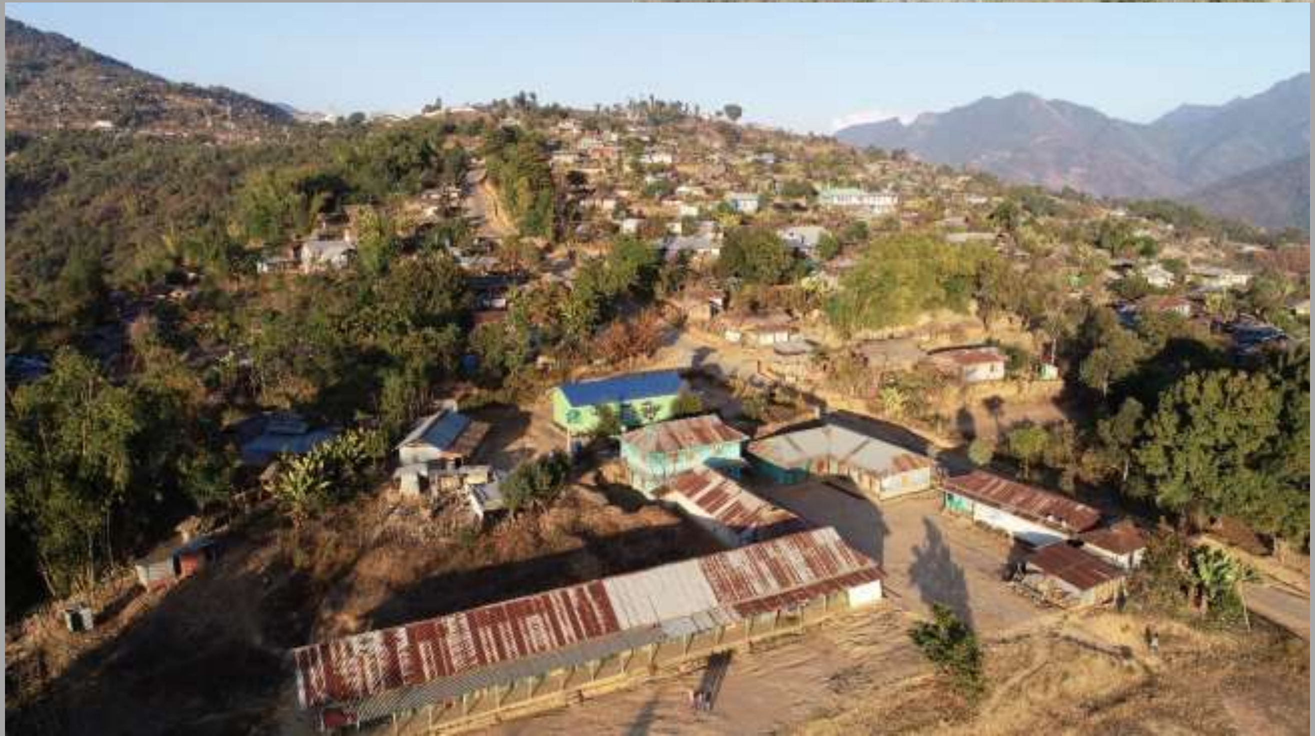


Plasticity Chart as per IS: 1498-1970

SMR system (after Romana, 1985 & Bieniawski 1989)

LOCATION	1		2		3	
	Value / Condition	Rating	Value or Condition	Rating	Value or Condition	Rating
1. UCS	6.91 Mn/m^2	2	7.63 Mn/m^2	2	7.34 Mn/m^2	2
2. RQD	-66.5%	3	-85.178%	3	-3.8%	3
3. Spacing of joints	35.69 mm	5	46 mm	5	130 mm	8
4. Condition of joints	Slightly rough surface Separation <1 mm; Highly weathered walls	20	Slightly rough surface Separation <1 mm; Highly weathered walls	20	Slickenside surface; continuous joints; separation <5 mm	10
5. Groundwater condition	Damp	10	Damp	10	Damp	10
RMR	= (1+2+3+4+5)	40	= (1+2+3+4+5)	40	= (1+2+3+4+5)	33
6. $F_1 = (\alpha_j - \alpha_s)$	71°	0.15	19°	0.7	-15°	1
7. $F_2 = \beta_j$	54°	1	80°	1	86°	1
8. $F_3 = \beta_j - \beta_s$ for plane failure where β_s= dip/angle of slope	19°	0	43°	0	51°	0
9. F_4 = Adjustment factor	Pre-splitting	10	Pre-splitting	10	Pre-splitting	10
SMR = $RMR+(F_1 x F_2 x F_3)+F_4$	40+{0.15x1x0}+10	50	40+{0.7x1x0}+10	50	33+{1x1x0}+10	43
10. Class	III		III		III	
11. Description	Normal rock; partially stable slope prone to failure by some joints or many wedges; requires systematic measures		Normal rock; partially stable slope prone to failure by some joints or many wedges; requires systematic measures		Normal rock; partially stable slope prone to failure by some joints or many wedges; requires systematic measures	

Drone Image

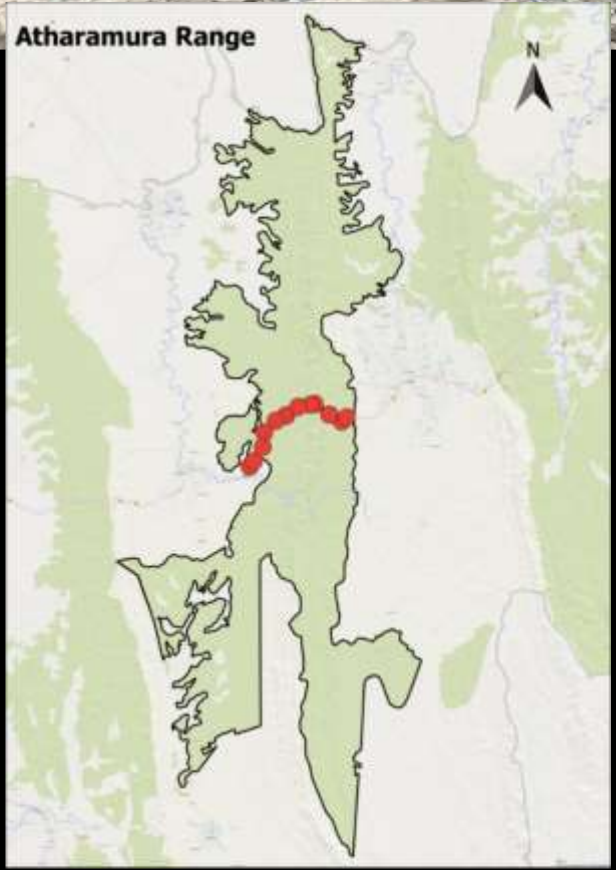


Work to be carried out

- ✓ Geological mapping
- ✓ Sampling & Laboratory analysis
- ✓ Lineament Mapping using satellite images
- ✓ Preparation of vulnerability and risk map
- ✓ Design appropriate remedial/mitigation plans

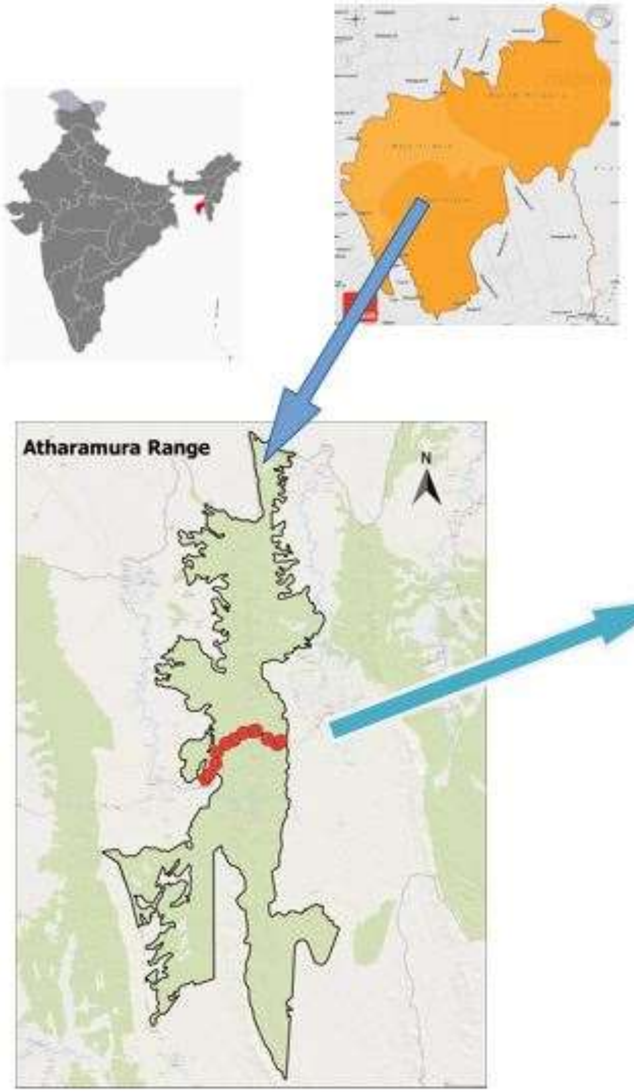
Geoscientific Studies − Geodetic, Geological, Geo-Morphological and Geotechnical of Active Landslides

