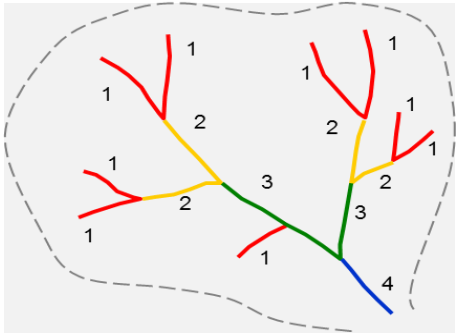
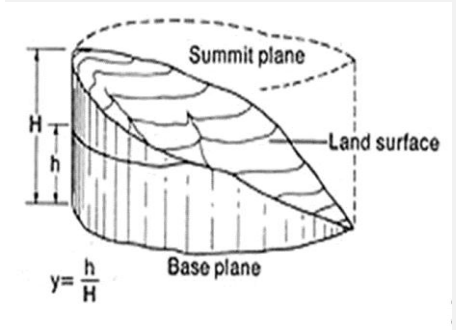
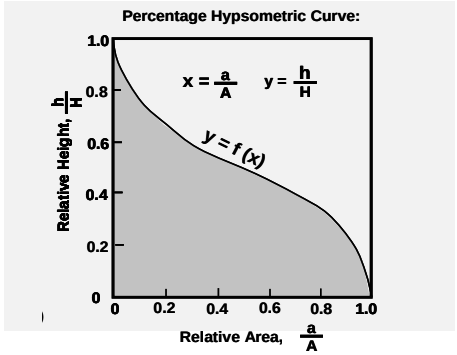




An Application of Quantitative Geomorphology on Regional Scale Landslide Hazard Assessment in Hong Kong

Angel K Y Ng
Geomorphologist
Ove Arup & Partners Hong Kong Limited



ARUP

Introduction

- What is the role of geomorphology in landslide hazard assessment?

Rotational slides at Stonebarrow, UK

What is Geomorphology?

'Geomorphology is the interdisciplinary and systematic study of landforms and their landscapes as well as the earth surface processes that create and change them.'

http://www.geomorph.org/main.html

GEOMORPHOLOGY
GEOMORPHOLOGIE
I.A.G

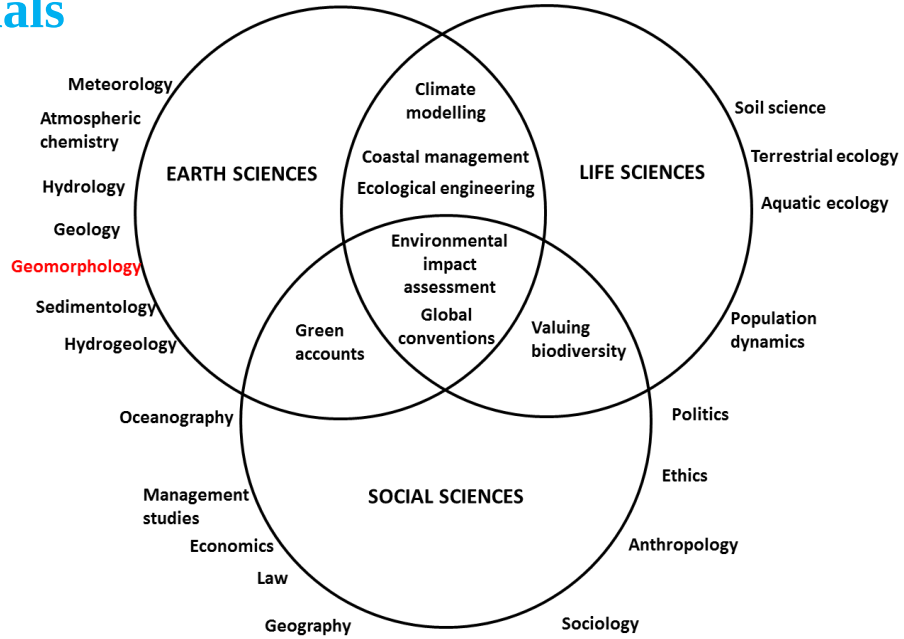
'Geomorphology is the science concerned with understanding the form of the Earth's land surface and the processes by which it is shaped, both at the present day as well as in the past.'

http://www.geomorphology.org.uk/

BSG British Society for Geomorphology

What is Geomorphology?

