

# Present Status of Landslides in Nepal and way forward

**Kabi Raj Paudyal, PhD**

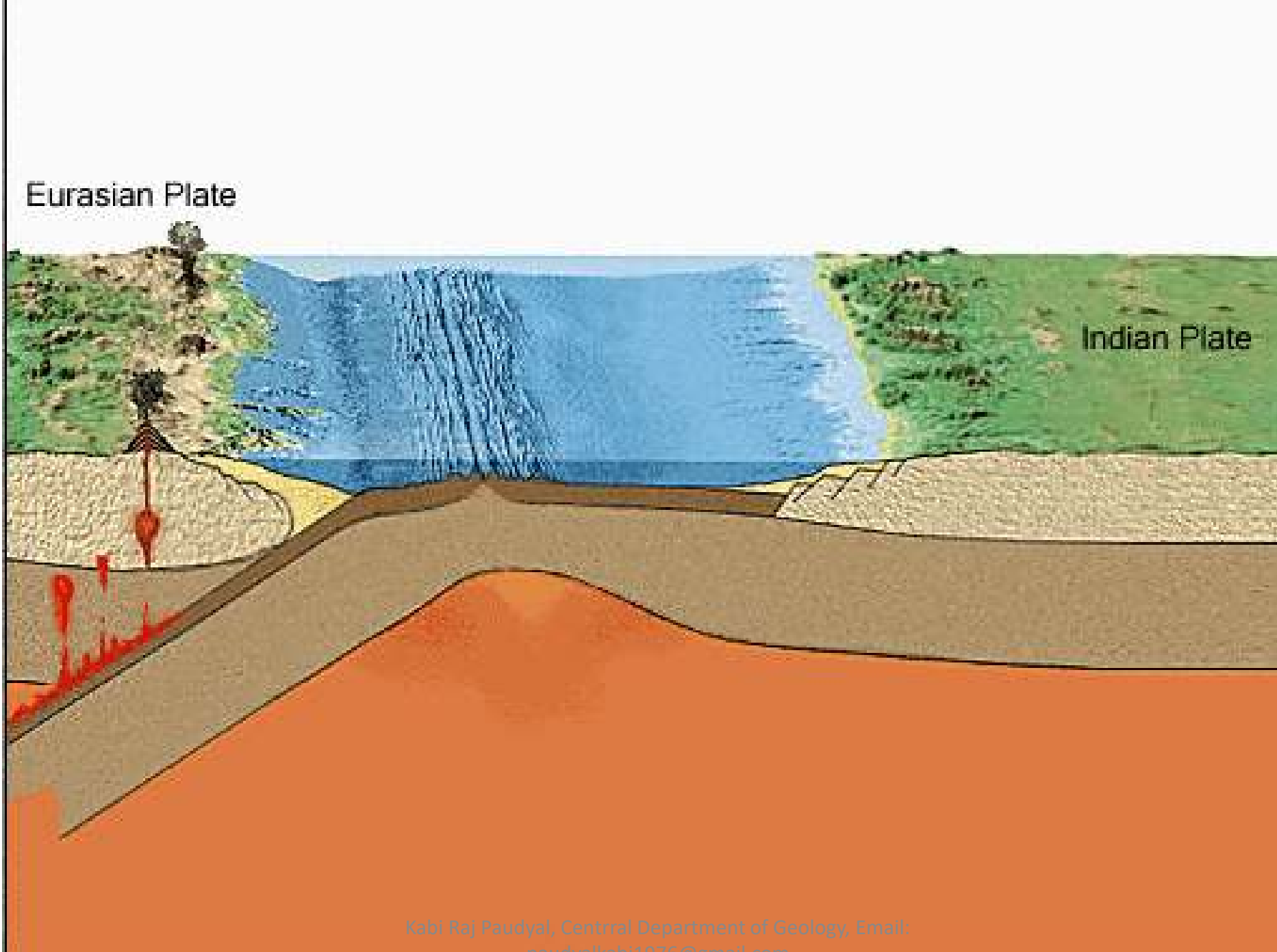
Coordinator: Master in Engineering Geology Program, Central Department of Geology

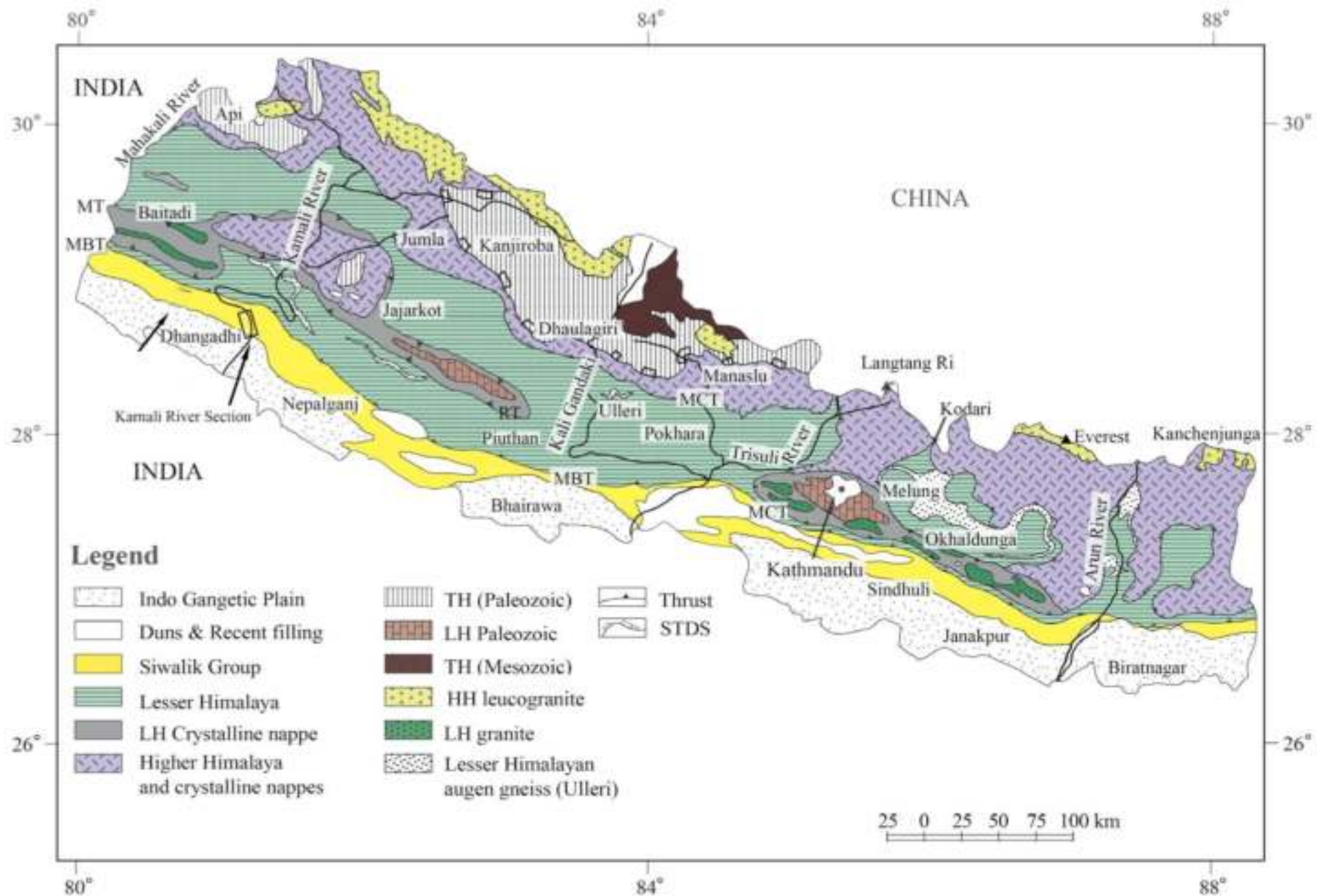
Immediate Past President: Nepal Geological Society.

*PhD Research: Geological Map and Tectonics*

## **Ongoing Research**

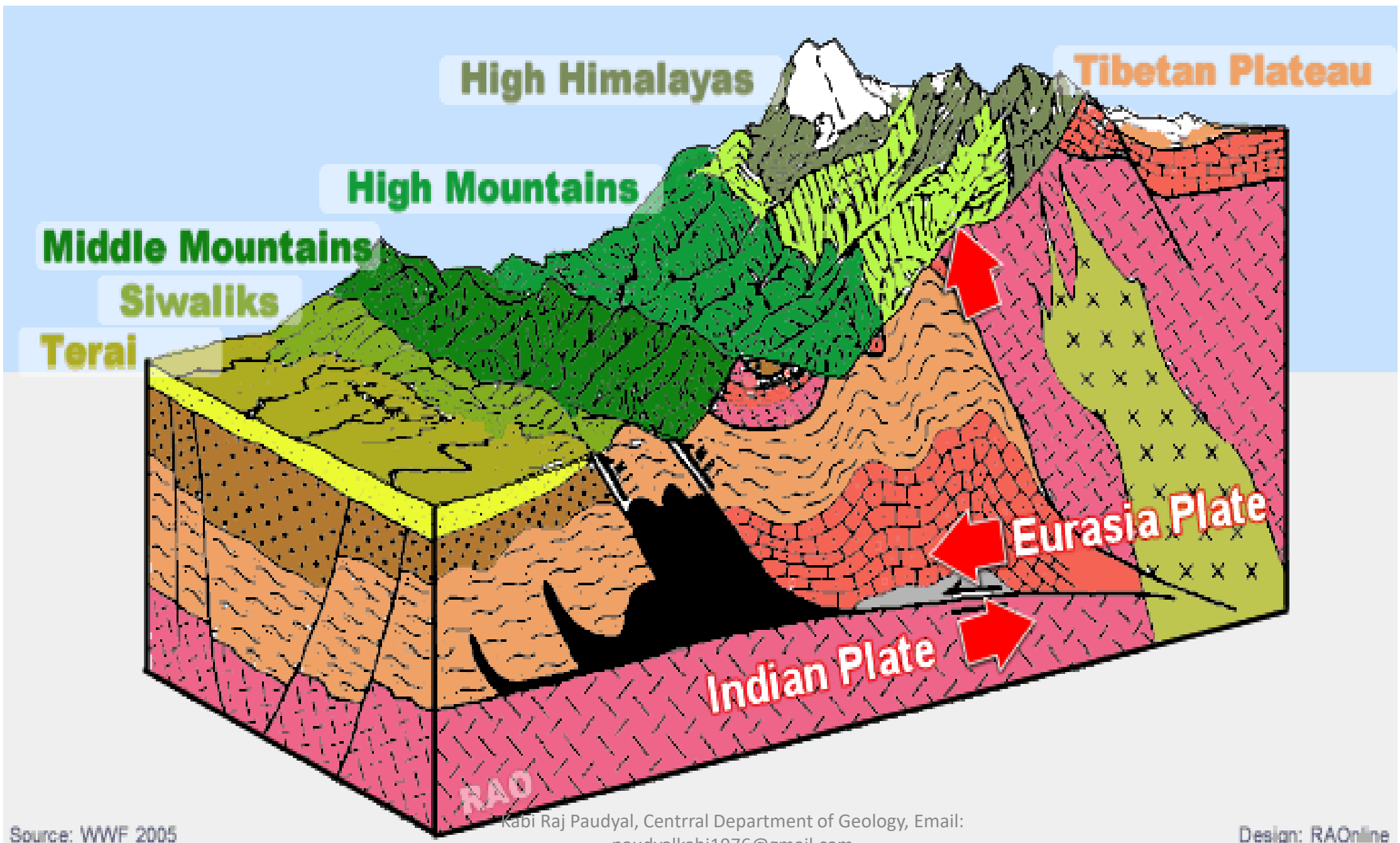
1. Mapping of Active faults in Nepal
2. Geological Sensitivity Analysis in Chure-Bhabar-Terai Regions
3. Mountain Aquifers in Hilly Regions
4. Mineral Resources Mapping