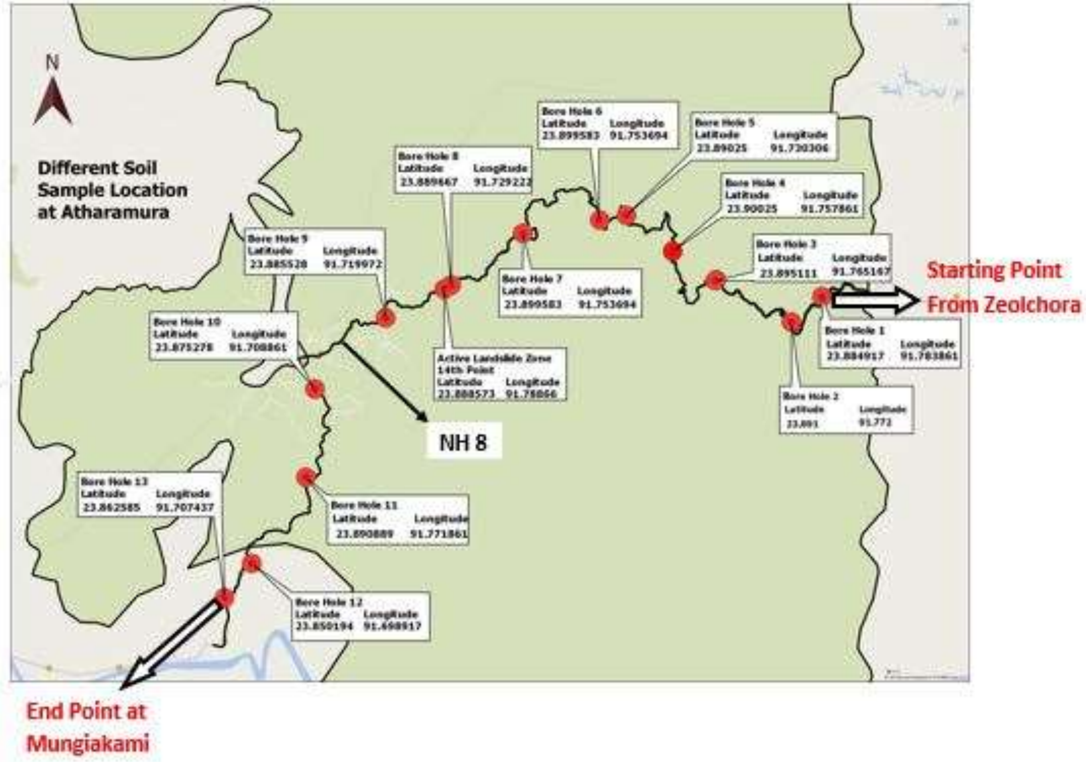
Dr. Sujit Kumar Pal
National Institute of Technology Agartala



- **Geological mapping across the road of the study area**
- **Large scale mapping on the landslide site of the study area**
- **Geotechnical study**
- **Soil sample analysis (upto 2 m depth)**
- **Direct shear tests of in-situ and remolded soil.**
- **Permeability tests of in-situ and remolded soils.**

DIFFERENT POINT OF SAMPLE COLLECTION





OBSERVATIONS

- From the geotechnical investigation of the collected soil sample in Atharamura region it is observed that most of the soil are silty-sand/ sandy silt type. Due to the presence of silt content in the soil, it behaves like liquid flow during heavy rainfall. And sand easily can dislocate as there is less cohesion.
- From the visual inspection, it is observed that the Atharamura region is of mostly artificial vertical cut.

COMPREHENSIVE RAINFALL INDUCED LANDSLIDE HAZARD ANALYSIS OF 'SUNSALI' AND 'NOONMATI' HILLS IN GUWAHATI REGION

Dr. A Murlikrishna IIT Guwahati

The work completed are:

1. Site visit and reconnaissance
2. In-situ infiltration test – (Guelph Permeameter and Mini-disk infiltrometer test)
3. Soil profile observation and measurements at cut-slopes – Sample collection at different depths
4. Laboratory test – (Liquid limit, Plastic limit, Grain size distribution) of the collected samples
5. Collection of Rainfall Data
6. Collection and procurement of Topographical data – Digital Elevation Model

Figure 2 Mini-disk Infiltrometer

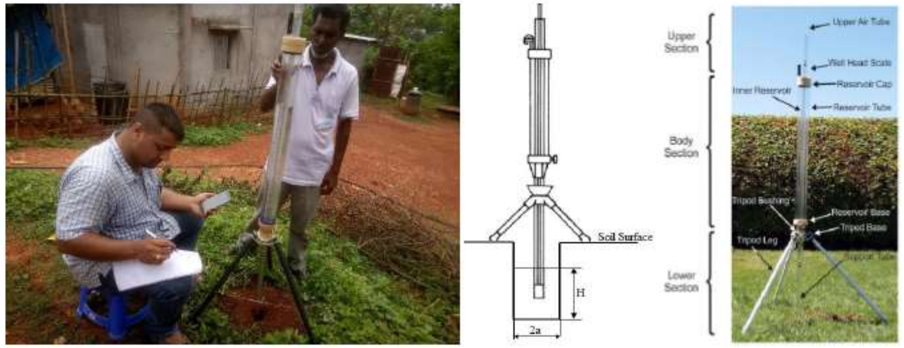


Figure 3 Guelph Permeameter

Table 3 Plastic limit and Liquid limit of soil samples

Site name	Depth from hill slope surface (m)	Liquid Limit	Plastic Limit	Plasticity Index	Soil Classification
Chunsali hill	1.0	48.7	26.48	22.22	CI
	2.5	--	--	--	Non-plastic sandy silt
Noonmati hill	1.0	52.0	32.87	19.1	MH
	2.5	--	--	--	Non-plastic sandy silt
Kailash nagar hill	1.0	46.8	28.92	17.9	MI
	2.5	--	--	--	Non-plastic sandy silt
Punnya nagar hill	1.0	45.9	27.7	18.2	MI
	2.5	--	--	--	Non-plastic sandy silt
[illegible]	[illegible]	[illegible]	.4	13.6	CL
	[illegible]	[illegible]	[illegible]	--	[illegible]