- **Geomorphology is the scientific study of earth's surface through time, with a particular emphasis on the landform, its formation processes, and materials**



Position of Geomorphology in science (after Gregory, 2000)

Or simply….

AG Watch
SCIENCE

The Science of Scenery

HOW GEOMORPHOLOGY CAN HELP ASIA COPE WITH ITS ENVIRONMENTAL CHALLENGES.

Text and Photos: DAVID HIGGITT

Geomorphology can be regarded as the 'science of scenery.' It seeks to explain how landscapes develop over time, the operation of earth surface processes such as erosion, landsliding and river flows, and the interactions between these processes and the landscape.

Geomorphology seeks to understand landform dynamics and to predict changes through careful field observation, computer modelling and experimentation.

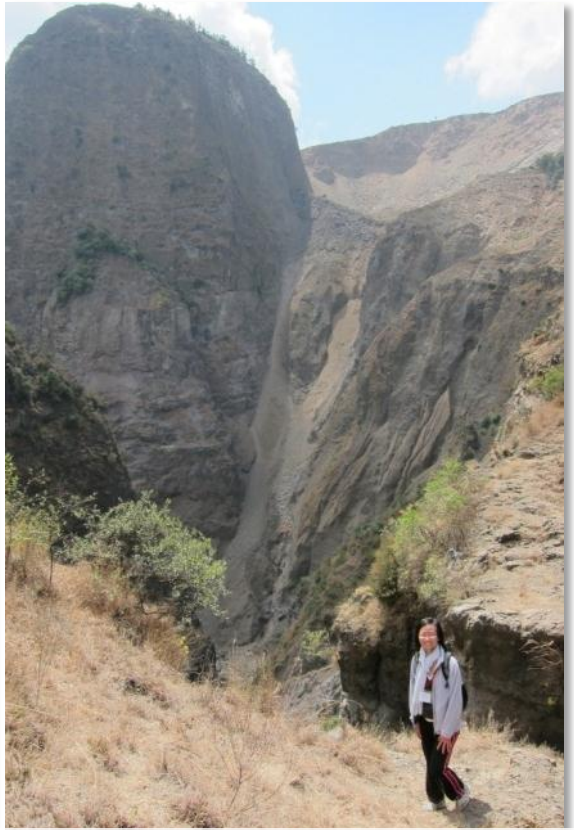
What geomorphology involves?

- History and epistemology of geomorphology
- Geomorphology and earth system science
- Planetary geomorphology
- Mega-geomorphology
- Tectonic geomorphology
- Volcanic geomorphology
- Magnitude and frequency in geomorphology
- Geomorphic processes and long term landscape evolution
- Rock control on geomorphic processes and landforms
- Quaternary geomorphology
- Hillslope processes and mass movements
- Fluvial geomorphology and river management
- Sediment budgets
- Coastal geomorphology and management
- Submarine geomorphology
- Aeolian systems and arid geomorphology
- Tropical geomorphology
- Cold region geomorphology
- Methods in Geomorphology
- Geomorphology and global environmental change

Landslides as a major Geomorphic Hazard

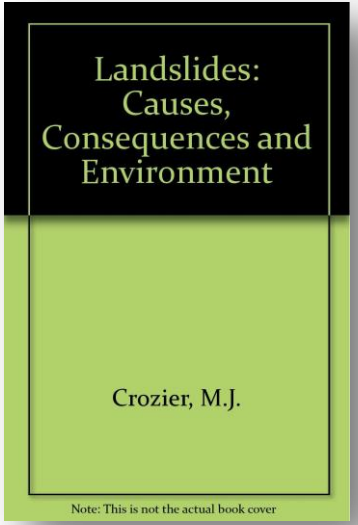
- Landslides is a type of mass movement processes that involve downslope movement of slope materials under the force of gravity

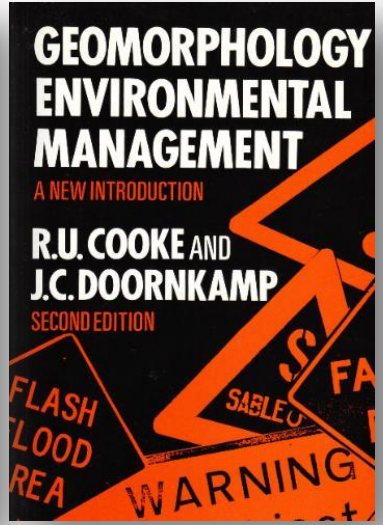
- Result in lowering the landscape and affect the society