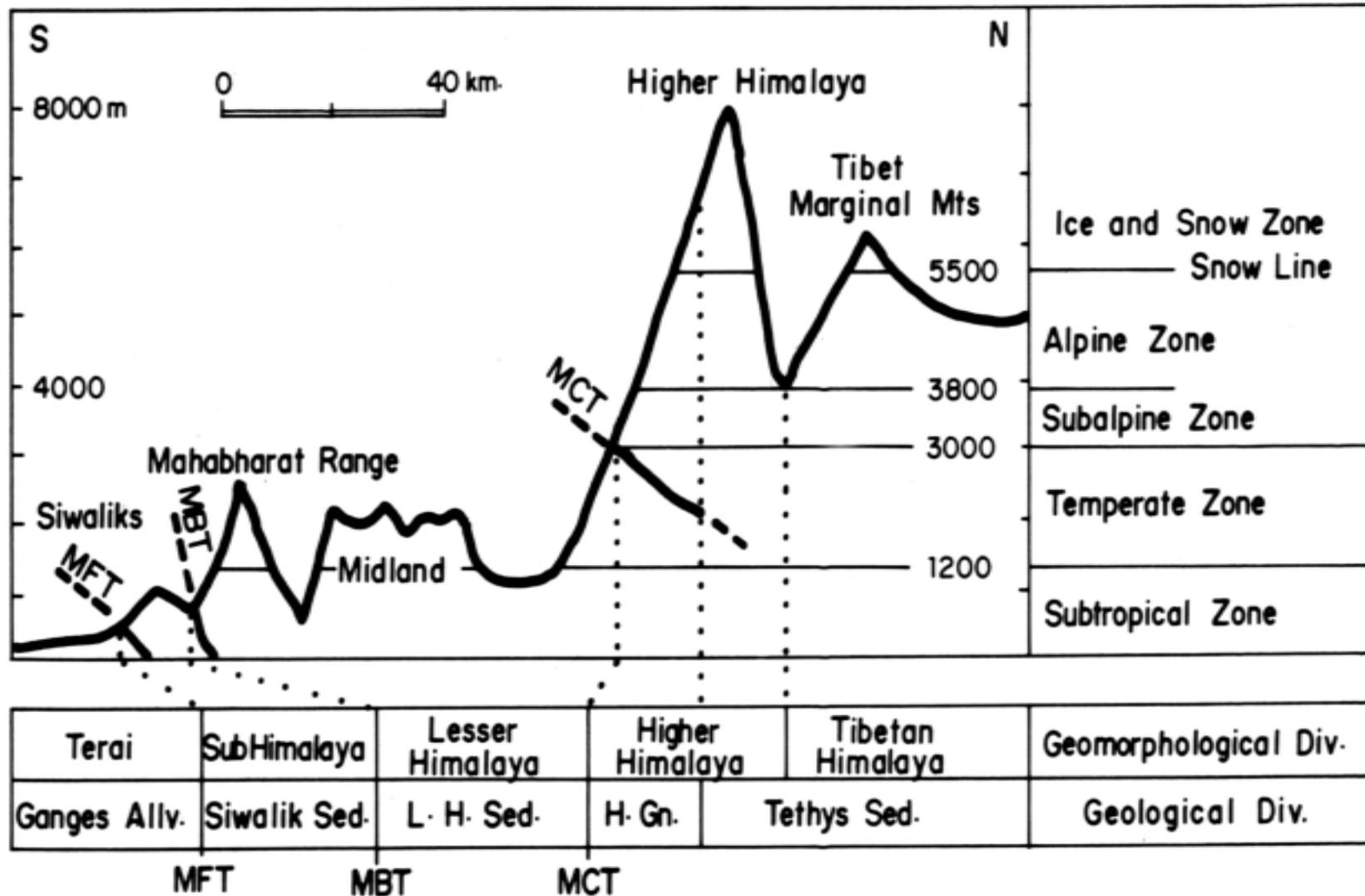




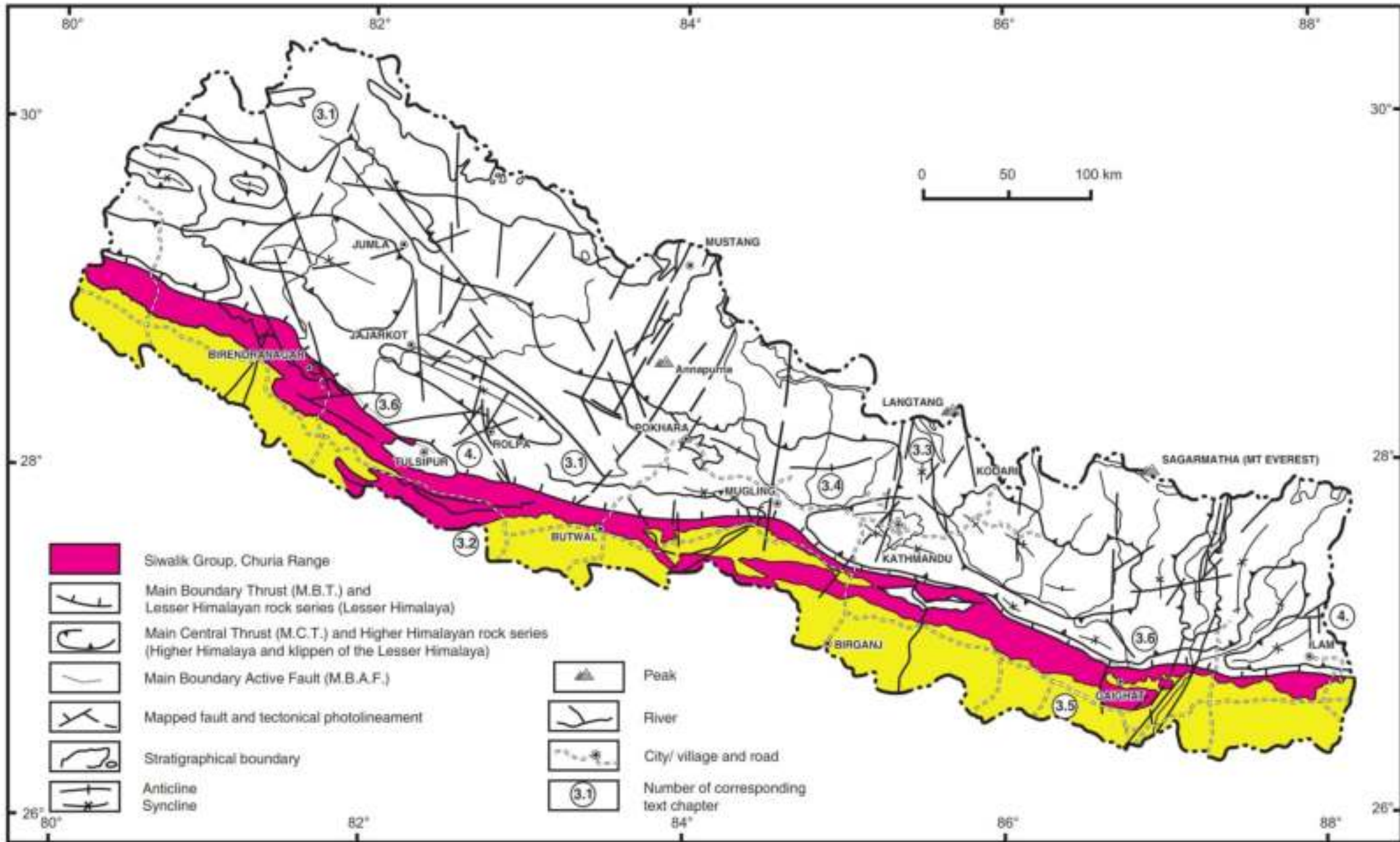
**Geological Map of Nepal (modified after Upreti and Le Fort, 1999)**

Kabi Raj Paudyal, Central Department of Geology, Email: paudyalkabi1976@gmail.com





**Fig. 1. Simplified cross section of the Himalayas. MFT: Main Frontal Thrust, MBT: Main Boundary Thrust, MCT: Main Central Thrust.**



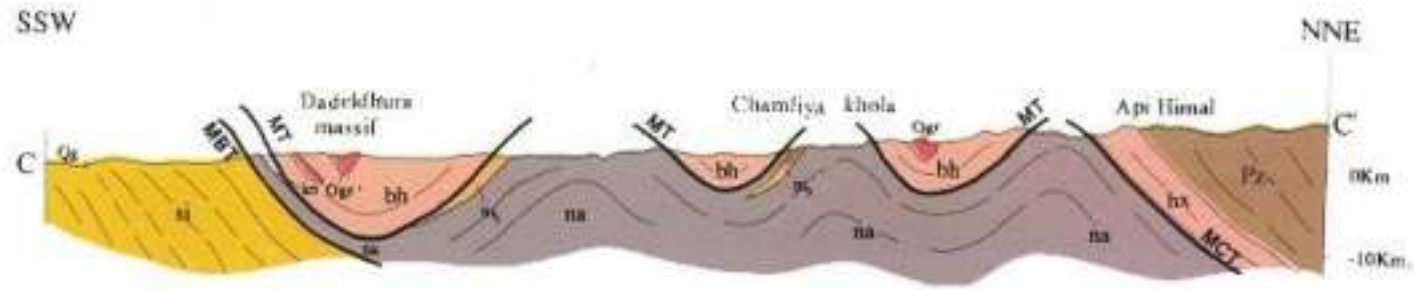
Schematic tectonic map of Nepal based on 1: 1,000,000 scale Geological map of Nepal (Amatya et al., 1998) and satellite image interpretation

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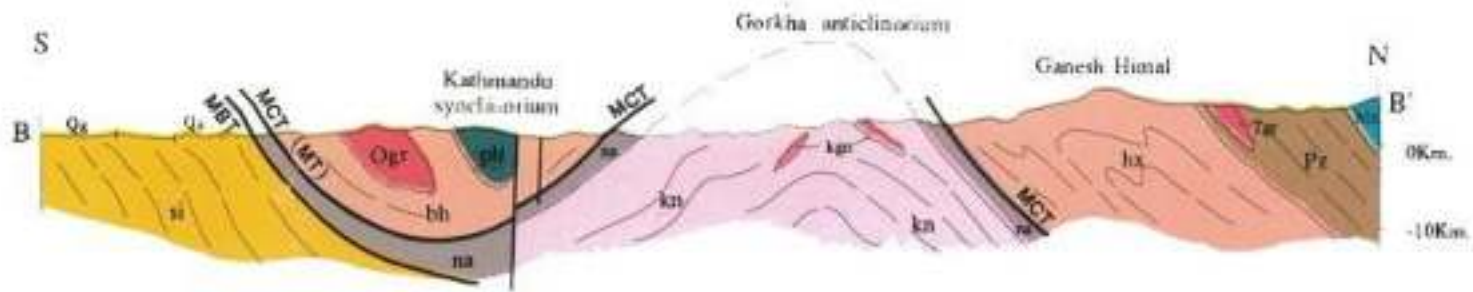
paudyal.kabi1976@gmail.com

# Active Faults of Nepal (Modified after Hoppe et al., )

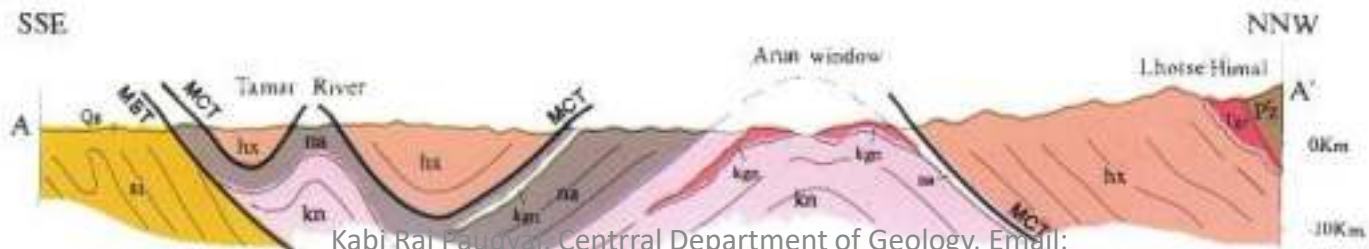
# GEOLOGICAL SECTION (Amatya and Jnawali, 1994)



Western Nepal



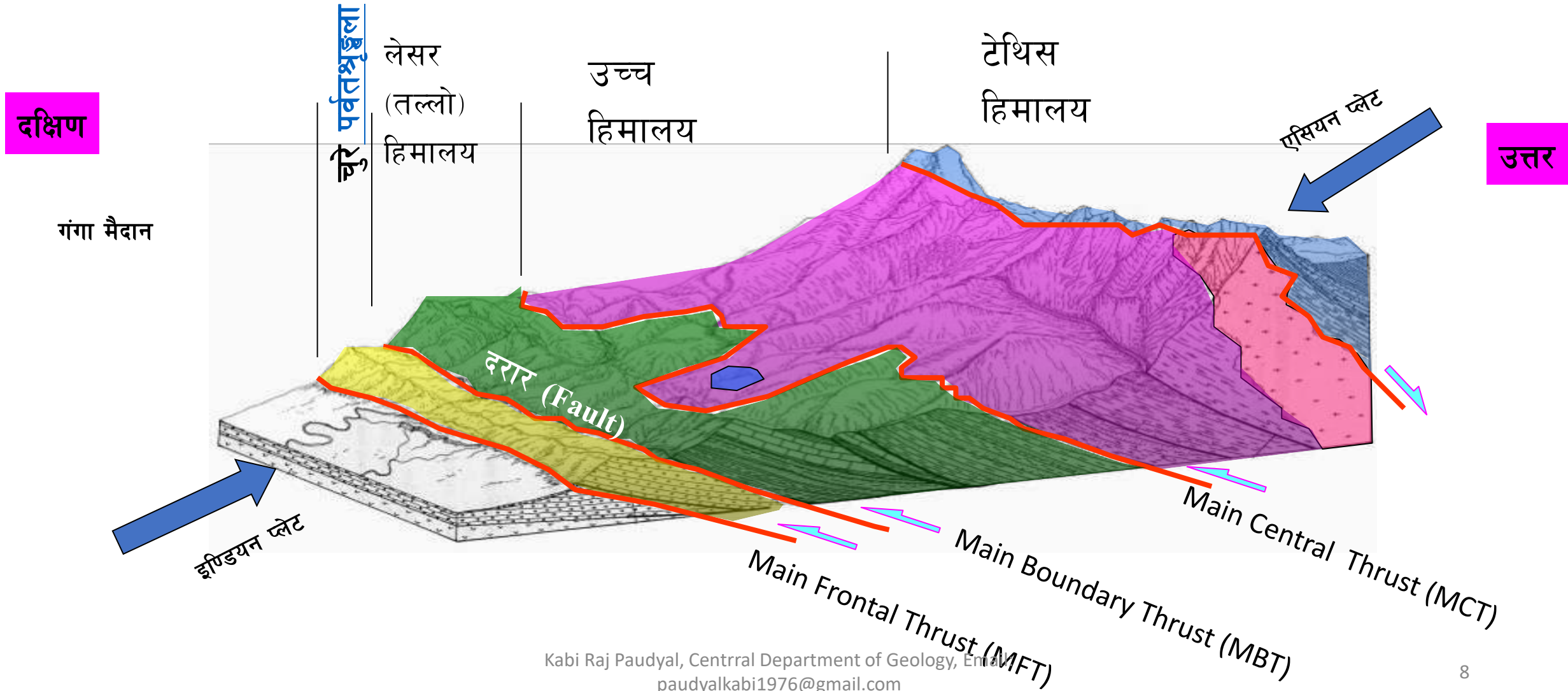
Central Nepal



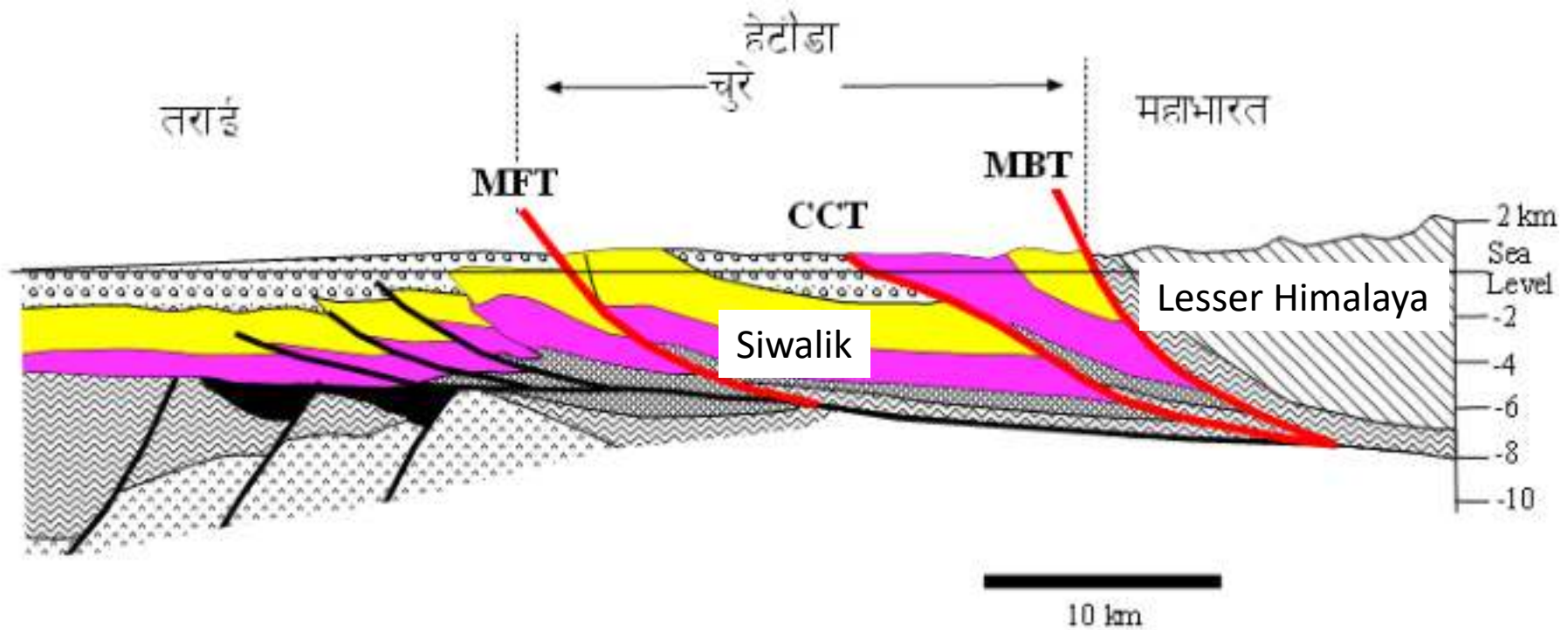
Eastern Nepal

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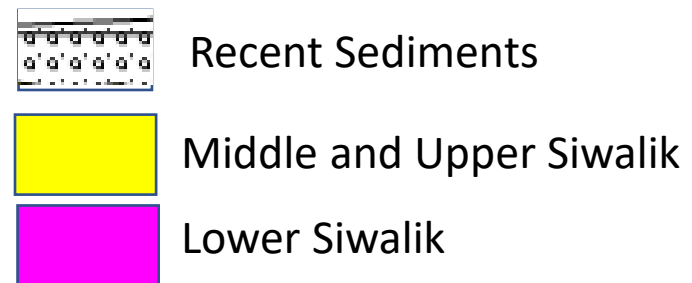
# नेपालको भौगर्भिक संरचना