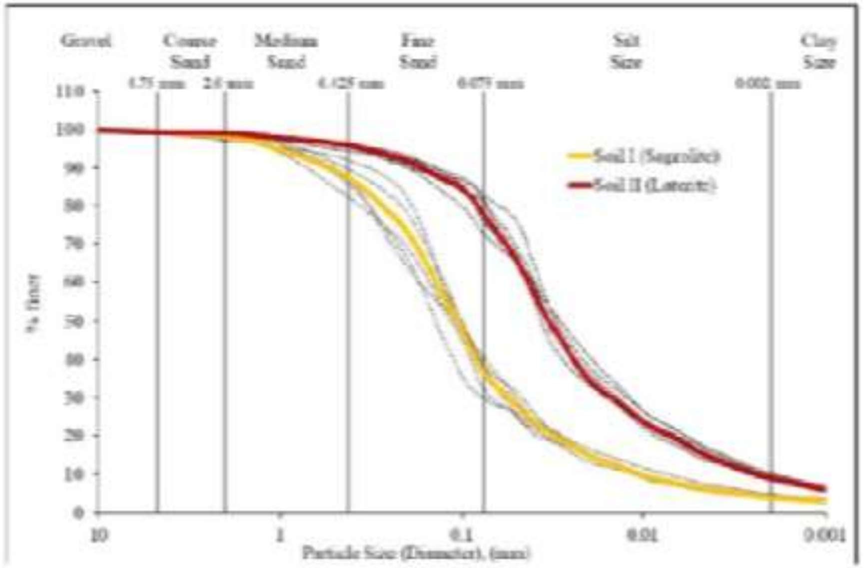


Figure 5 Grain size distribution of collected soil sample

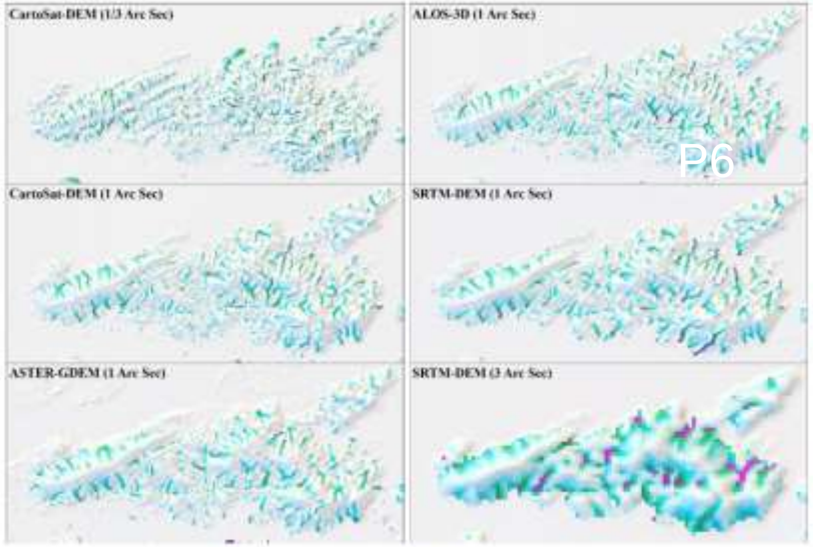


Figure 11 Drainage pattern of Sunsali-Noonmati hill derived from the corresponding DEMs

P6

8. FURTHER WORK

The data collected shall be used for landslides triggering analysis of the Noonmati-Sunsali hill. The future work consists of:

- Procurement of Equipment for field installation
- Numerical Simulations
- TRIGRS analyses

In the present analysis, the QGIS (Quantum Geographic Information System) software has been used to represent the landslide affected area near Zeolcherra. The QGIS is free and open-source software that supports viewing, editing and analysis of geospatial data.

EFFECT OF LANDSLIDE

P-7

Before landslide

After Landslide

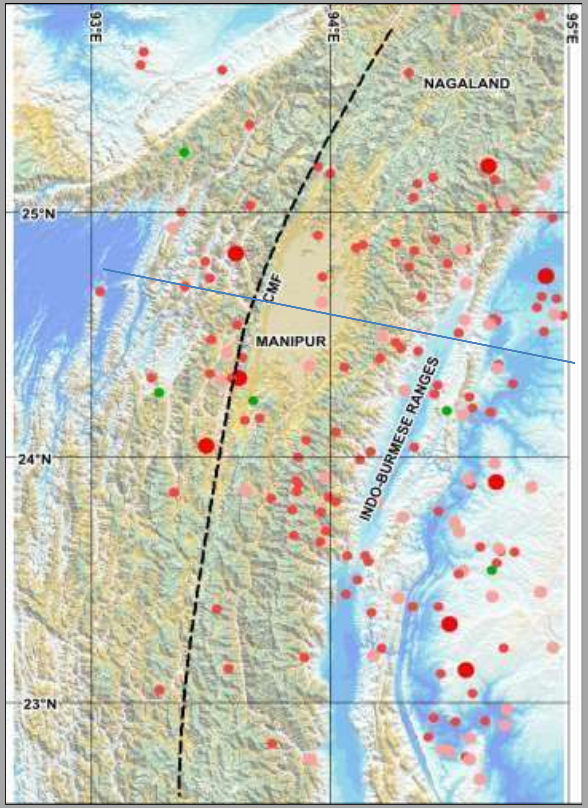
Before landslide

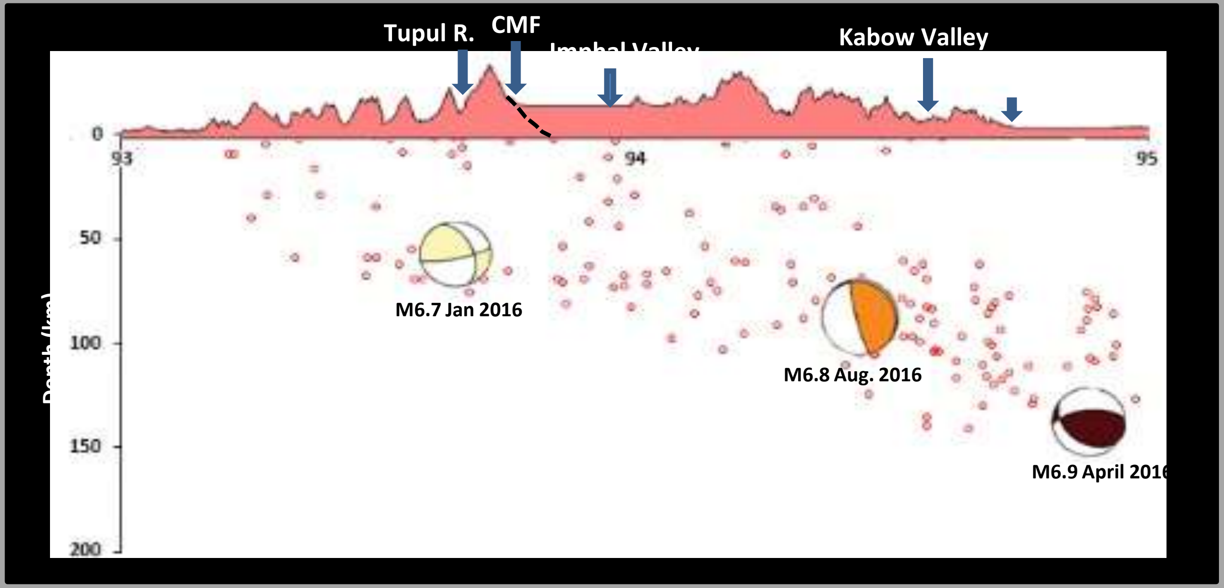
After Landslide

Future Work

- Collection of rock samples for evaluation of mechanical strength and Rock mass rating
- Measurement and collection of joint data for evaluation of their role in failure of rocks and consequent landslides
- Collection of others structural data which are responsible for failure of rocks thereby causing landslides.
- Determination of the extent of circular surface along which failure takes place at least for one slide area
- Evaluation of mass of materials above the circular surface at least for one slide area
- Correlation of mechanical strength of rock, joint data, extent of circular surface and mass of material lying above for determination of failure of rocks and consequent landslide
- Mitigation measures along the section of the highway under investigation

Characterization of Source Parameters and Some Empirical Relations between them for Eastern and Western part of Churachandpur Mao Fault I B R





Sl	Parameter	Western side of CMF		Eastern side of CMF	
		Min	Max	Min	Max
1	Moment magnitude Mw	2.3	6.0	2.3	6.4
2	Seismic Moment Mo	12.5	18.1	12.6	18.7
3	Corner frequency fc	0.5	7.4	0.28	6.50
4	Stress drop (bars)	0.1	57.6	0.1	89.5
5	Rupture radius (km)	0.195	3.3	0.04	4.80
6	Rupture Area (sq.km)	0.12	34.2	0.01	34.21

Inferences

- CMF a large dextral geomorphic, the offset is observed about 3 km along the horizontal fault trace and 1.5 km in vertical. It may be the result of impediment posed by the Shillong Block to westward motion of IBR. If the IBR is not moving westward as fast in the north as it moves in south, then the dextral slip fault with the orientation of CMF could be consequence and manifestation of that differential motion. It is an aseismic fault where large number of landslide trigger regularly. CMF is much younger than IBR in age, as observed geomorphic features in Imphal valley.