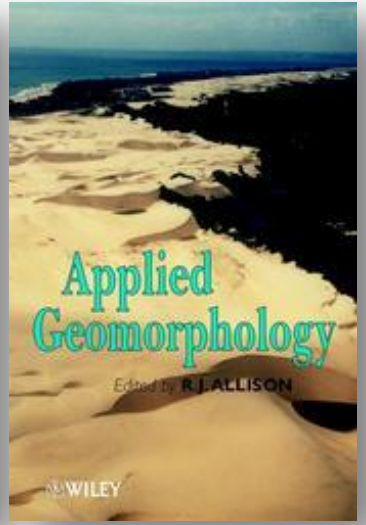


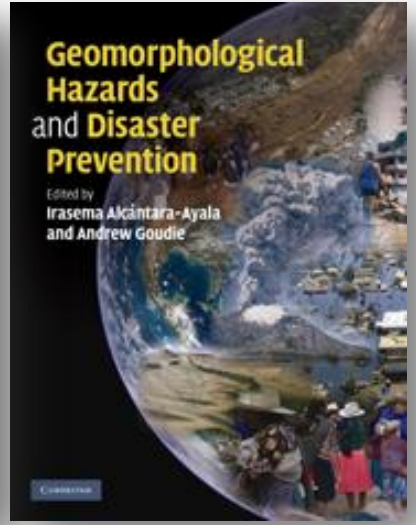
Landslide Mapping Course in Ethiopia

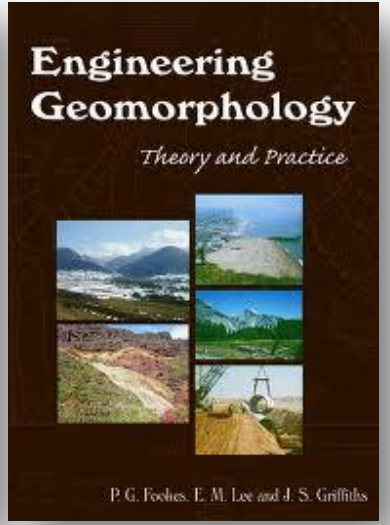
Landslide Hazard Assessment – a key topic in Applied Geomorphology