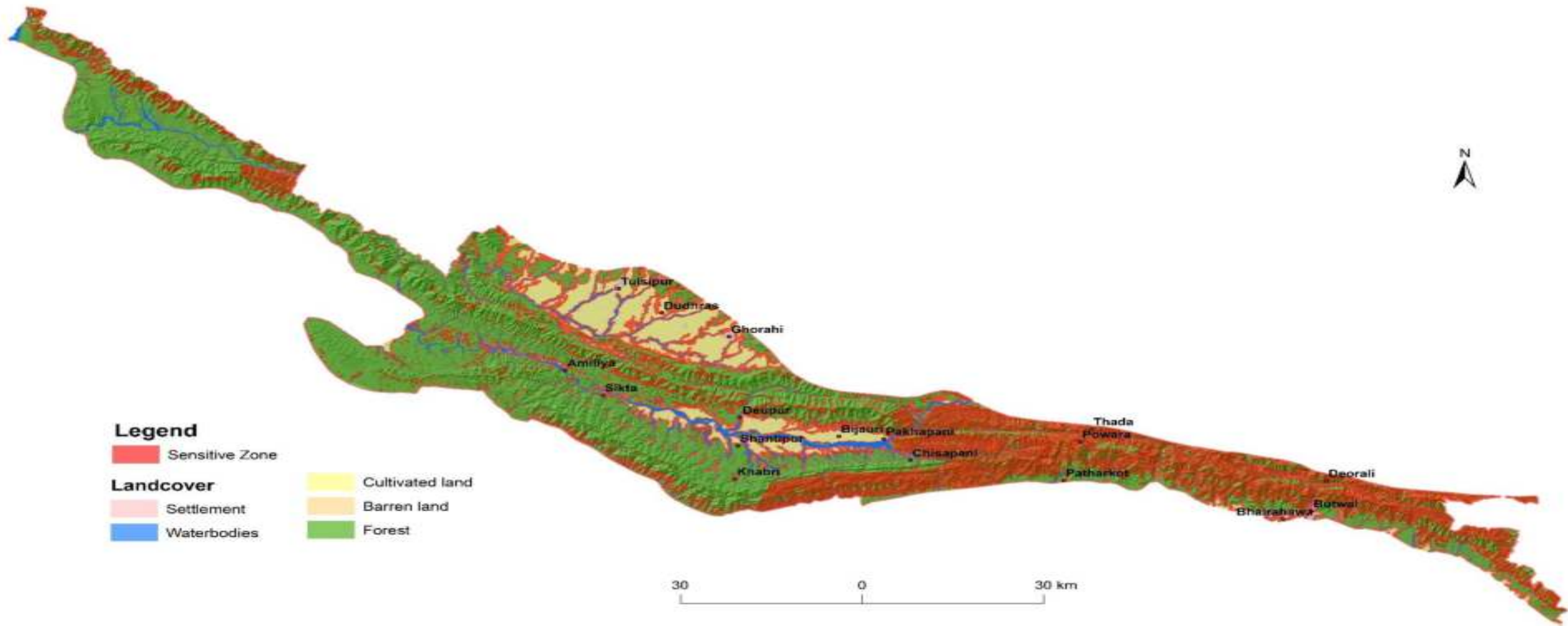




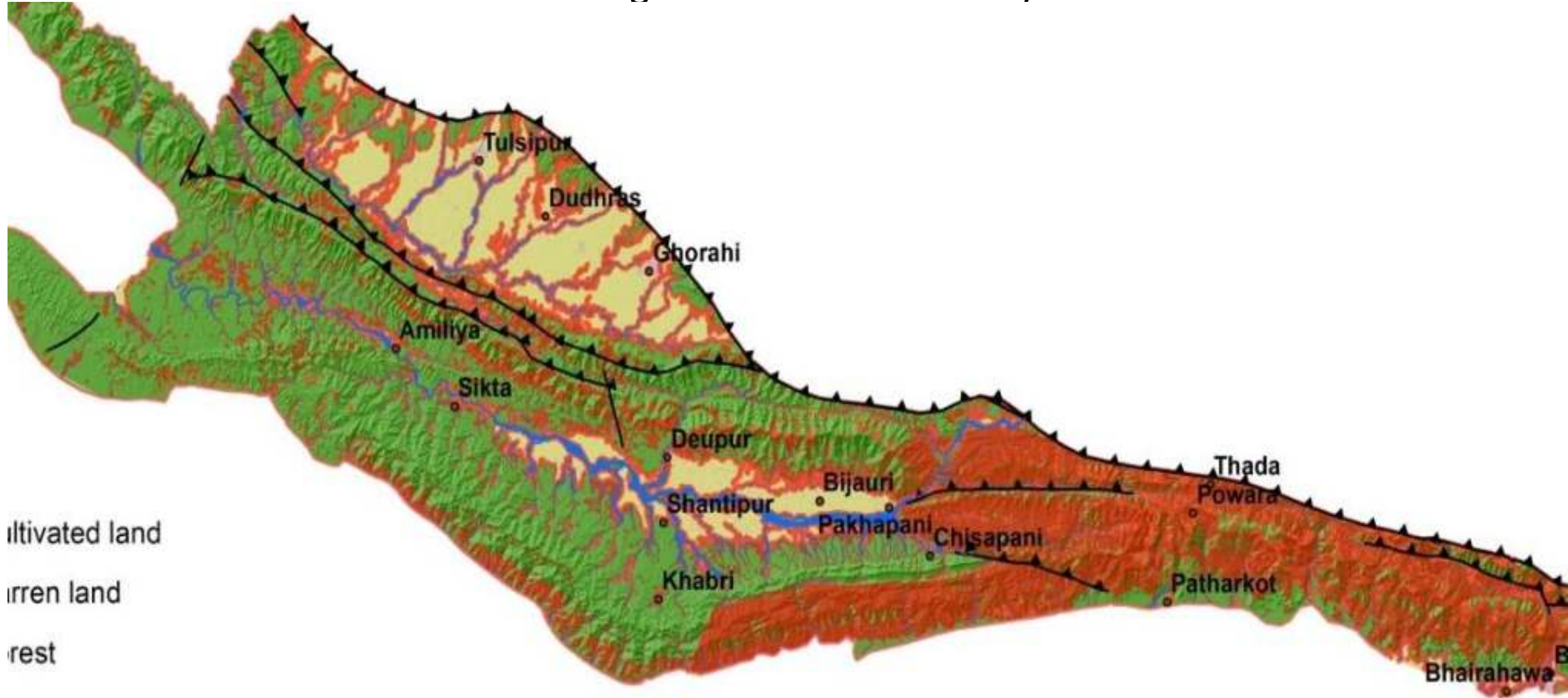
CCT: Central Churia Thrust  
 MFT: Main Frontal Thrust  
 MBT: Main Boundary Thrust



# Regional Geological Sensitivity Map of Province No.-5



# Geological Control of Sensitivity



# Natural Disasters in Tectonic Units of Nepal

Tectonic Unit	Geodisasters
Indo Gangetic Plain	Inundation, Flood
Siwalik	Landslide (mostly rock fall), Erosion
Lesser Himalaya	Landslide, LDOF, land subsidence
Higher Himalaya	Landslide (Mostly rock slide), GLOF
Tibetan Tethys Himalaya	Less common landslide (failure of colluvial and morainic material on steep valley slope)

**But most of the perturbation is controlled by adverse geological structures.**

# Control of Landslide

- Cloud burst induced landslide
- Structure induced landslide
- Earthquake induced landslide

## **Potential region for frequent landslide occurrences**

- River bank due to toe cutting by river
- Haphazardly constructed roadways
- Area proximal to Active fault
- Steep slope covered with soil

# Landslides Types

Different landslide types can be identified as shown in following Figure (USGS, 2004)