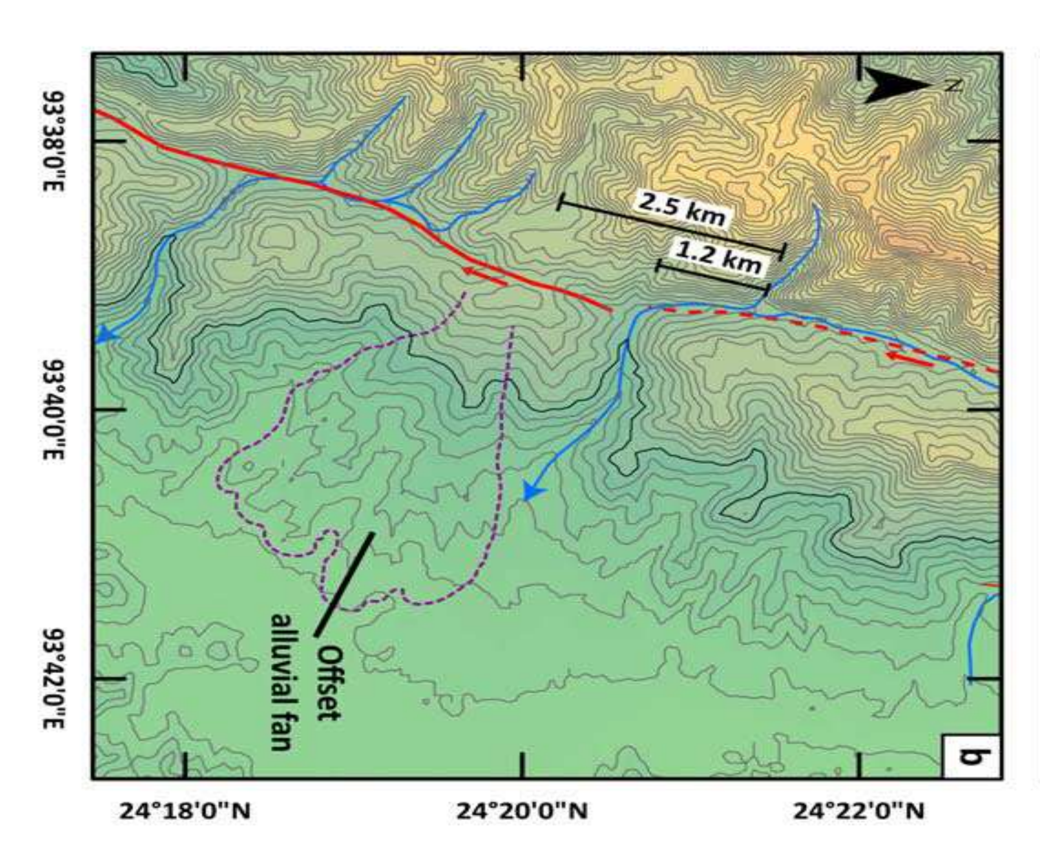
- 161 events are used for this study. Estimated stress drop values are found to be very scattered. Stress-drop behavior also depends on the tectonic characteristics of the region. Moreover, the properties of the earth’s crust change from one to another location. Thus, stress drop observations cannot extrapolate from high stress drop regions to moderate or low stress drop regions and vice versa even for earthquakes of similar magnitudes and depths.

- Estimated lower stress drop values for those events near the fault while higher stress drop for far away events from the fault irrespective of magnitude. However, increased in stress drop is observed with increased in focal depth. The focal depth of earthquakes increases towards east when triggered in IBA. If the CMF forms the plate boundary, the source parameters using only 161 events are not significant to compare the Indian Plate and IBR. We require to analyse further more numbers of event both for western and eastern part of CMF

- The crustal velocity abruptly changes from Indian plate 5.2 cm/yr and IBR is 3.6 cm/yr. CMF accommodates 16mm/yr slip of the IBA.

- Three earthquakes (None, Mawlaik and Chauk) of 2016 also confirm the differences in focal depth as well as source parameters in the IBA region.

CMF is ~170 km long right-lateral oblique-slip tectonic discontinuity of the Indo-Burmese Range near Imphal, having distinct geomorphic expressions. Along the western flank of the Imphal basin, many of the eastward flowing rivers and basins exhibit dextral deflections and warping along the CMF.