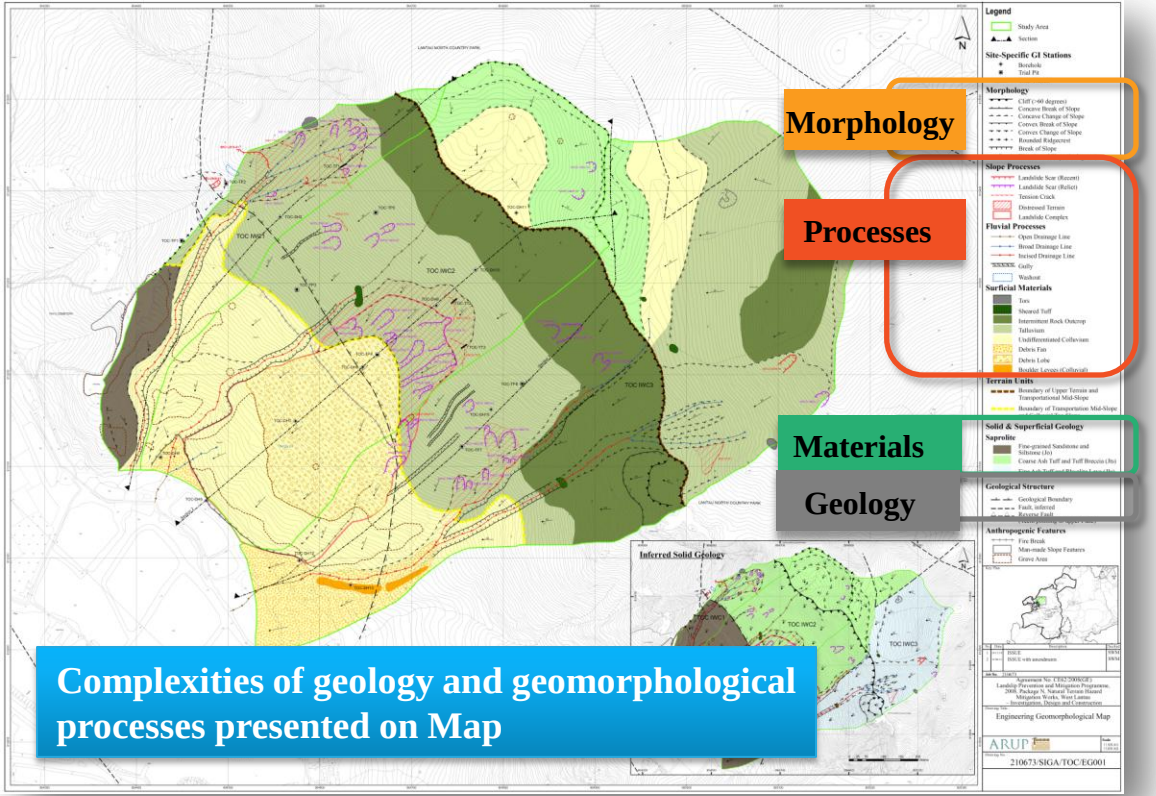


- Understanding the interactions between ‘form’, ‘processes’ and ‘materials’ helps explain how landslide behaves and mitigate its impact

Application of Geomorphology on Landslide Assessment

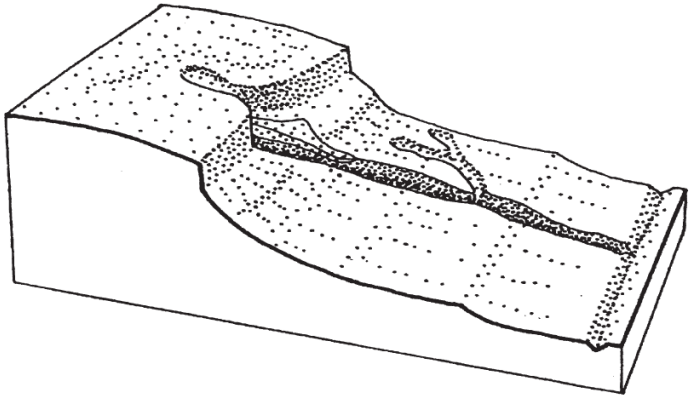
Geomorphological Mapping

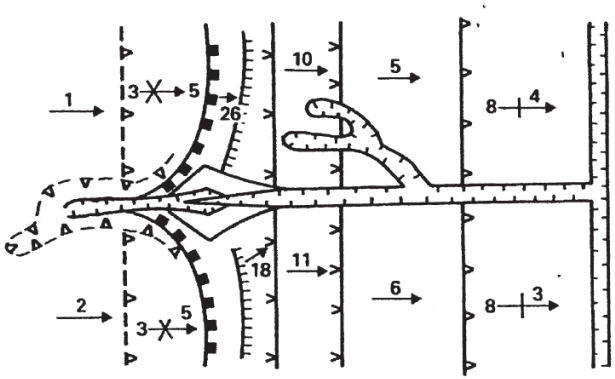
- **Geomorphology mapping is used to record the morphology, surface processes and materials**