**Falls:** Rock falls, Debris falls, Earth fall

**Topples:**

**Slides:**

Rotational slides

Translational slides

Slumps

Lateral spreads

Flows

Rock flows

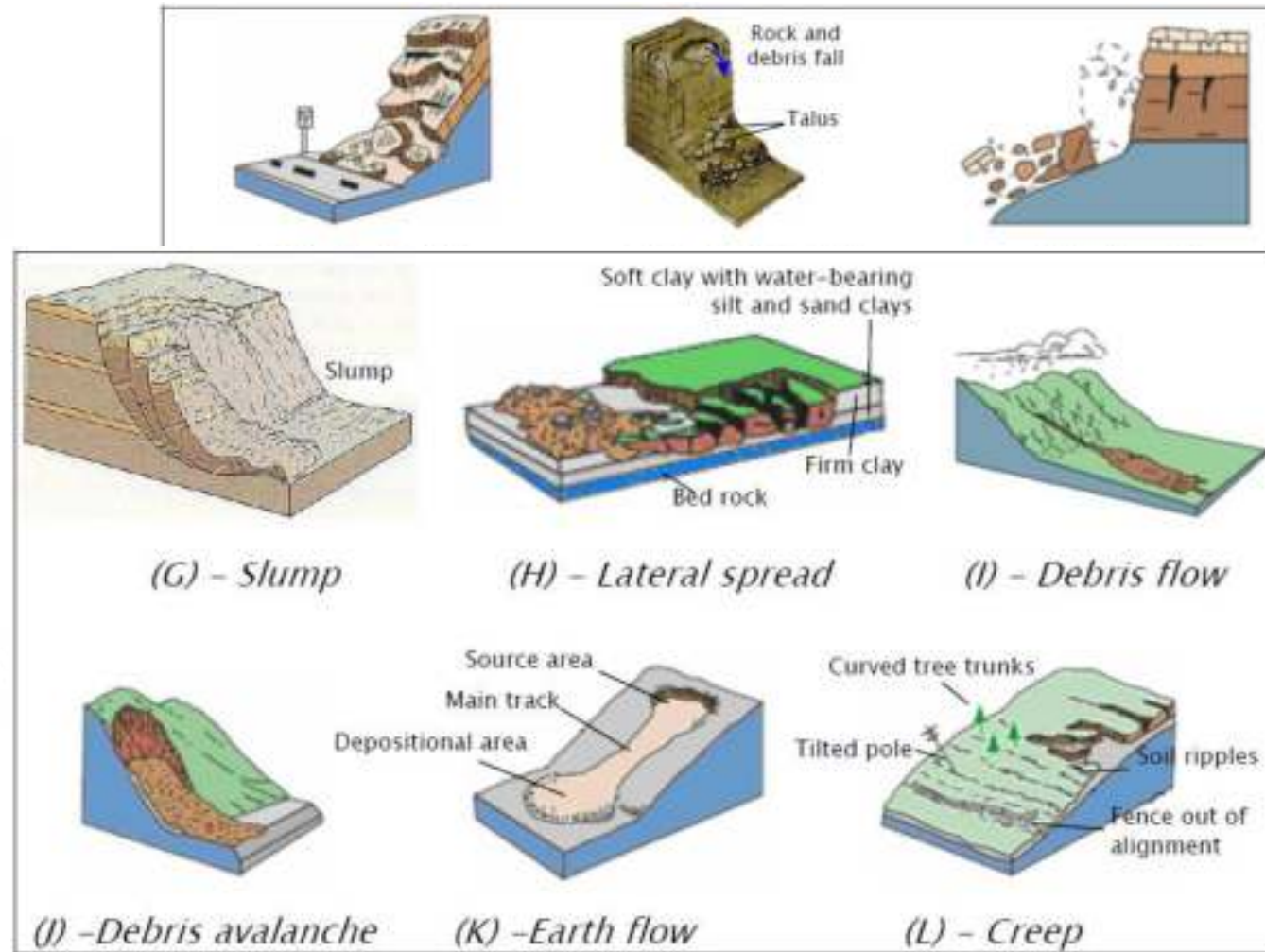
Debris flowing

Debris avalanches

Earth flows

Mud flows

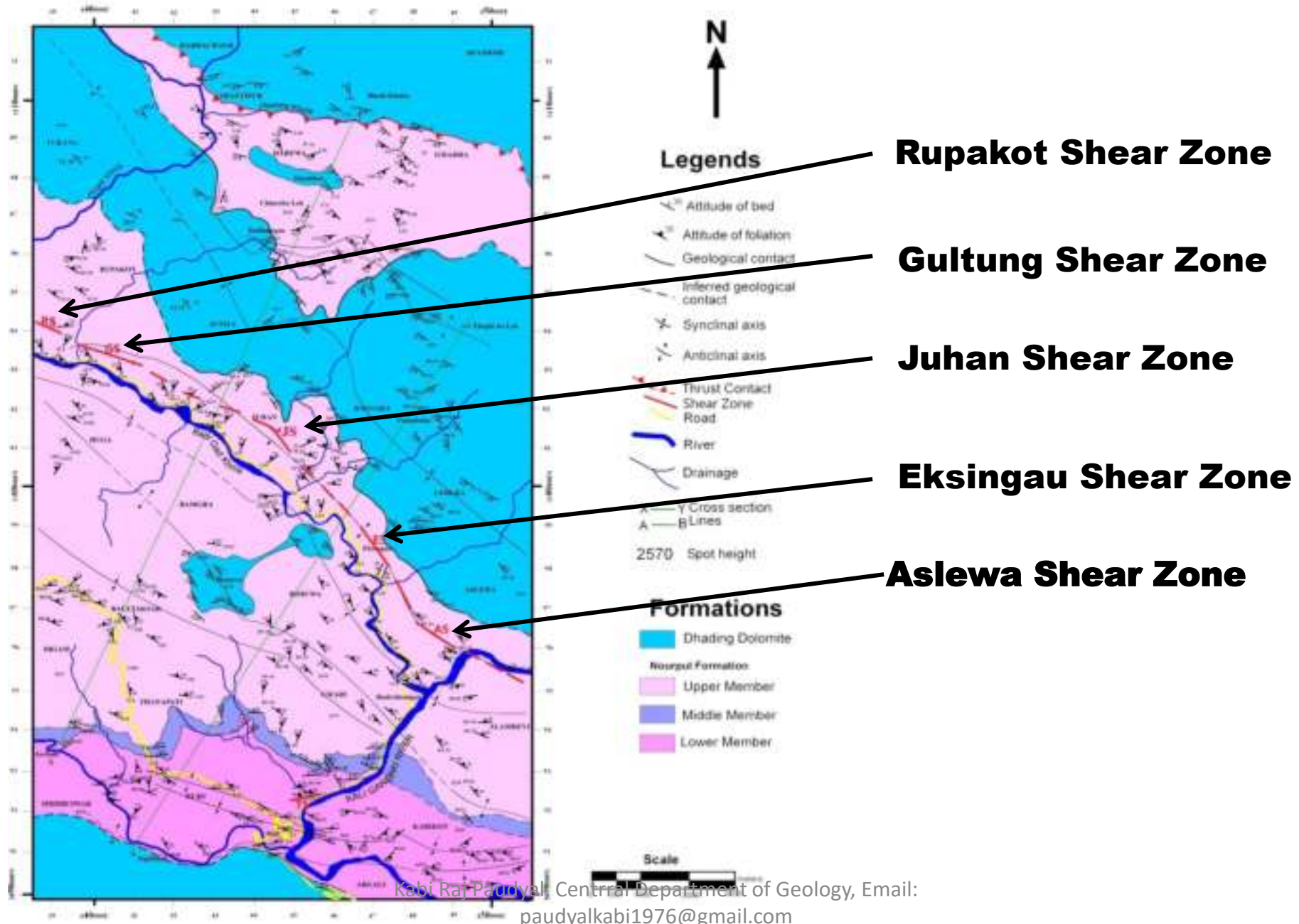
Complex movements



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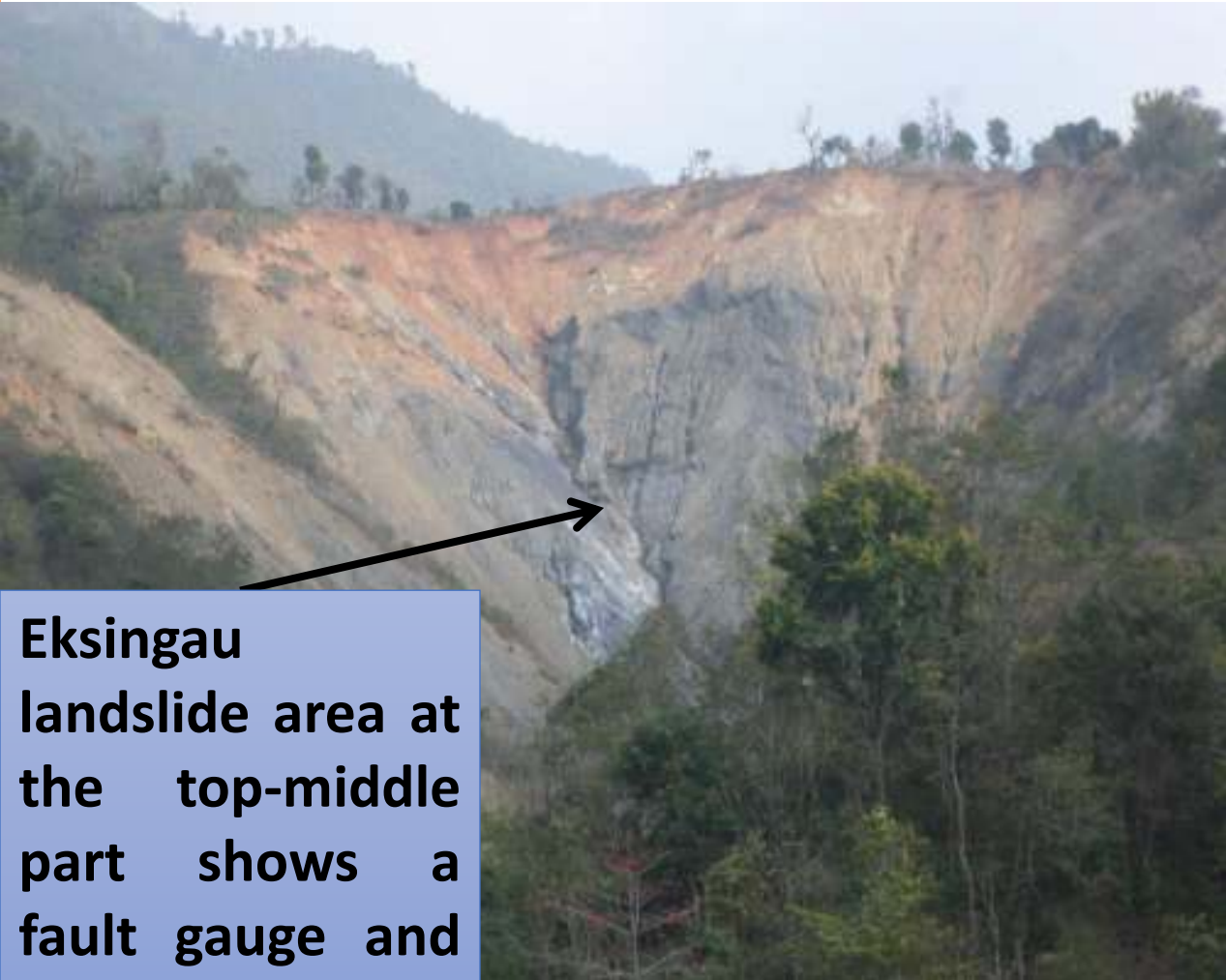
Schematic illustration of the major types of landslide movement (USGS, 2004)

# Geological Map of Ridi-Shantipur Area



**Eksingau Shear Zone (ES):** The Eksingau Shear Zone lies in the village of Eksingau and Pipal Dada area of Limgha VDC. In this area, a large active landslide is observed. In the middle part of landslide, fault gauge is observed.

## Development of Eksingh Pahiro



**Eksingau landslide area at the top-middle part shows a fault gauge and slickensides**





# Juhan Shear Zone



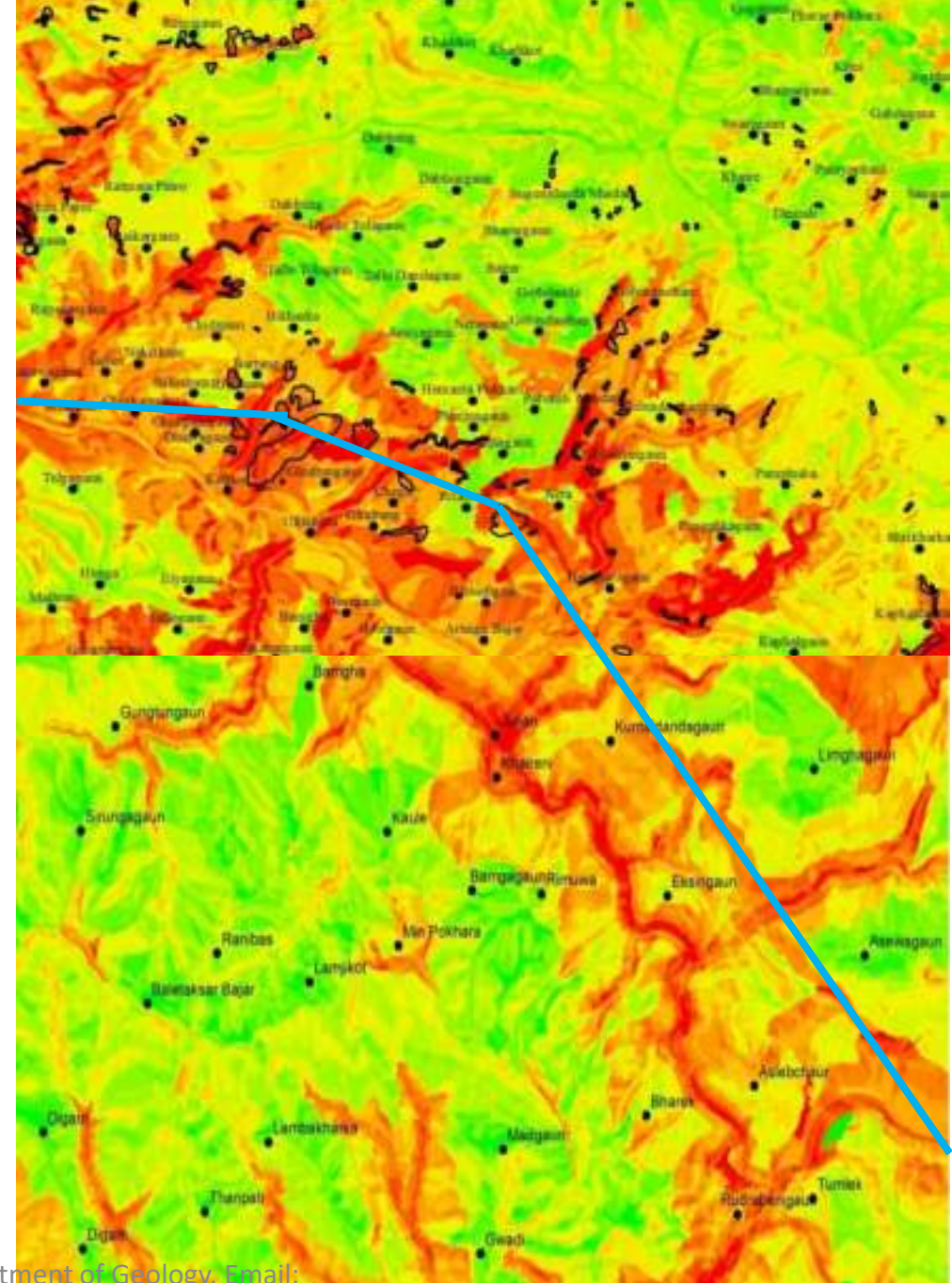
# Ulli Khola Shear Zone



**Rupakot Shear Zone (RS):** lies in uphill section of Rupakot VDC. In this shear zone a large landslide occurs. At middle part of this landslide has a wide zone of fault gauge and a number of slickenside were observed.



**Outline of Rupakot landslide**



- Google earth clearly shows the extension of the Badi Gad Fault in the present study area which is also verified in the field.

## Displacement of Terraces (Terrace Tilting)





**Fig : landslide**



**fig : lake formed by landslide**

**Source: Prativa**



**Fig: lake before outburst**

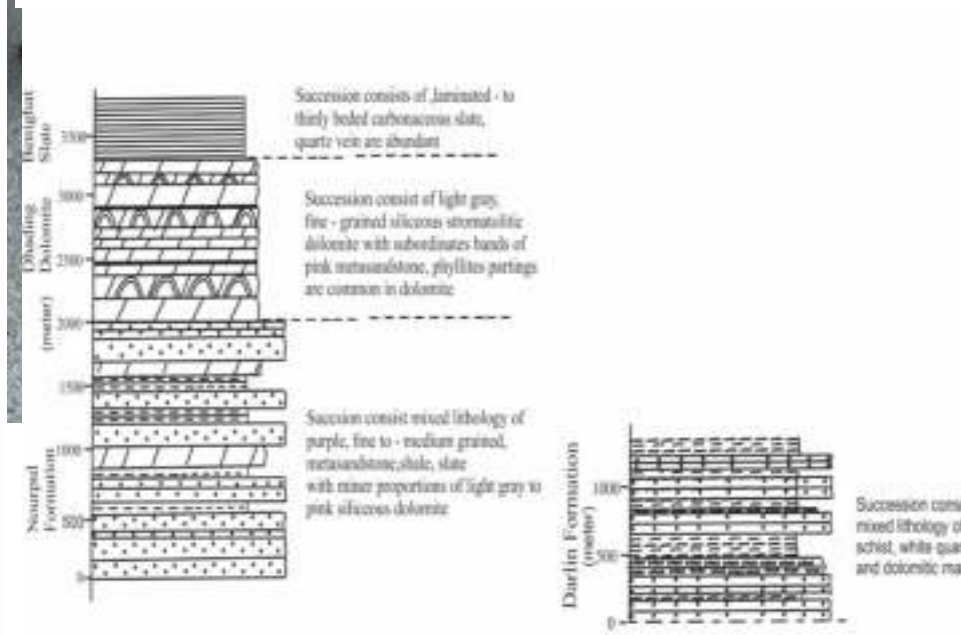
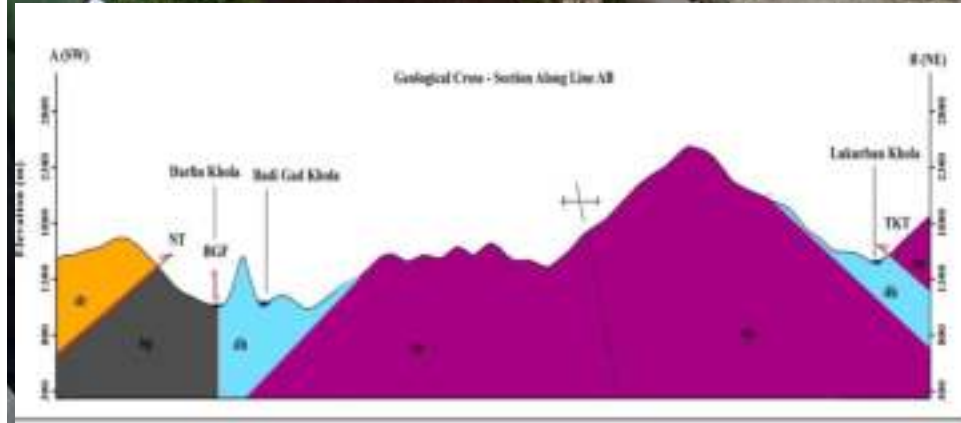
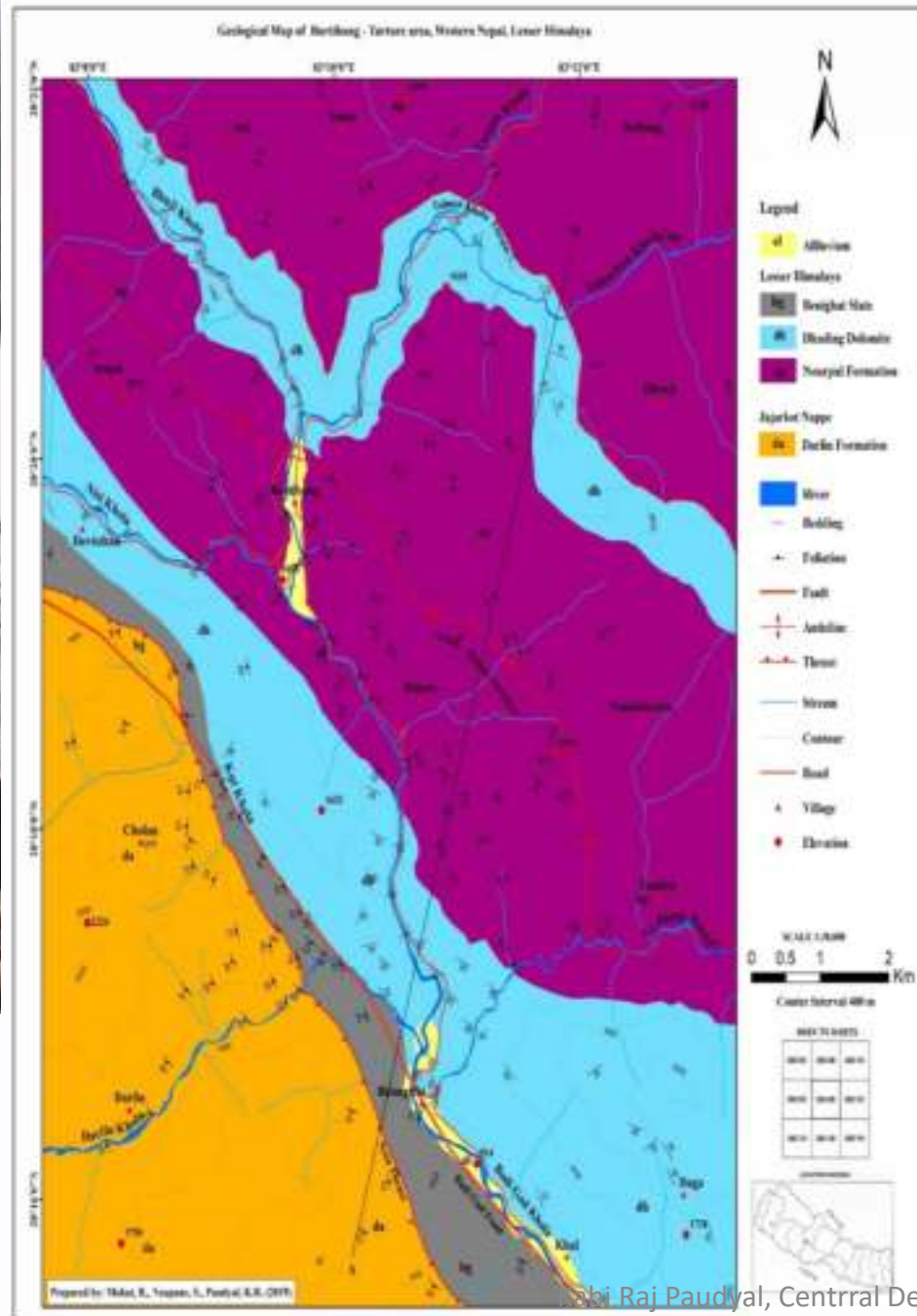