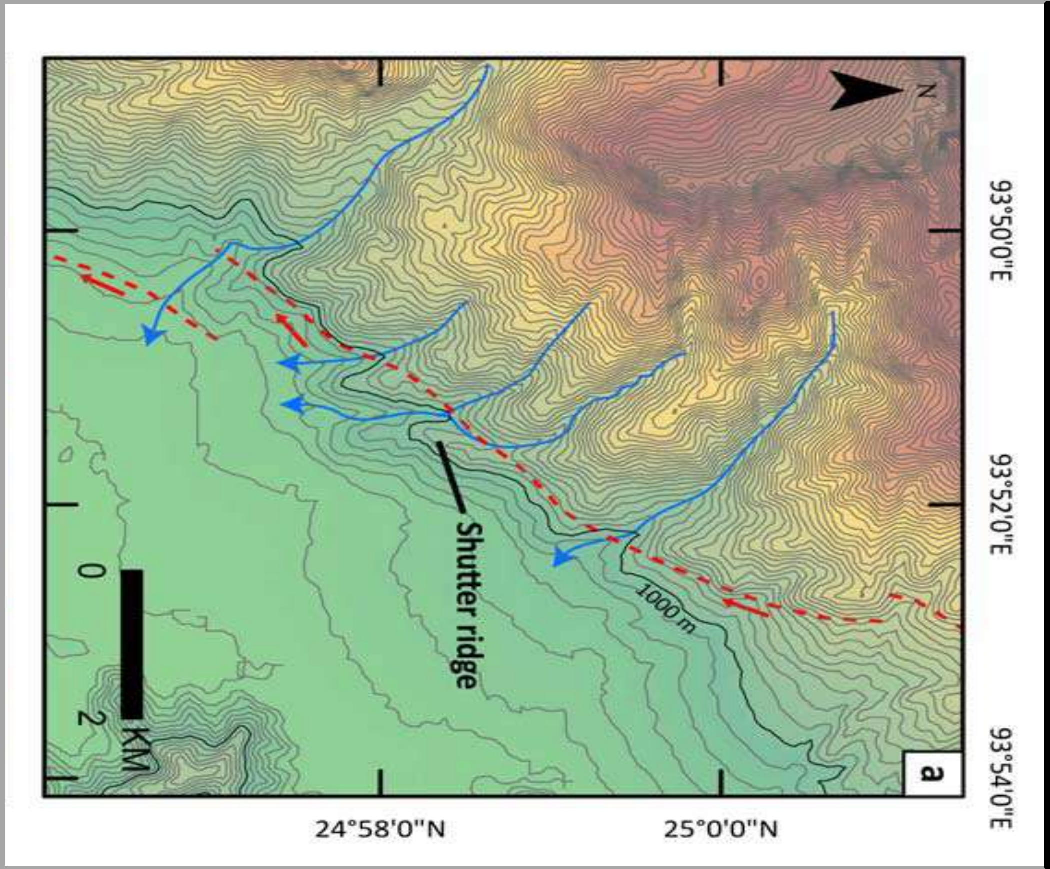


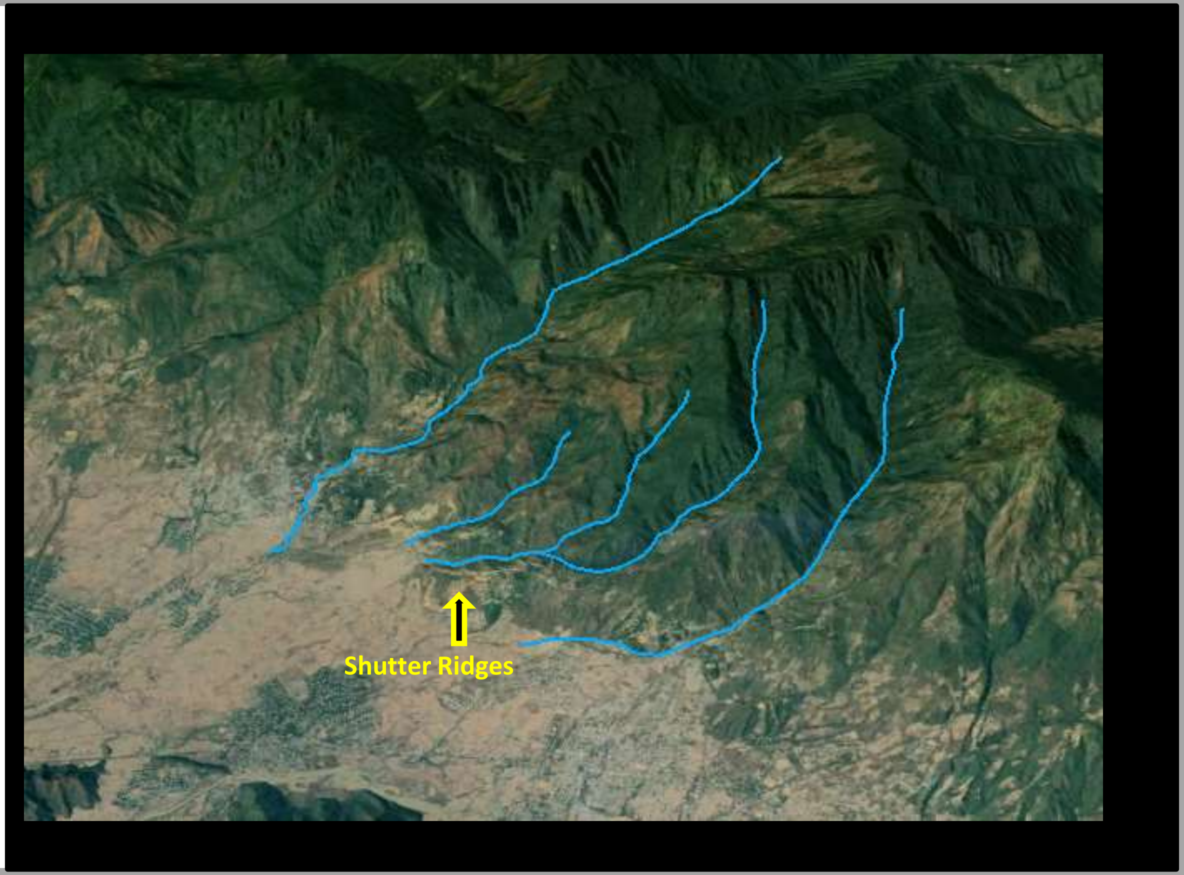
Along the western flank of the Imphal basin, many of the eastward flowing rivers and basins exhibit dextral deflections and warping along the CMF.

This NNE-SSW-striking fault also shows a clear vertical component in the SRTM topography, as the range rises up steeply more than 1000 m from the basin floor to the mountain crest.

The largest dextral geomorphic offset is about 3 km along the fault trace, whereas the vertical offset is likely more than 1.5 km.

Both, vertical and right-lateral offsets diminish northward and southward, and the geomorphological evidence becomes less compelling north and south of the basin





There are a number of different ways to classify landforms. One way is to categorize landforms by how they are created :landforms that are built (depositional),landforms that are carved (erosional), and landforms that are made by movements of the Earth's crust (tectonic). Andrew Alden 2019

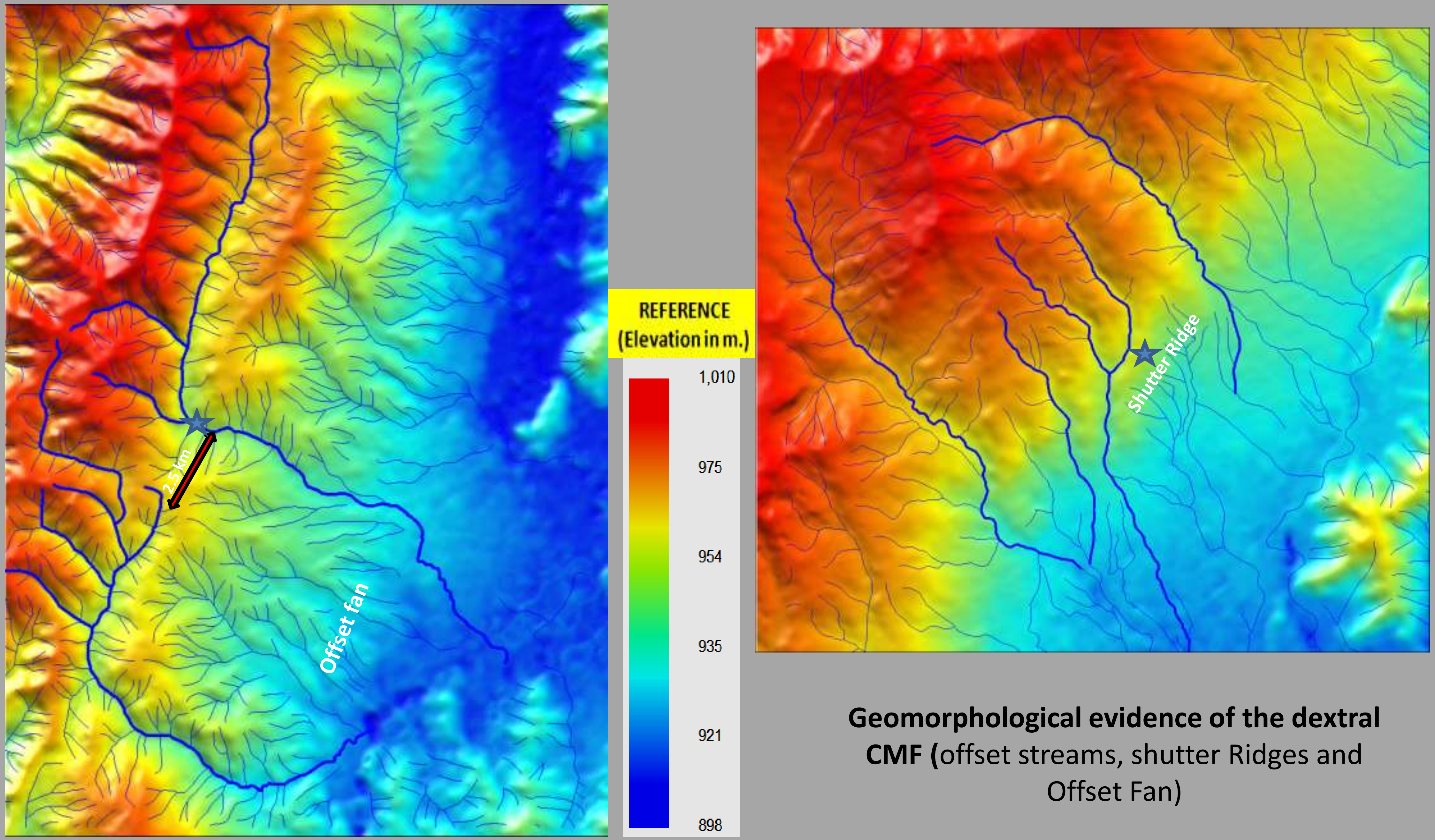
This shutter ridge represents a left lateral strike slip movement of about 1.2km An additional 2.5 km m left lateral displacement can be deduced from the offset of the first order streams that drain towards it.

There is no evidence for young deformation in the sedimentary fill of the small basin, however, the lithological nature of this clay-rich sediment can prevent the preservation of any sedimentary or tectonic structure.

A shutter ridge is a barrier formed across a stream-valley by tectonic activity, which blocks the downstream flow (Burbank and Anderson, 2001). The barrier can be formed by vertical (usually reversed) or lateral displacement. The blocked stream can change its course and flow around the barrier or it can fill the natural reservoir formed beyond the tectonic dam with sediments that accumulate up to the top of the barrier and then overflow.