Complexities of geology and geomorphological processes presented on Map

Use of Morphological Mapping Symbols





Morphological mapping symbols

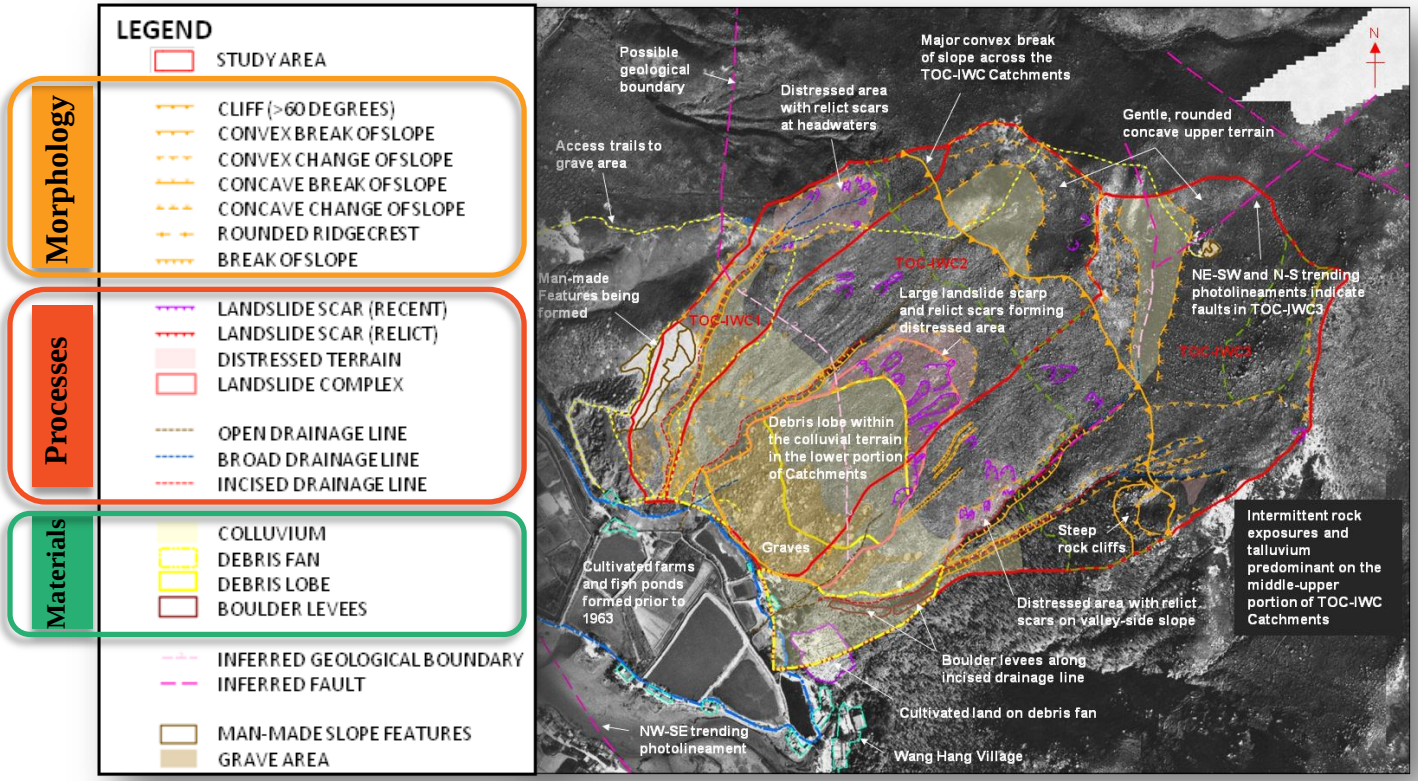
- Angular convex break of slope
- Angular concave break of slope
- Smoothly convex change of slope
- Smoothly concave change of slope
- 11 Direction of slope (angle in degrees)
- Cliffs (bedrock 40° or more)
- * Breaks of slope
- * Changes of slope
- Convex slope unit
- Concave slope unit

* Convex and concave too close together to allow use of separate symbols

After Savigear (1965)

Reading the landscape…

Key Skills – Aerial Photo Interpretation



API for Landslide Hazard Assessment at Tai O

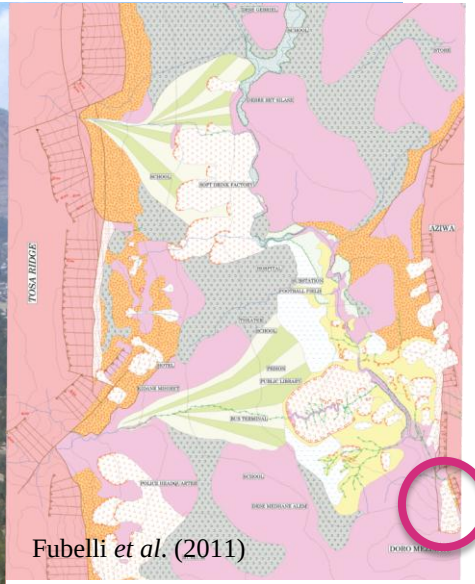
Reading the landscape…..