**fig: lake after outburst**

**Source: Prativa**



# Geological map of Burtibang – Turture Area



iral failure of

Fig. Generalize stratigraphy of the study area

# Turture Landslide

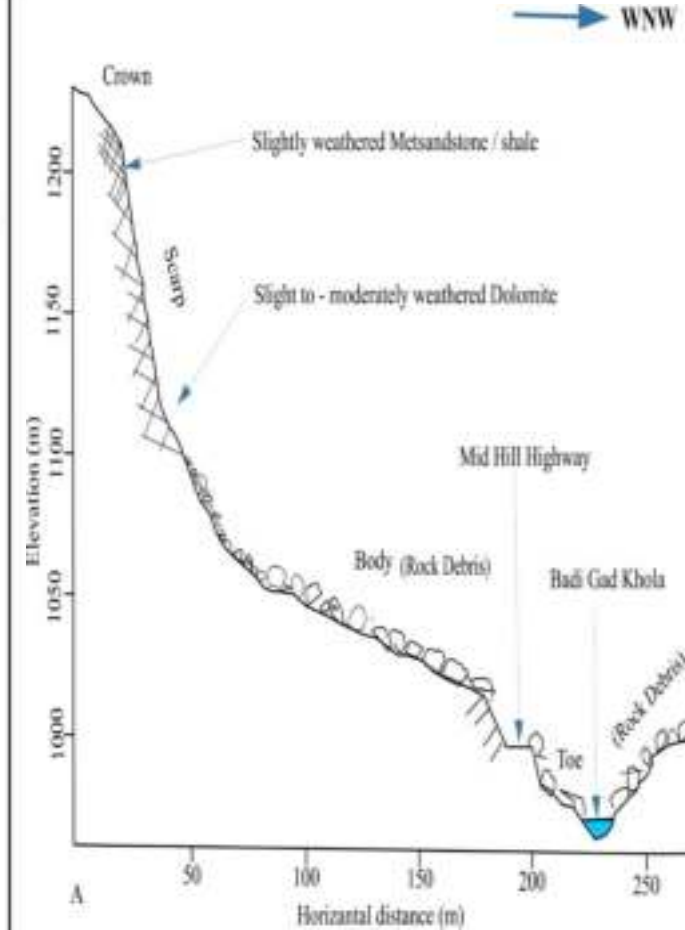
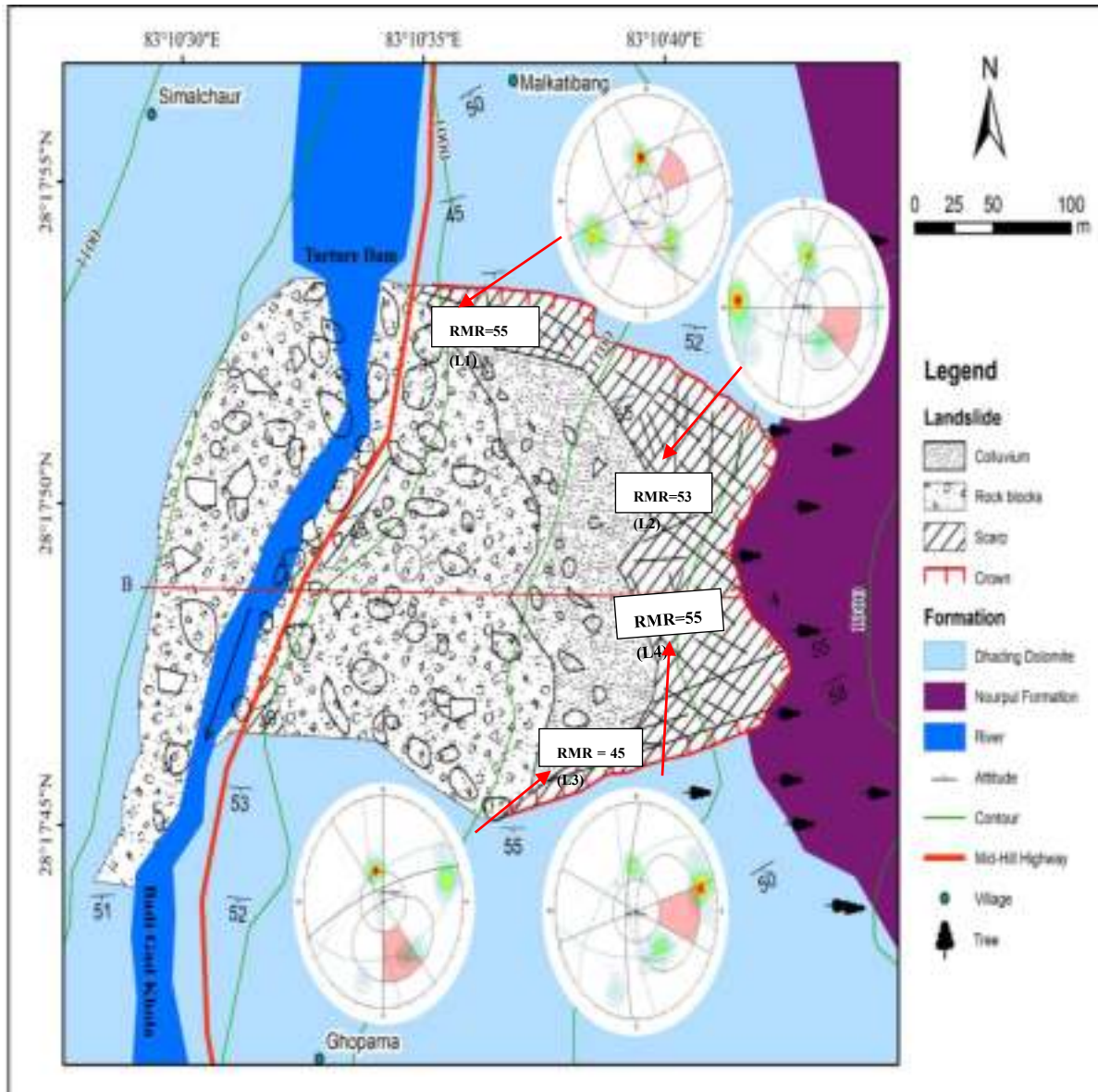


Fig. Cross – section view of Turture landslide

Fig. Engineering Geological map of Turture Landslide. Kabi Raj Paudyal, Central Department of Geology, Email: paudyalkabi1976@gmail.com