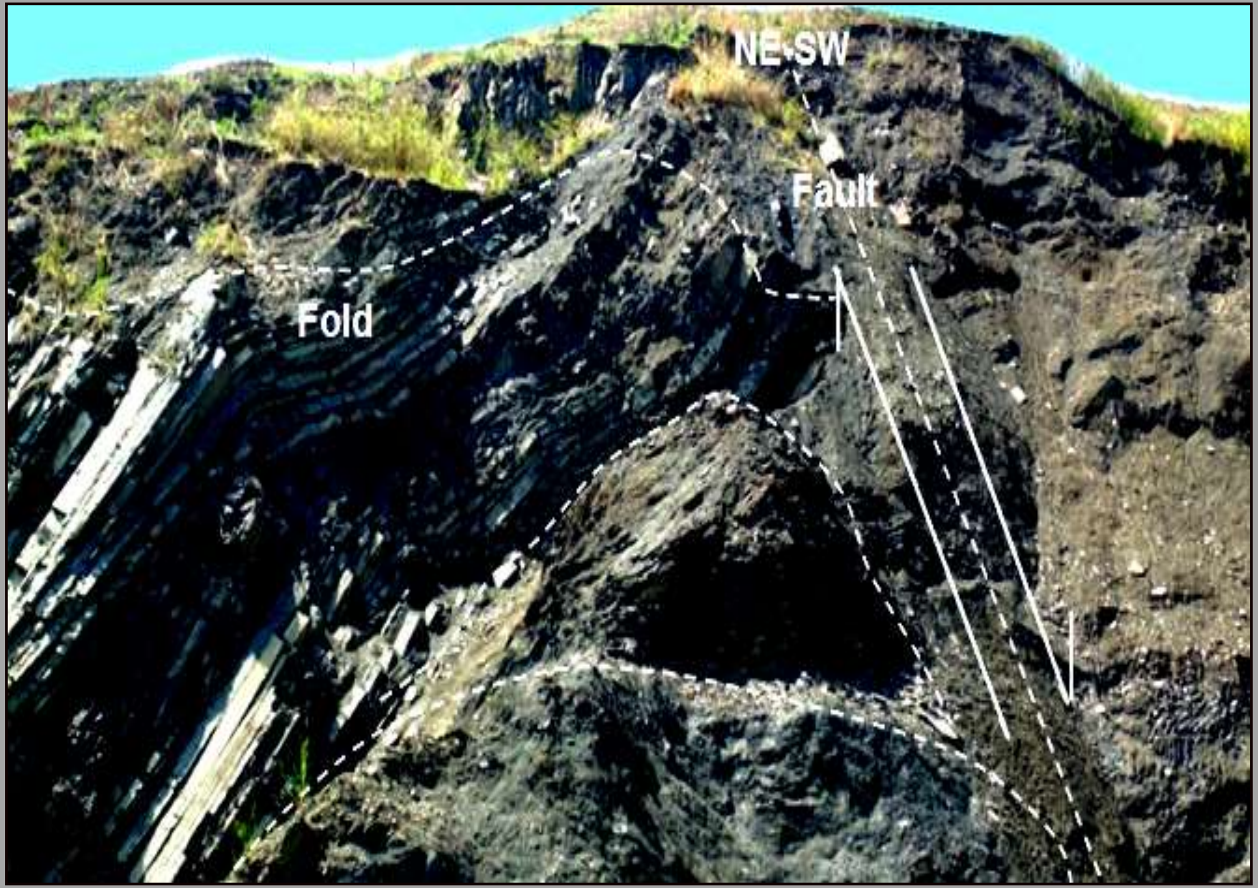
Two streams that had been blocked by shutter ridges are found along the Churachandpur Mao Fault (CMF). Based on offset stream channels, he estimated a horizontal displacement of about 2.5 km along this segment

Highly crushed zone along CMF in Churachandpur



★Field Photographs

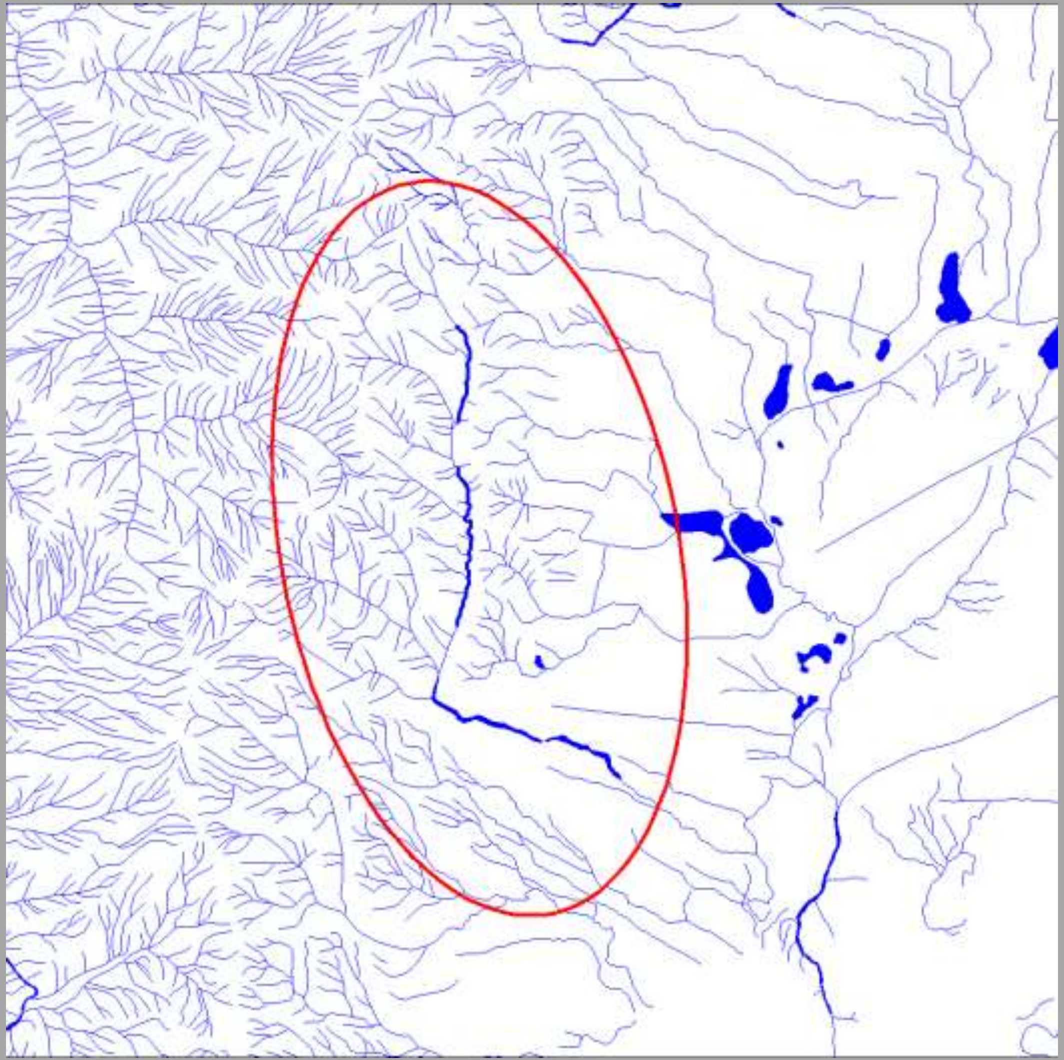
Geomorphological evidence of the dextral CMF (offset streams, shutter Ridges and Offset Fan)