Key Skills – Field Mapping

Field trip at the IAG Regional Conference, Ethiopia

Key Skills – Field Interpretation

Translational rock slide, Dessie Basin. Ethiopia

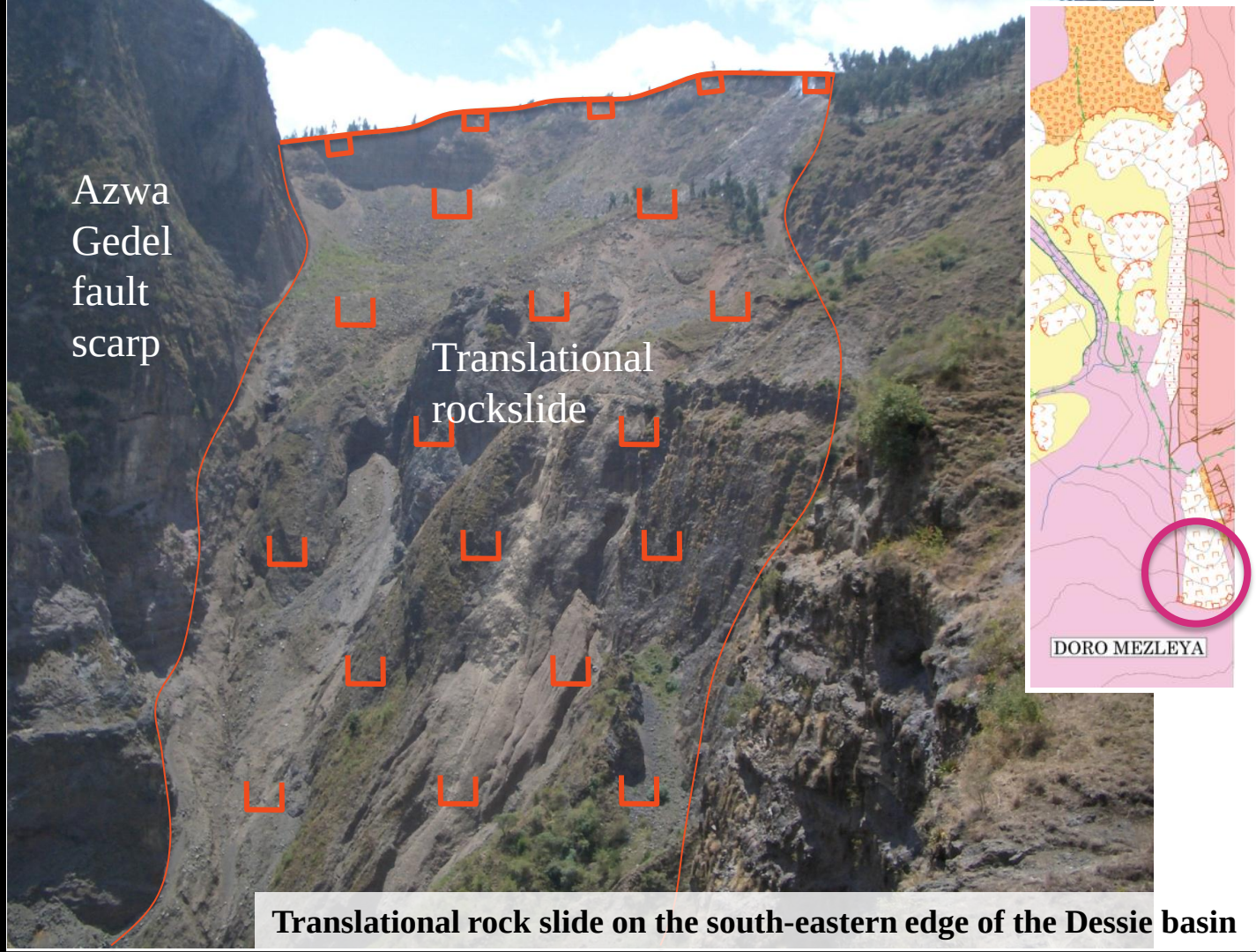


Fubelli *et al*. (2011)

LANDFORMS DUE TO GRAVITY AND RELATED DEPOSITS

- Debris flow
- Fall landslide scarp
- Rotational landslide scarp
- Translational landslide scarp
- Fall/avalanche landslide body
- Rotational landslide body
- Translational landslide body