**Large Landslide along the Lakhandehi River**



**Toe cutting of hill side by river during flood at Tintale.**



**Rainfall induced land damage around Pathharkot.**

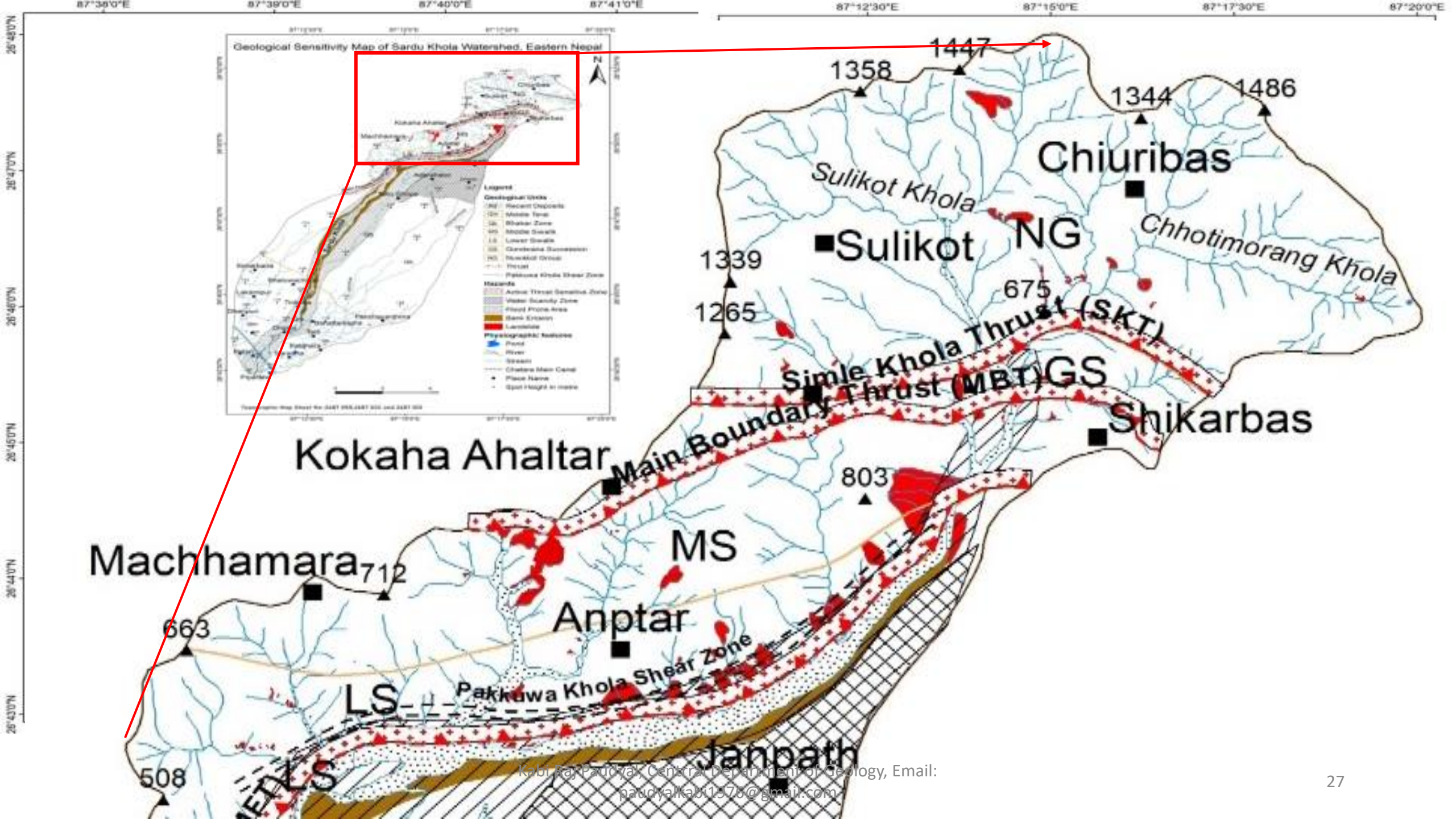


Siwalik

Main Frontal Thrust

Terai Plain

Khutti Khola, Siraha



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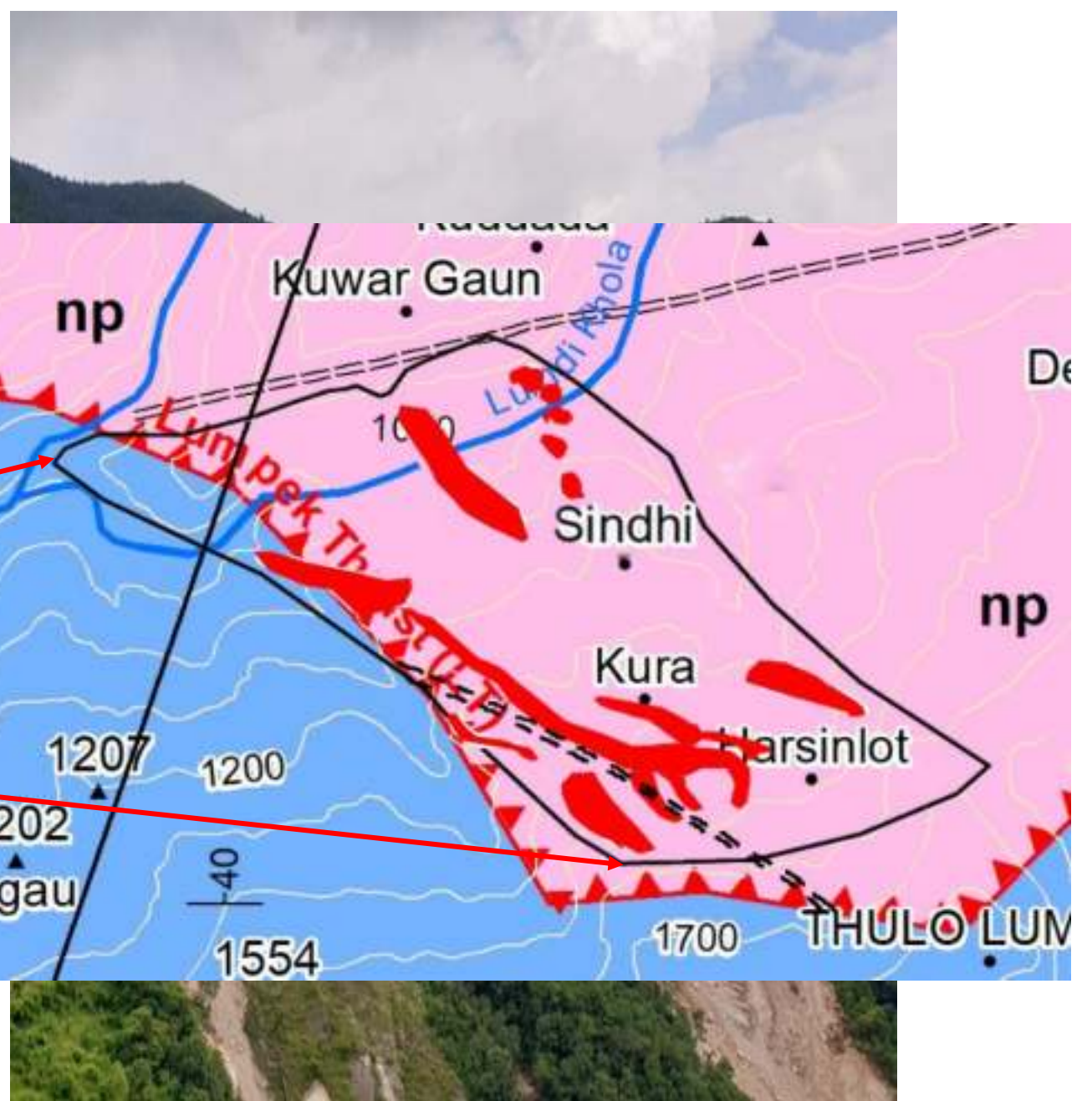
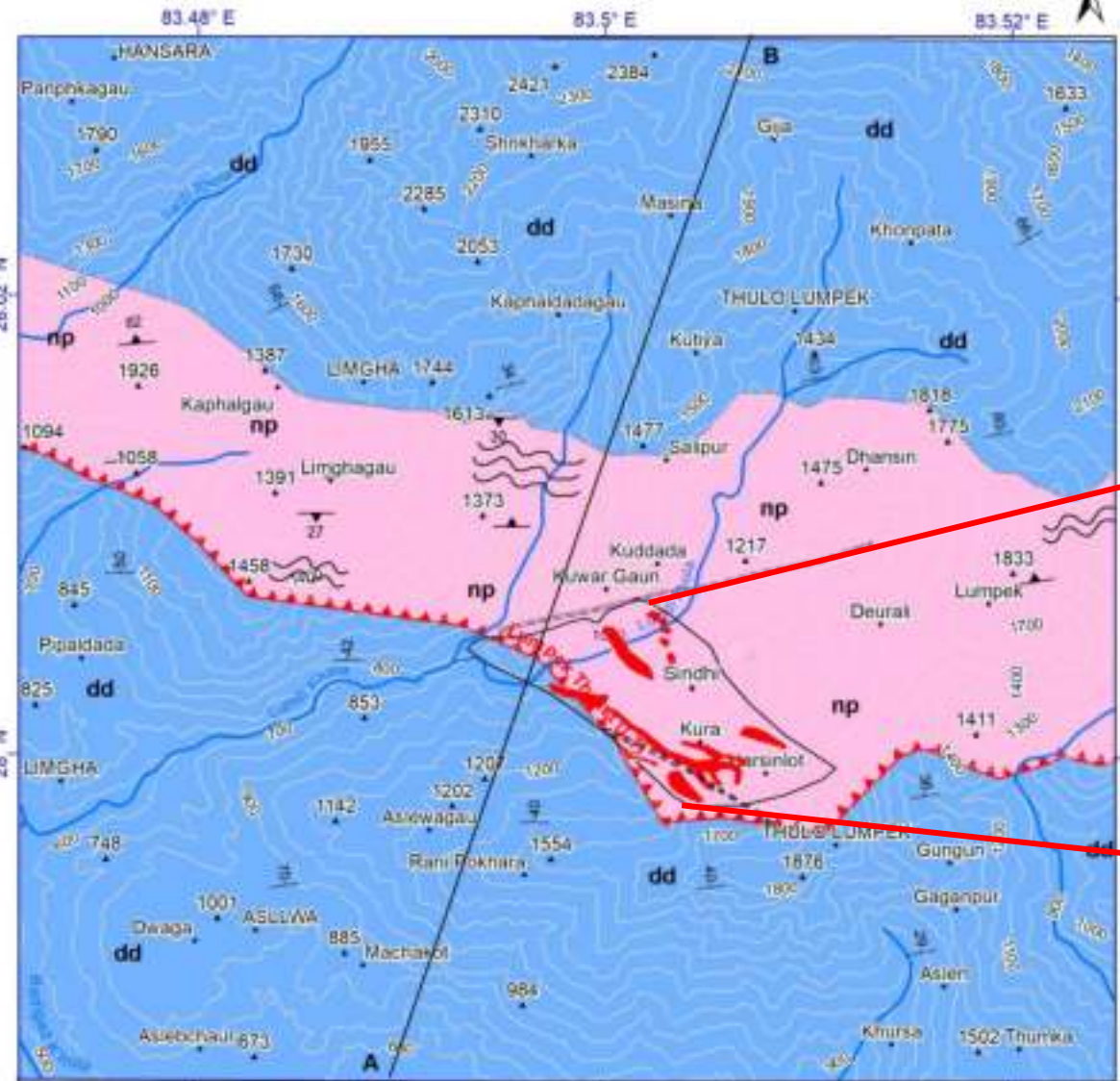


## **Different landside Location of Thulo Lumpek at 2076 Shrawan 7/8**

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Geological Map of Sindhi Areas of Thulo Lumpek, Gulmi, Province-5



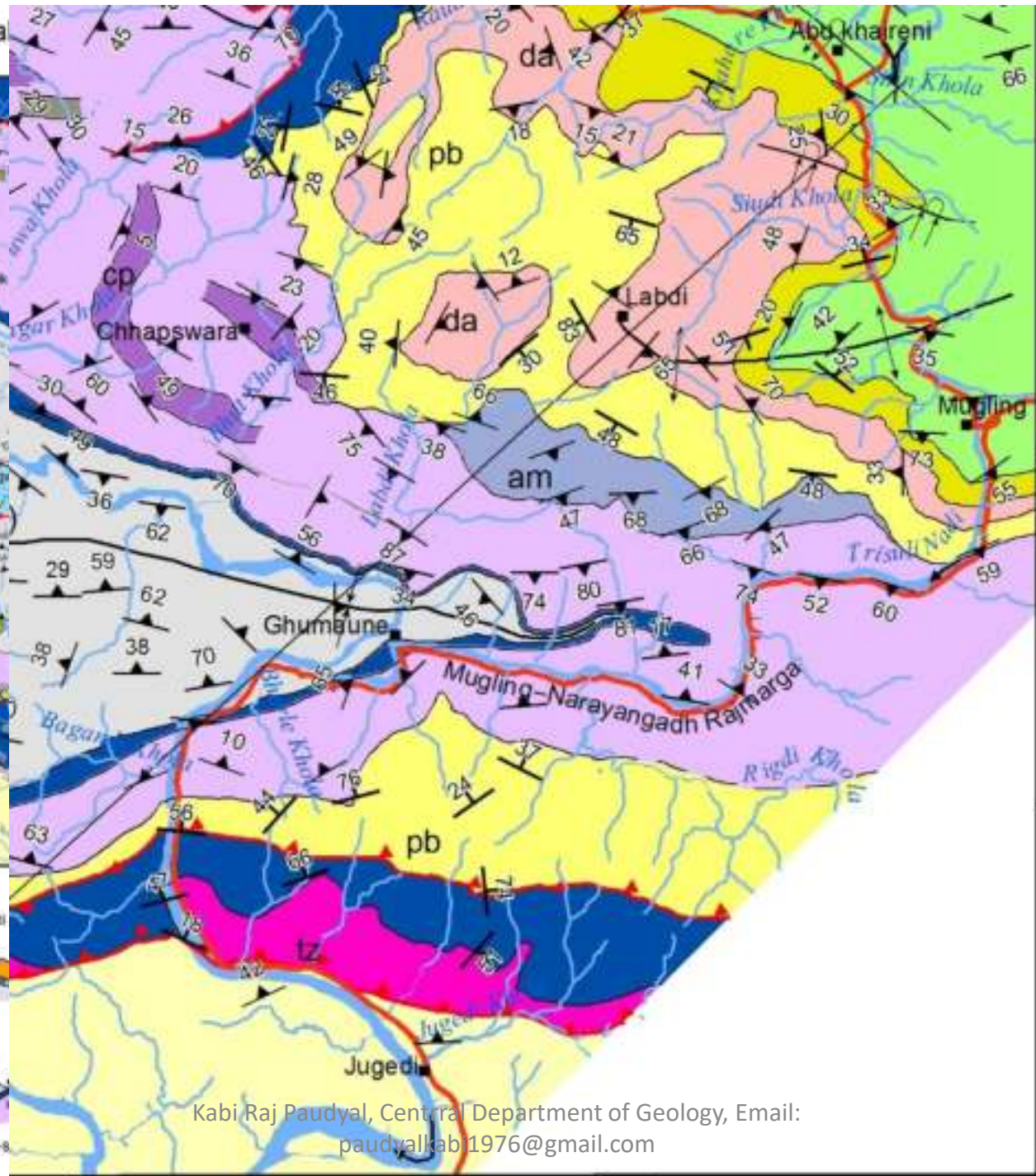
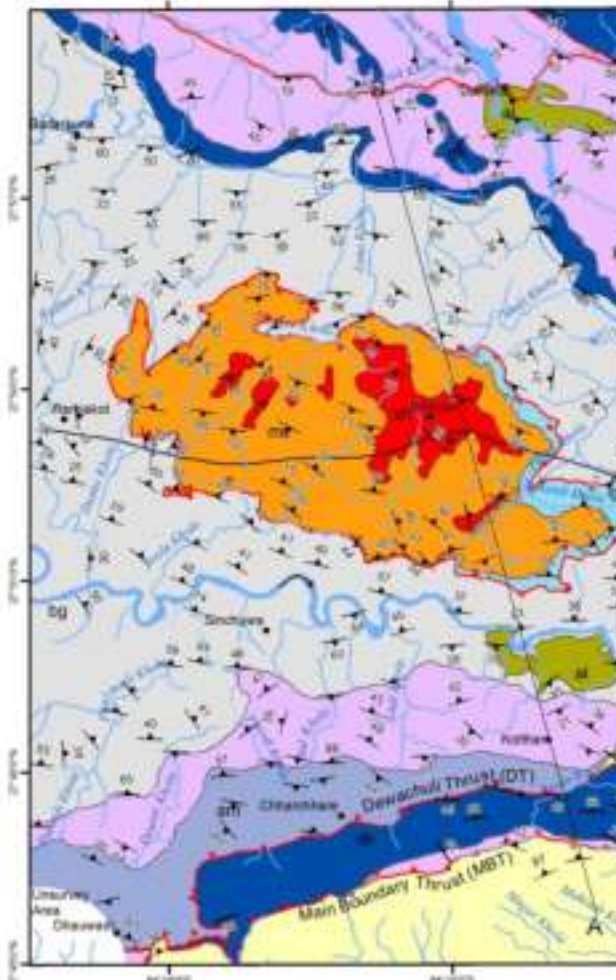
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pauadyalkabi1976@gmail.com

**Dry landslide claims two in Narayangadh-Mugling road, April 4 2017 (Source: Nepal Media Online)**

Geological

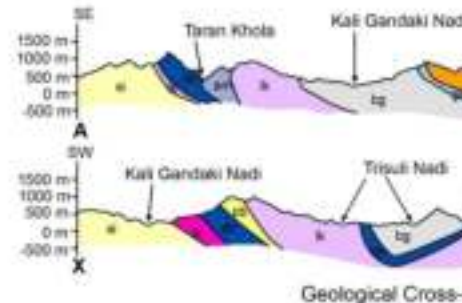


Lesser Himalaya

dstone line



ngadh-Mugling  
(Media Online)



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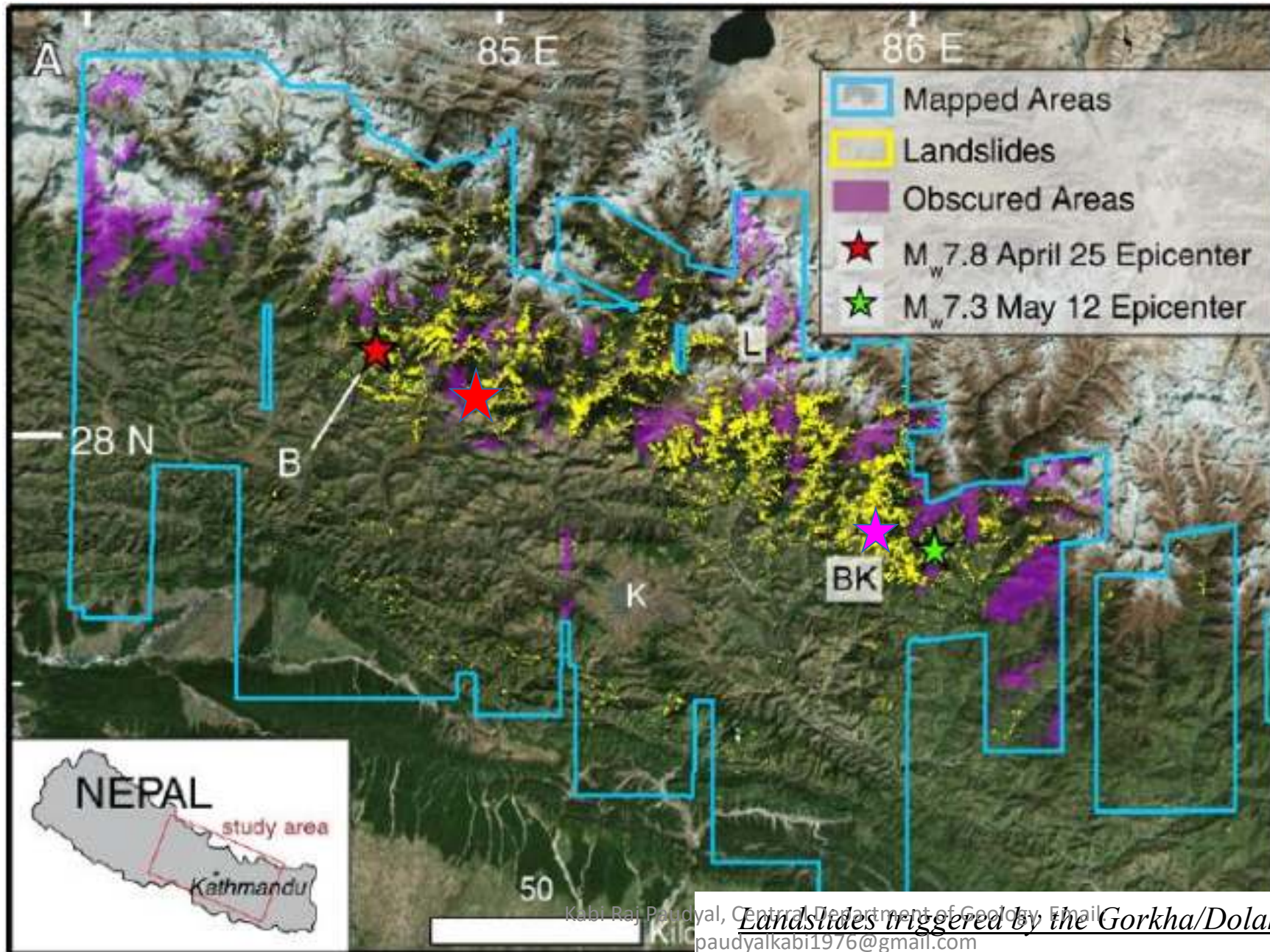