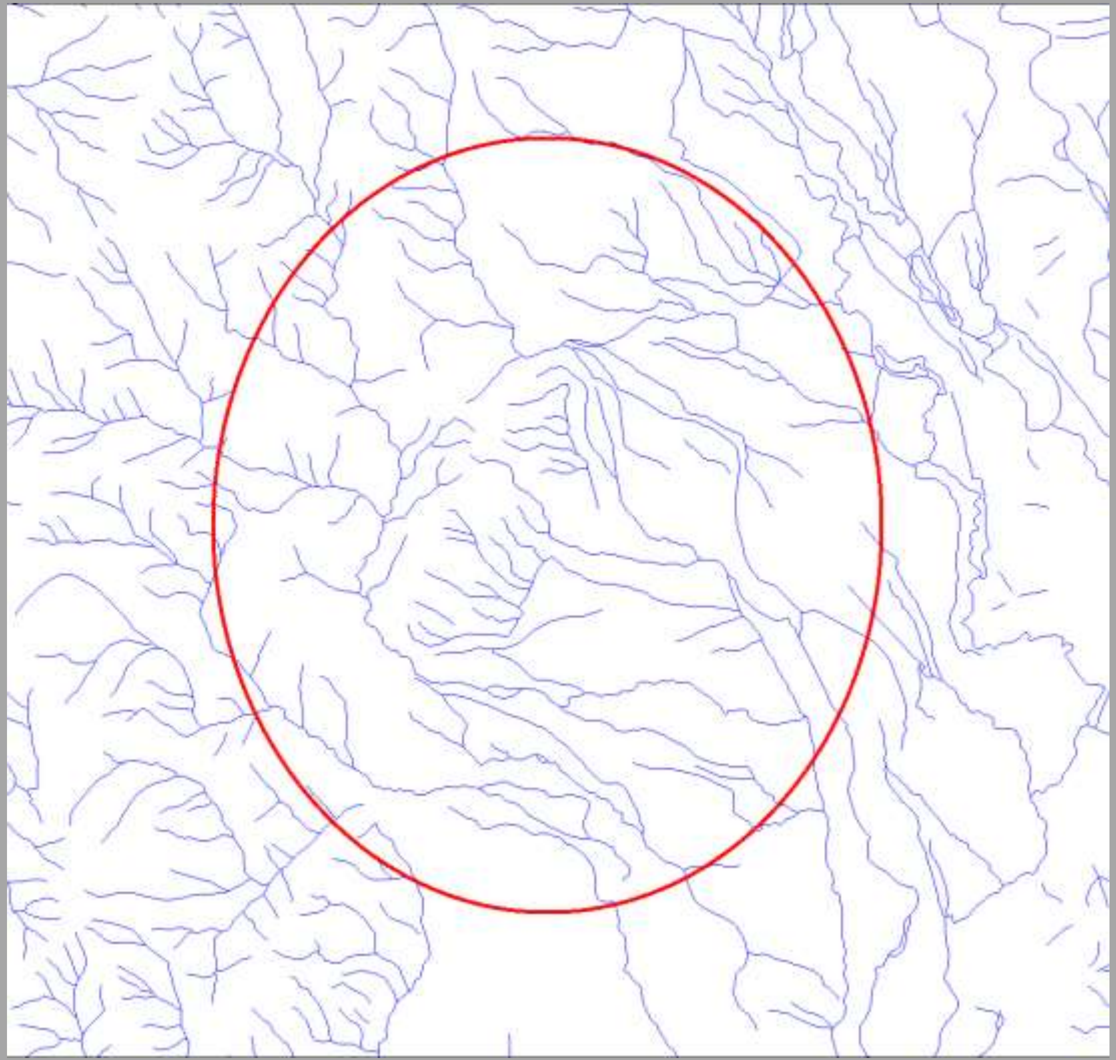
CMF traces along the surface


Approach road from Makhan village to Leimakhong on the Shutter ridge

View of the Shutter Ridge from the approach road



Right lateral bend of Thongjaorok River along the CMF



Right lateral bend of Singda River along the CMF

P-8 **Role of Lithology and Geological Structure in causing landslide in and around Kohima along the Road Section of NH-27 (Dimapur-Imphal Highway) and Landslide Hazard Mitigation**

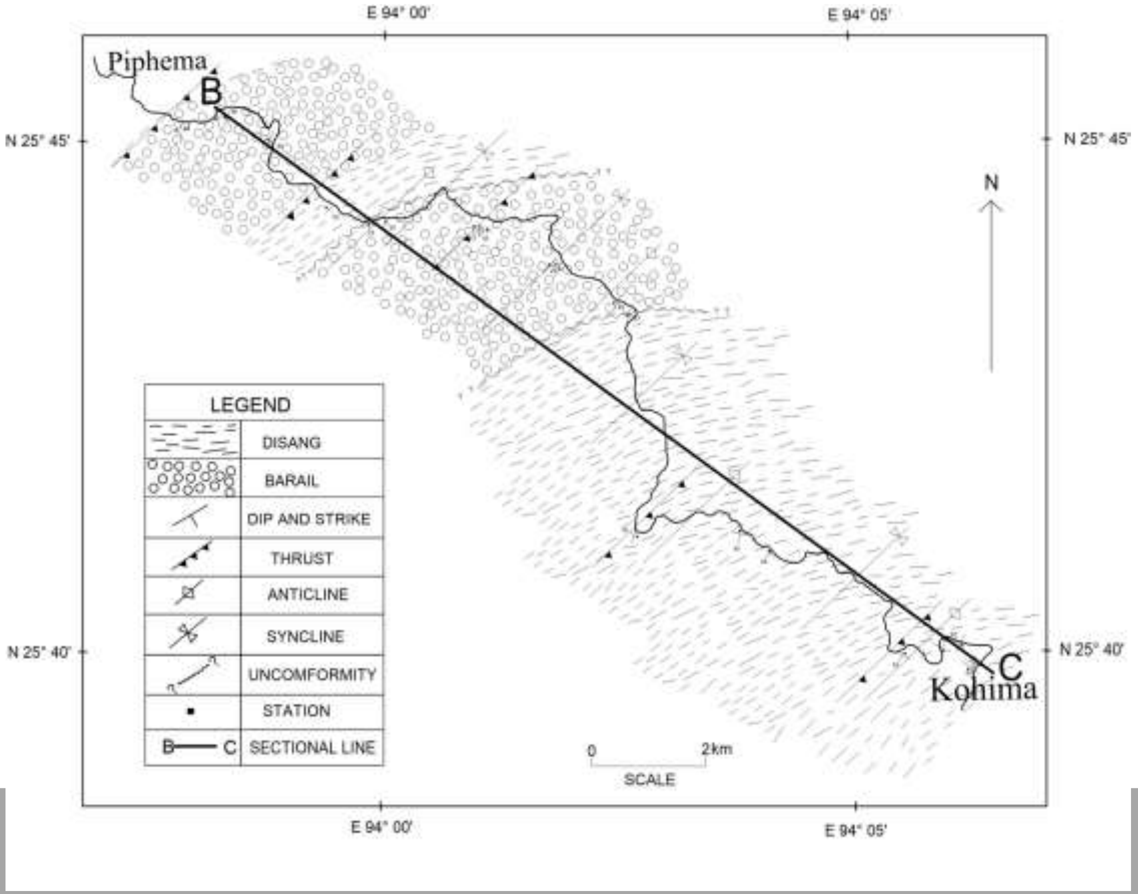
Principal Investigator:Dr. Ch. Mangi Khuman
Department of Geology Nagaland University, Kohima

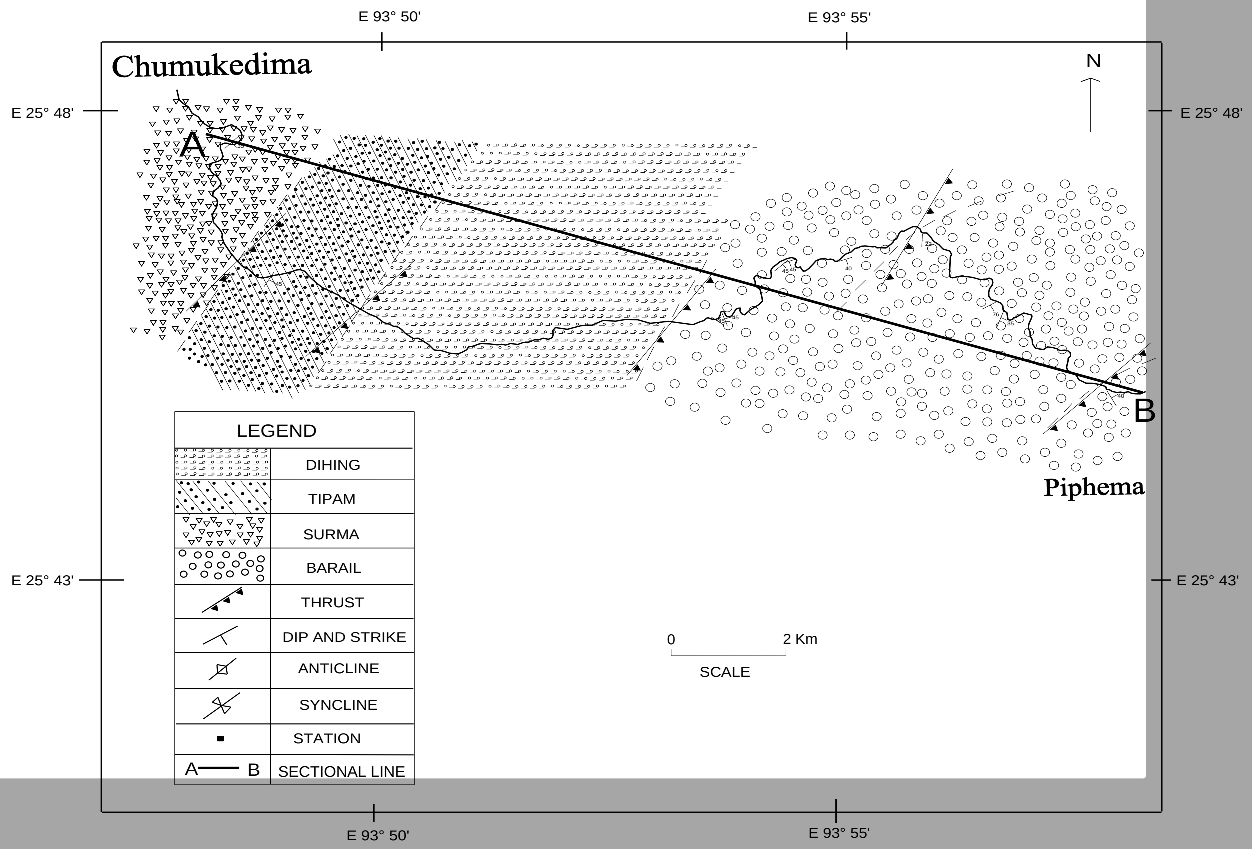
Preparation of geological profiles across various cross sections and identification of important structures causing the landslides