Key Skills – Field Interpretation

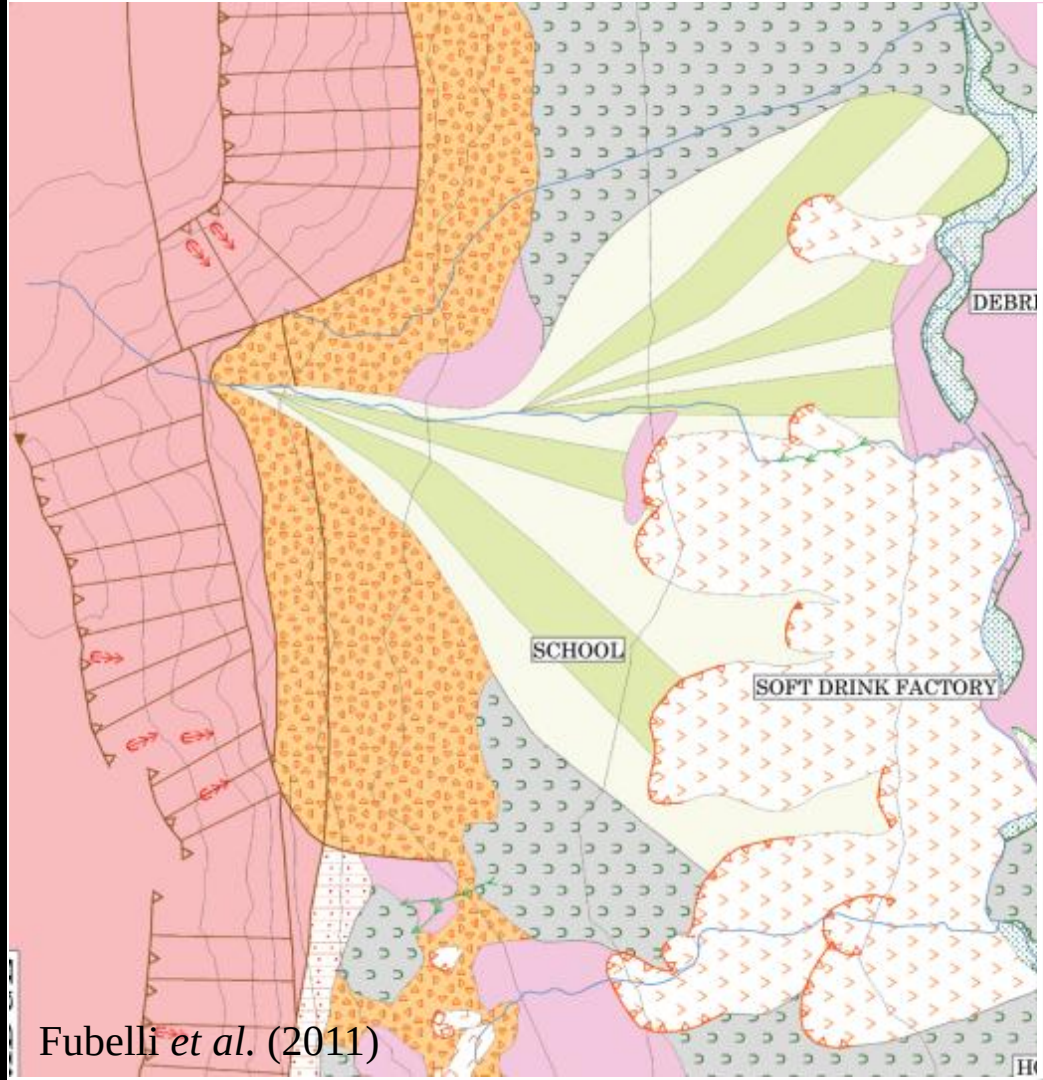


Translational rock slide on the south-eastern edge of the Dessie basin

Key Skills – Field Interpretation

Rotational earth slides inducted by the lateral erosion of the Borkena River

What and where is the risk?

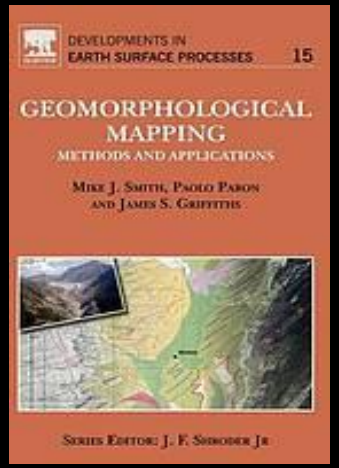


Fubelli *et al.* (2011)

- How geomorphology was applied in landslide assessment in Hong Kong?