# Landslide due to weak geological formation, torrential rainfall (141mm) and steep topology at Jure, Sindhupalchowk (source: Case Study Report by UNU)

**156 human** losses, **2 dozen** houses were swept away  
About 5.5 million cubic meters of Earth mass were slide

**Geological Weakness:** Presence of **4 sets of joints**, lithology of **phyllite with quartz veins** and presence of **spring, surface water** seeped into joints and increase the **pore water pressure**

# Rapid Landslides triggered by the Gorkha/Dolakha sequences



25000 landslides  
Co and post-seismic

Mapped in the years after  
the landslide by team of  
Pascal Lacroix

**Combined effect of weakening of rock mass by Gorkha Earthquake and LDOF in Tibet. 67 houses swept away**

## **Rock fall in Rasuwa after Gorkha Earthquake**



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**14th July 2016, Bhotekoshi Flood: Damaged slope and houses (Himalaya Times)**

# Ground Rupture and Landslide Induced by Gorkha Earthquakes (2015)



Photograph Supported by: Keshav Bhattarai

Duguna Gadhi, Sindhupalchowk, Gorkha EQ-2015

Kabita Poudyal, Central Department of Geology, Email: paudyal.kabi1976@gmail.com

Tatopani, Sindhupalchowk, Gorkha EQ-2015



**Presenter: Group-1**

**Bibek Dhakal**

**Mohan Raj Shrestha**

**Keshav Bhattarai**

**Prakash Bhusal**

**Prithivi Bir Thapa**

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**Rock Falls at Siddhababa, Siddhartha Highway  
(The Kathmandu Post)**

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**Dry landslide claims two in Narayangadh-Mugling  
road, April 4 2017 (Source: Nepal Media Online)**

# Landslide due to Human causes

**Slope failure at BP highway, no any human loss but highway was block about 4-5 months**

**Bolero buried due to landslide, driver was injured at Doti (25<sup>th</sup> Ashad 077)**



# Improper practice of road excavation

Slope Failure at Mallesi village, Bajhang where 6 people were killed and 1 are missing as per police and several houses were also swept away.

Landslide at Dhovan, Palpa-Butwal Road Section, road blockage, possibly plane failure with big boulder, increased unit weight due to heavy rainfall, results due to **unscientific road excavation practices though CCT.**





# Landslide incept after rainfall due to unscientific slope cutting

Cultivation land slide down due to slope cutting

Slope failure due to road cutting at Dordi, Lamjung (10<sup>th</sup> Ashad 077)



Interbedding of Quartzite and Schist, highly fragile rock mass, presence of minor fold,





# Ramche Landslide





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# **Some Representative Example of Major Landslide That Occurs This Years**



२०७७ वैशाख देखि असार ३१ सम्मका विपद्का मुख्य घटनाहरूको विवरण								
पहिरो			बाढी			चट्याङ्ग		
मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते
११	४३	८४	५	६	३	४७	०	१६१
२०७७ जेठ ३० मनसुन सुरु भएदेखि असार ३१ सम्मका विपद्का मुख्य घटनाहरूको विवरण								
पहिरो			बाढी			चट्याङ्ग		
मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते
१७	४३	८३	२	५	१	१७	०	४२

## दैनिक विपद् बलेटिन

### २०७७ वैशाख देखि असार ३१ सम्मका विपद्का मुख्य घटनाहरूको विवरण

पहिरो			बाढी			चट्याङ्ग		
मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते
११	४३	८४	५	६	३	४७	०	१६१

### २०७७ जेठ ३० मनसुन सुरु भएदेखि असार ३१ सम्मका विपद्का मुख्य घटनाहरूको विवरण

पहिरो			बाढी			चट्याङ्ग		
मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते	मृत्यु	बेपत्ता	घाइते
१७	४३	८३	२	५	१	१७	०	४२

- स्याङ्जाको कासीगडकी -४ चहरे खोलाका बाढी आएको भनि गाउँका ६ जना पैरत बाढी हेर्न गएकोमा एघारौँ मधिकाट पहिरो आई निजहरु पुरिएको । प्रहरी र स्थानीयले खोजतलास गर्ने क्रममा २ जनाको **छाँटि** जवनचामा उद्धार, ३ जना **मृत्यु**, १ **बेपत्ता** । सोही गाउँमा एक व्यक्तिको डग्लार भन्कैदा २ वटा **गाई भरेको** । बिस्वा गाउँपालिका वडा नं. ६ अरावीको एक घर भन्कैदा मुई तलाका रहेको ६ वटा बाघा पुरिएर भरेको र अन्य सामग्री समेत गरी **४ लाख ५० हजार रुपैयाँ** बराबरको क्षति ।
- नवलपरासी पूर्वको पैडाकोट नगरपालिका वडा नं. १२ सिर्खौली नदीको किनारमा रहेको खेतको पानी कटाउने क्रममा तीन व्यक्तिलाई **खंगली बँदेल**ले आक्रमण गरि **छाँटि** । मधकिन्दु नगरपालिका वडा नं. २ कुमालटारमा एउटा गेट मधिकाट **पहिरो** आई पुरिएको । पल्लिनन्दन गाउँपालिका वडा नं.१ चडकी मुनीमा एउटा घरको भागा कोटा राती भरेको अघिरत वर्षाको कारण भन्कैदा **५० हजार रुपैयाँ** बराबर क्षति ।
- भोरङको** जुडिगमा गाउँपालिका वडा नं. ४ चोकुवाको एकघरमा अचानक **आगलागी** हुँदा **१ लाख रुपैयाँ** बराबरको क्षति । अघिरत वर्षाछि चिसाडखोला आएको बाढीको कारण आगलागी रहेका जमिन कटान गरि चगाउँदा कानेपौखरी गाउँपालिका वडा नं. ४ को २०० वटा टिकको रुख लगायत १० जना व्यक्तिहरुले लगाएको केरा र बैसा खेती समेत जग्गा चगाउँदा **३ करोड २० लाख ६६ हजार रुपैयाँ** बराबरको क्षति ।

### घटना सारांश...

- महोत्तरीको ज्योधर नगरपालिका वडा नं. ६ सुर्वाडाँमा अघिरत वर्षाको कारण एउटा घरको भित्ता भन्कैदा **१ लाख ५० हजार रुपैयाँ** बराबरको क्षति ।
- रौतहटको गौर नगरपालिका वडा नं. २ सुमहर टोलको एक घर अघिरत वर्षाको कारण भन्कैदा **२ लाख रुपैयाँ** बराबरको क्षति ।
- जलियापुरको माहाकाल गाउँपालिका वडा नं.६ हुट्टिटाको एक घरको भित्ता अघिरत वर्षाको कारण भन्कैदा **५७ हजार रुपैयाँ** बराबरको क्षति । माहाकाल गाउँपालिका वडा नं. ३ खोरभञ्ज्याङ स्थित एक कृषि घरमा अलेनीमा सुकाउने राखेको चाउराबाट आगे सन्कैदा अचानक **आगलागी** हुँदा घर र घरमा भएको तलाकपहा फर्निचर र अन्नघान, नन्द गरी **१० लाख ९ हजार रुपैयाँ** बराबरको क्षति । सल्लिपुर महानगरपालिका वडा नं. २८ हरिसिद्धिस्थित एक फर्निचर फालतमा अचानक बिजली स्ट भई **आगलागी** । आगलागीबाट फर्निचरका सामान तथा सगै रोको अर्को एक स्टिल एण्ड मेटल



**6 death 1 missing, Source : Kantipur News.**

**बझाङ पहिरो अपडेट : उद्धार गर्न गएको नेपाली सेनाको गाडी दुर्घटनामा, ३ जना घाइते, Nishan News**

**पर्वत पहिरो अपडेट : ९ जनाको शव भेटियो**

Read more at: <https://thahakhabar.com/news/100554>

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**सिन्धुपाल्चोक पहिरो : 4 death, 20 still missing (Source: from different online media)**



**जाजरकोट पहिरो अपडेट : बेपत्तामध्ये ११ जनाको शव भेटियो, एक जनाको खोजी चल्दै, 500 house displaced.**

**Source: Ujyalo online , RSS and Nayapage**



**कास्की पहिरो (Image Source: Vishwanews.com)-**

**Total 7 death and 11 injured (Source: Kathmandu Press online)**

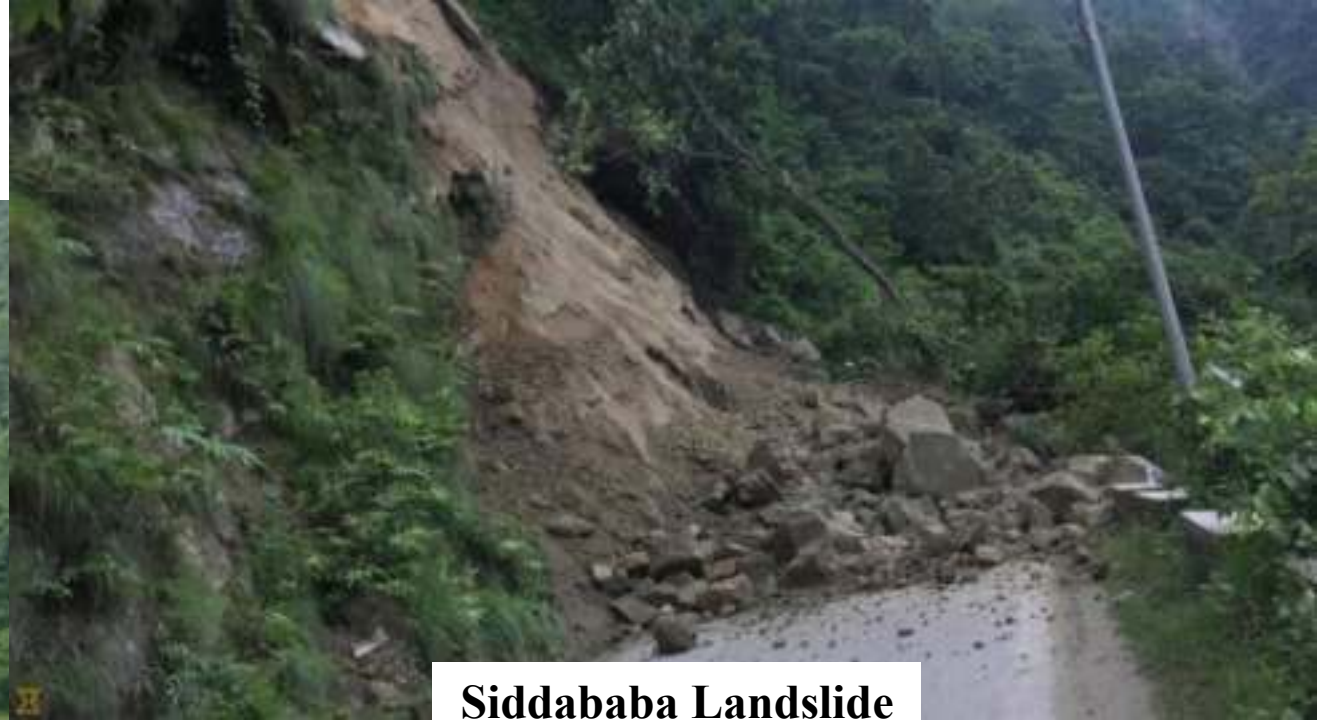


**Tanahun Landslide, 10 death, 2 missing (Asar 29, 2077), Source: Annapurna Post.**

**Myagdi Landslide (28 death, Marang and Bim),  
Source: Annapurna post and online media**



# Several roadway are blocked by landslide this year



**Siddababa Landslide**



एक वर्ष नपुगदै भासियो नारायणगढ-मुग्लिन सडक (29 Asar 2077) at 17 Kilo

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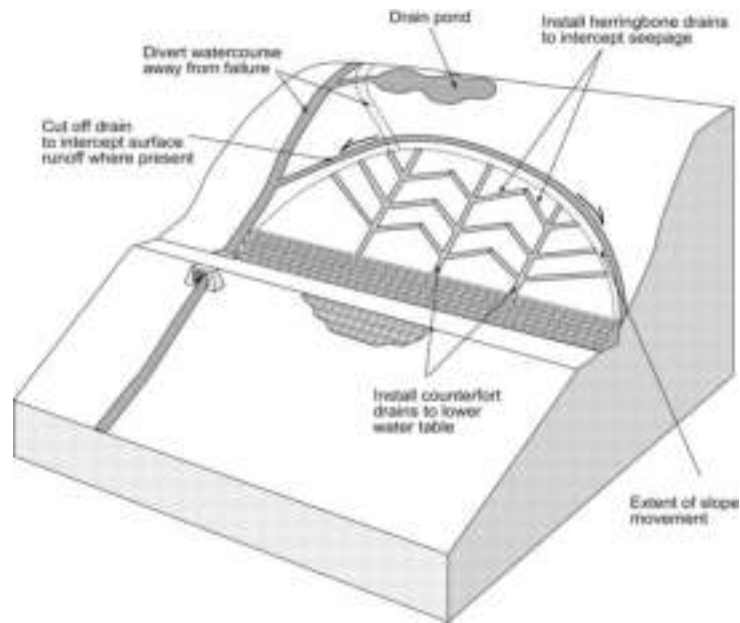
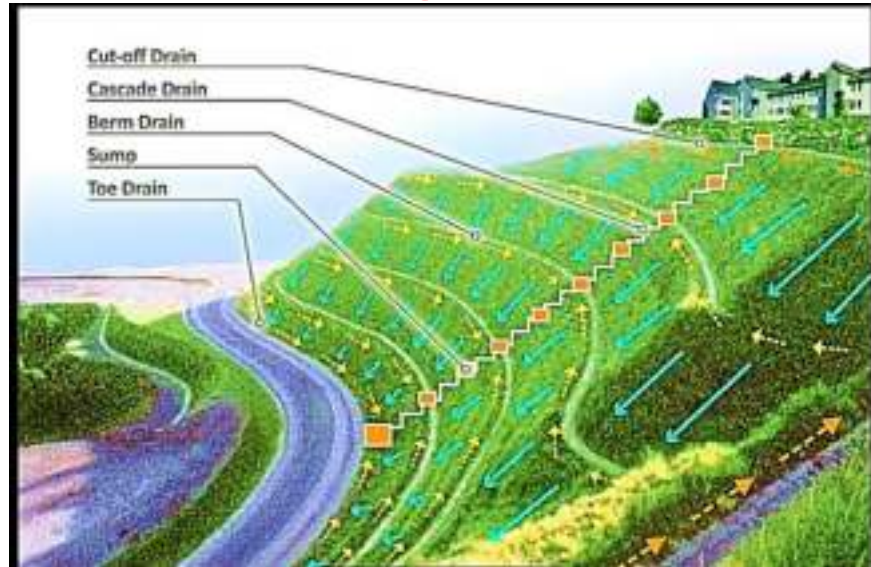
मनाङको नासाँ गाउँपालिका १ तालडाँडा नजिकै चामे र घेराङ जाने सडकमा खसेको पहिरो । तस्बिर: कान्तिपर ।