Litho-logging and Estimation of unconsolidated mass cover

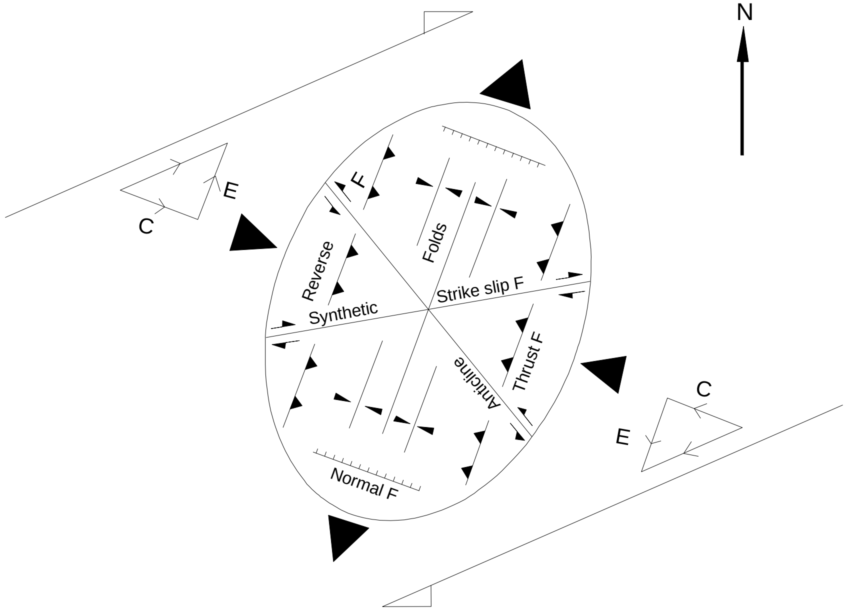
Evaluation of Mechanical Strength and Mass Rating of the Rocks for finding the cause of landslides

P-8


E 94° 00'
E 94° 05'
N 25° 45'
N 25° 40'
Piphema
B
C
Kohima
N
LEGEND
DISANG
BARAIL
DIP AND STRIKE
THRUST
ANTICLINE
SYNCLINE
UNCOMFORMITY
STATION
B — C SECTIONAL LINE
0 2km
SCALE


E 93° 50'
E 93° 55'
E 25° 48'
E 25° 43'
Chumukedima
A
B
Piphema
N
LEGEND
DIHING
TIPAM
SURMA
BARAIL
THRUST
DIP AND STRIKE
ANTICLINE
SYNCLINE
STATION
A — B SECTIONAL LINE
0 2 Km
SCALE

P-8



C - COMPRESSION MOTION VECTOR

E - EXTENSION MOTION VECTOR

P - PLATE MOTION VECTOR

Fig.: Dextral shear deformation mechanism of the IMR

Photograph showing close joints in the thinly bedded sandstone. Little disturbance makes the rock crumble down because of the closely spaced joint and bedding planes

RAINFALL INDUCED LANDSLIDE HAZARDS AND FORCAST AND PREVENTION

P-10

Dr. Devesh Walia, Project Investigator, Department of Environmental Studies, NEHU

- Geomorphologic and structural mapping
- Microscopic study of thin section of various rock types for determining the nature of rock types – porosity-permeability
- Shear strength studies and geotechnical properties and analysis.
- To estimate the threshold levels of rain in triggering landslides in different sections of highways.

Progress

To estimate the threshold levels of rain in triggering landslides in different sections of highways, the weather parameters such as rainfall data, daily temperature, Pressure, Relative Humidity, Vapour Pressure etc. was collected from IMD, Guwahati (from 2015- May 2019). One weather station has also been installed at Barnyhat, Meghalaya.

The rock samples for the microscopic studies has been prepared but thin section for determination of rock type- porosity-permeability is still to be carried out.

P-10

- ➢Further Microscopic Study for determining the nature of rock types-porosity and permeability.
- ➢Further analysis of soil and rock mechanical properties and relationship with slope failures.
- ➢Soil Moisture Variation data of the Study area with every rainfall- balance is also to be prepared.
- ➢Preparation of final report of the project

Recommendations for Networking Projects in NE India

1. Prof. Arun Kumar highlighted the importance of landslides R&D programme in the context of the pace of development in NE region particularly, with reference to infrastructure development. He hope that the DST programme of Landslide Hazard Mitigation would be of immense help in mitigation of the impact of landslides in this region and also develop the scientific capability for undertaking such investigations. He apprised the PI's about the use of **Drone in the Landslide/ terrain mapping**.
2. The information disseminated through the **whatsapp group** was appreciated as the members have been getting the recent information and work with reference to the Landslides in the region. He stressed that all PI's will ensure their inputs to him from time to time for DST meetings so that he is able to make presentation on their behalf and getting any support.

3. Dr. Bhoop Singh, Head, NRDMS ,DST ensured all the support from DST for implementing all the R & D projects in this programme. He also appreciated the mapping devices like drone in large scale mapping including landslide which is quick and precise and give comprehensive view of the targeted area. The drone given to Manipur University will be comprehensively used by all the PI's on demand and hiring basis.
4. Dr. Singh emphasized the need to develop a website in Manipur University on this program with the inputs from all the PI's. Prof. Arun Kumar will coordinate this activity. To receive the inputs from the PI's a template will be developed and integrated inputs will be uploaded on the website. The training programmes on Large Scale Mapping conducted by the MU to all the PI's and project staff will provide good basis to carry out the further work.

Capacity building, overall coordination of various projects under Networking programme on Landslide Hazards Mitigation in NE India

Prof Arun Kumar requested to DST officials for approving the appropriation of Recurring Expenses

As per the DST approval a post of JRF was sanctioned with 6.6 L for financial support for two years. As a coordinator of this project the basic role was to organise meetings, training programs etc. Since PI have PG students in the Department lot of work conducting training and other coordination task was done with the help of PG students therefor no regular JFR was appointed However the exclusive meeting for PI's organised in NEHU, Shillong in June 2018 and Geotechnical Training program for all PI's in February 2019 at IIT Guwahati and review meeting with large scale mapping training program in September 2019 at MU Imphal, PI has incurred an expenditure to the tune of 3.50 L. Since there was a saving of the salary of the JFR such expenditure may be met out from the project fund with out and escalation of the funds. For subsequent training programs and training program also the PI may be allowed to utilise the saving of the salary head of the JRF may be utilised.

General Recommendations:

1. The review meeting should be held every six months so as to build up the seriousness in the research activities.
2. The new technologies like drone, high resolution satellite images and other data acquisition techniques like InSAR, ALTEM may also be explored for supporting the further R&D projects. For this a Brain Storming session can be organised after Six months. The funding of Rs 5.0 Lakhs may be given by DST.
3. The impact of Landslide investigations is not realised as yet in terms of the stake holder's requirements. May be joint meeting with stake holders and PI's can be held to show case the R&D outputs and the feedback from the stake holders about their utility.
4. R & D investigations of landslide is the continuous process, DST may continue to evolve and support such R & D activities in NE region after the present program is over. For that more experts and participants be invited to discuss the research gap areas. This process will help in developing the expertise, capacity building and skill development in this part of the Country.
5. All the projects are recommended for extension till December 2020 to bring them to logical conclusion. This is based on the requests made by all the PI's during monitoring meeting.
6. The re-appropriation of the budget for the salary of the JRF (under P12) is recommended for meeting the expenditure for conducting Trainings and subsequent review meetings