# **Mitigation Measures of Landslide**

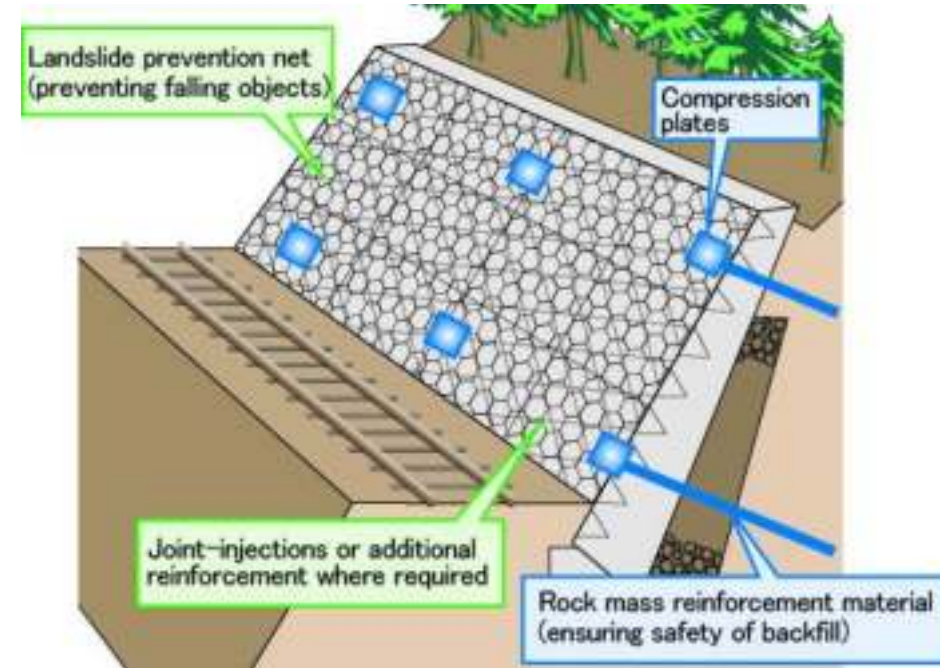
**Video .....**

# Landslide Mitigation: Rock Slope

## Drainage



## Protection Measures



Embankment and rockfall netting

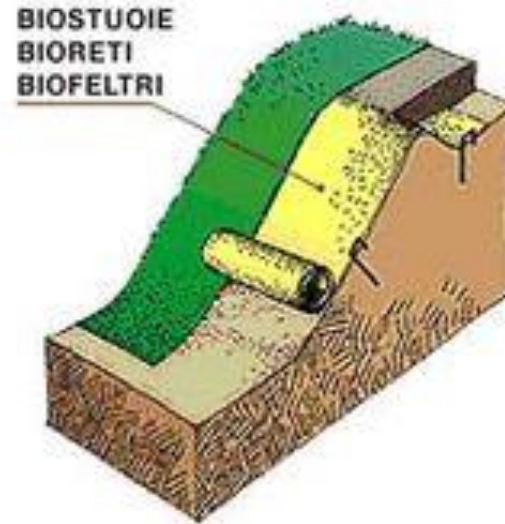
# Landslide Mitigation: Soil Slope

## Geometric modification

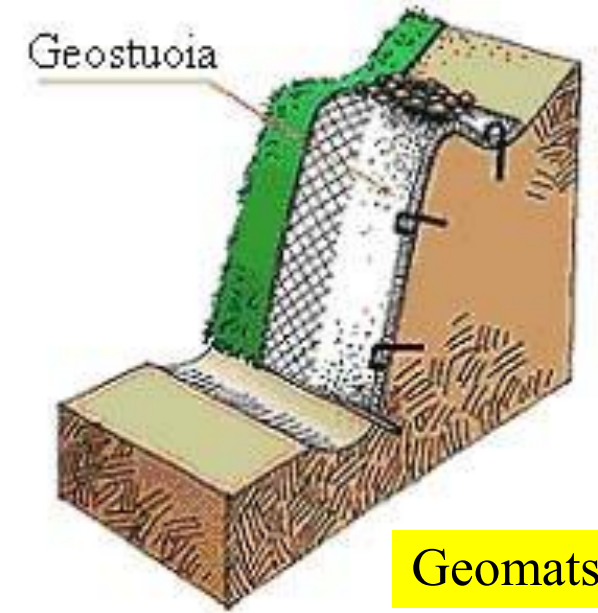


Embankment: Gabion Wall

## Surface erosion control



Bionets



Geomats



Retaining Wall



Brushwood Solution



Slope treatment by jute/coir netting



# Case Study: Krishna Bhir Landslide

## Stabilization Measures

- Bio-Engineering
- Cascade Structure
- Gabion wall
- Stone Masonry wall
- Shallow and deep drainage through culprit and pipes.

Stone Masonry Wall with Weep Holes for Drainage



Artificial Drain Pipes in the Gabion Walls



Cascade Structure



Picture Credit: Sumit Maskey, Maskey 2016

Culvert



# Case Study: BP Highway

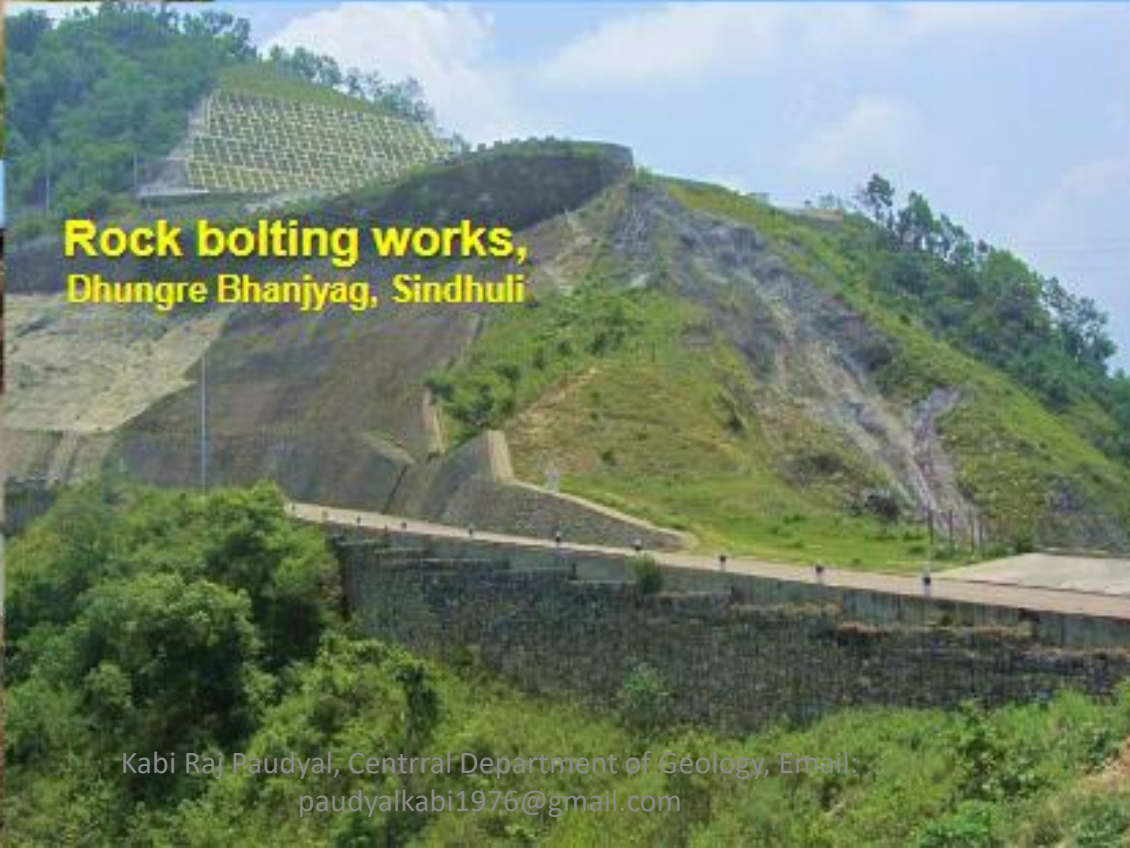


**Before**

**Sindhuli Road**  
Sec II 17+400,  
Dhungre Bhanjyang  
(DoR/JICA/DWIDP)



**After**



**Rock bolting works,  
Dhungre Bhanjyang, Sindhuli**

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Picture collected by  
Devraj Badal from  
various online sources.  
58

# Case Study: BP Highway

## Bioengineering Methods



Various Landslide techniques used for the sustainable road along BP Highway, Sindhuli, Picture Collection: Devraj Badal From internet,

Various structural techniques such as shotcrete, embankment, etc



**Anchoring works, Sindhuli Road  
DWIDP/DoR /JICA**

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paudyalkabi1976@gmail.com

# Case Study: Narayanghat-Mugling Road



ROCK Bolting



Mitigation of  
Landslide with  
various  
techniques viz.  
Rock Bolting,  
Netting and  
gabion wall.  
Picture  
Collection:  
Sujan Neupane





**Jute netting on crown**

**Kush, Amriso plantation**

**Khayer plantation**

**Drainage management with riprap and cascade wall drainage**

**Nigalo plantation**

**Nigalo, Amriso, Kush, Siuidi, Areri, Tilka plantation**

Kabi Raj Paudyal, Central Department of Geology, Email: paudyalkabi1976@gmail.com

# Case Study: Various Landslide in Sigas Gaunpalika

## Mitigation Measure for Naturally Triggered Landslide



**Dhum Landslide, Sigas – 3 Baitadi.**

**Animation & Photograph: Sabin Bhattarai**

Kabi Raj Paudyal, Central Department of Geology, Email: paudyal.kr1976@gmail.com

# Case Study: Various Landslide in Sigas Gaunpalika

## Mitigation Measure for Landslide Triggered by Anthropogenic Factor



Importance  
of Trees



**Mitigation of road cut slide by various process, such as embankment and bioengineering. First priority is not to excavate in this geologically unstable region.**

**PC: Sabin Bhattarai**

Kabi Raj Paudyal, Central Department of Geology, Email:  
paudyalkabi1976@gmail.com

# Conclusion

- Though there are several causes for landslide occurrences in Nepal Himalaya, Geology is the major cause.
- The location of concentration of landslides are controlled by weathering of rocks in steep and rugged slope, active faults, shear zones, axis of antiform, fractured terrain and the position of mountain aquifers.
- Major triggering factors of landslides are concentrated precipitation, developmental activity, quarry and deforestation.
- The immediate steps for mitigation of landslides should be cost effective and of public participatory approach.
- Proper drainage management and use of extensive bioengineering should be adopted for the sustainable mitigation of landslides.



# Recommendations

- Stop haphazard construction of mountain roads.
- Stop haphazard mining of construction materials.
- Investigate the potential zones of landslides rigorously, both from government and non-governmental agencies.
- Settlement should be avoid from the risk area
- Possibilities of rockfall and landslides throughout all the road networks should be identified and mitigation measures should be adopted.

# Role of Central and Province Government

- Study and identification of vulnerable zone, preparation of expert (1 hour Helicopter survey by geologist as per the direction from government should be stopped after landslide)
- Central and Province Government should include landslide in school level curriculum
- Development without geological study should be stopped. DOR should establish vacancies of geologist
- ICIMOD Study on 14 district marked 1,55,000 houses in vulnerable condition. What are the preparation?

# G-to-G/P-to-P Research with University

# Role of Local Government

- Settlement located in old landslides due to many advantage
- Social data bank preparation from local community
- Local practices such as sealing of crack, filling of holes, drainage management, management of overland flow of rainwater at and around the communities should be strictly implemented, bioengineering practices of ethnobotanical plants like Amriso, Kush, Nigalo, Khayer, Siudi, Kimbu, Tilka, Dabdabe, Areri, Phaledo, etc.
- Unscientific road construction practices. Sediment influx along with water from gulleys
- Settlement located below house and agricultural land should be avoided.

पहिरो गइसकेपछि पहिरोको अध्ययन गर्ने होइन कि पहिरो जानुभन्दा अगाडि नै पहिरो सम्भावित ठाउँ पहिचान गरि उपयुक्त पहिरो नियन्त्रणको विधि अपनाउनु पर्दछ ।

## केन्द्रीय सरकार

- जोखिम अध्ययन गर्ने, जोखिम युक्त स्थान पहिचान गर्न सक्ने तालिम प्राप्त अनुभवी विज्ञ टोली तयारी अवस्थामा राख्नु पर्दछ ।
- २०७२ मा भूकम्प गयो ? हेलिकप्टरबाट भूगर्भविद पुगेर १ घण्टामा उपयुक्त स्थानको पहिचान कसरी सम्भव छ र ?
- विद्यालय शिक्षामा : केन्द्रीय र प्रान्तीय सरकारले
- भौगर्भिक अध्ययन विना, विकास गर्ने परम्परा छ । सडक विभाग जस्तो संवेदनशिल ठाउँमा ई.भूगर्भविदको दरबन्दी सम्म छैन , लाज लाग्छ ।
- २०७२ को भूकम्प पछि ICIMOD ले १४ जिल्लाको भूगोल बारे अध्ययन गरेर प्रतीवेदनमा करिब एक लाख ५५ हजार घर पहिरो जन्य जोखिममा रहेको उल्लेख गरेको छ । ती ठाउँहरुमा के छ तयारी ? ?

# स्थानिय सरकार

१) मानिसहरु पहिला पहिरो गएको ठाउँमा किन बस्छन् ?

- भिरालो ठाउँ केहि हद सम्म सम्मो बनेको हुन्छ
- खेतीपाती राम्रो हुनु
- पानी पलाएको हुन्छ
- घाँस पात उम्रे पछि र केहि पुस्ता पछि मान्छेले पहिलेको पहिरोको घटना विर्सको हुन्छन् र बस्दछन् । थाहा नपाएर, नजानेर बस्दछन् ।
- पहिरो खसेर बनेको थुम्कोमा नै वस्ती बसेको देखिन्छ

२) स्थानियले आँफु बसेको ठाउँको बारेमा आँफै धेरै सुचना दिन सक्दछन् । त्यसबाट Social Data Bank बन्दछ ।

३) नेपालमा करिब एक सय दिनको हाराहारीमा रहने दक्षिण एसियाली मनसुन प्रवेश संगै जनतालाई कुलो काट्ने, भल काट्ने, चिराहरु टाल्ने, किरा-मुसाको प्वालहरु टाल्ने, सचेत गराउनु पर्दछ ।

४) अहिले घर-घरमा पुग्ने गरी बाटो खनिएको छ, पहिले खोल्सीबाट बग्ने पानी अहिले सडकबाट बग्छ, पानी मात्र बग्दैन ढुङ्गामाटो समेत बगाएर लैजान्छ, जसले खोला थुनिने र खोलामा बहाव बढि हुने देखिन्छ ।

५) धेरै वस्तीहरु छन् : माथि खेत तल घर/गोठ