Landslides triggered by June 2008 rainstorm on Lantau Island

Application of Geomorphological Mapping in HK



Geotechnical Engineering Office, Civil Engineering and Development Department
The Government of the Hong Kong Special Administrative Region

GEO Technical Guidance Note No. 22 (TGN 22)
Guidelines on Geomorphological Mapping for Natural Terrain Hazard Studies

Issue No. : 1	Revision: -	Date : 22.12.2004	Page : 1 of 8

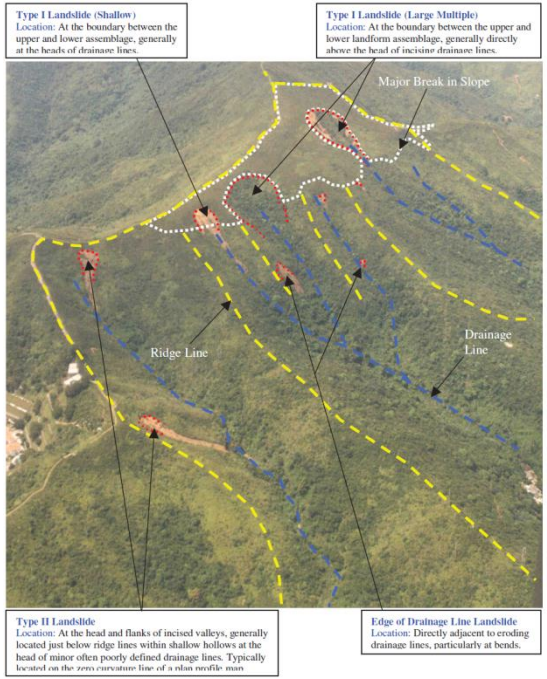


Figure 1 - Major Break in Slope Associated with Landsliding (Halcrow, 2003)

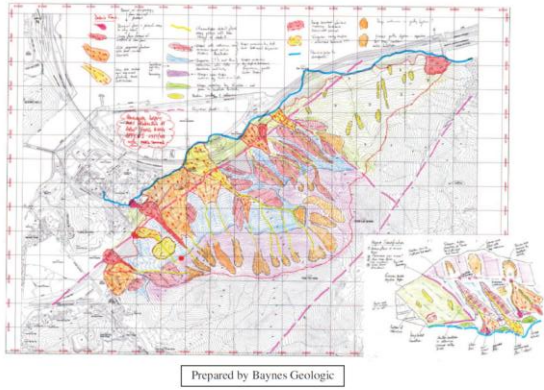


Figure 4 - Reconnaissance Morphogenetic Map for North Lantau (Ove Arup, 2004)

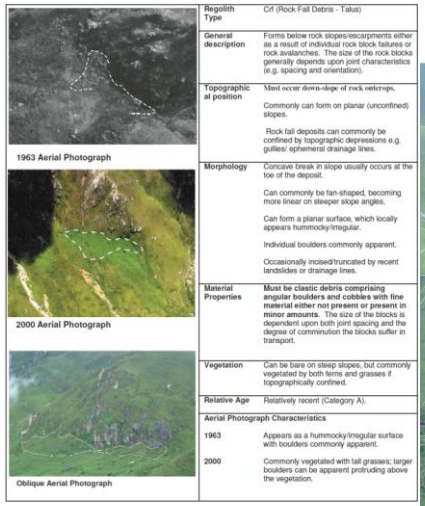


Figure 2 - An Example of Regolith Mapping Guide (MFJV, 2002)

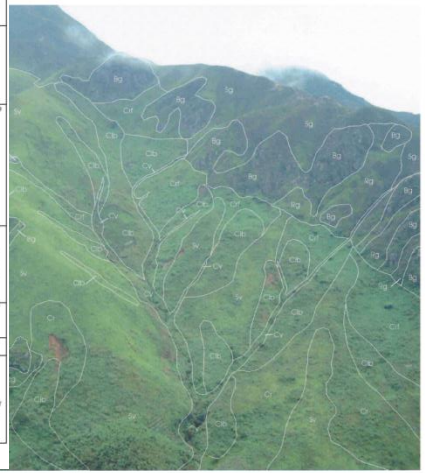
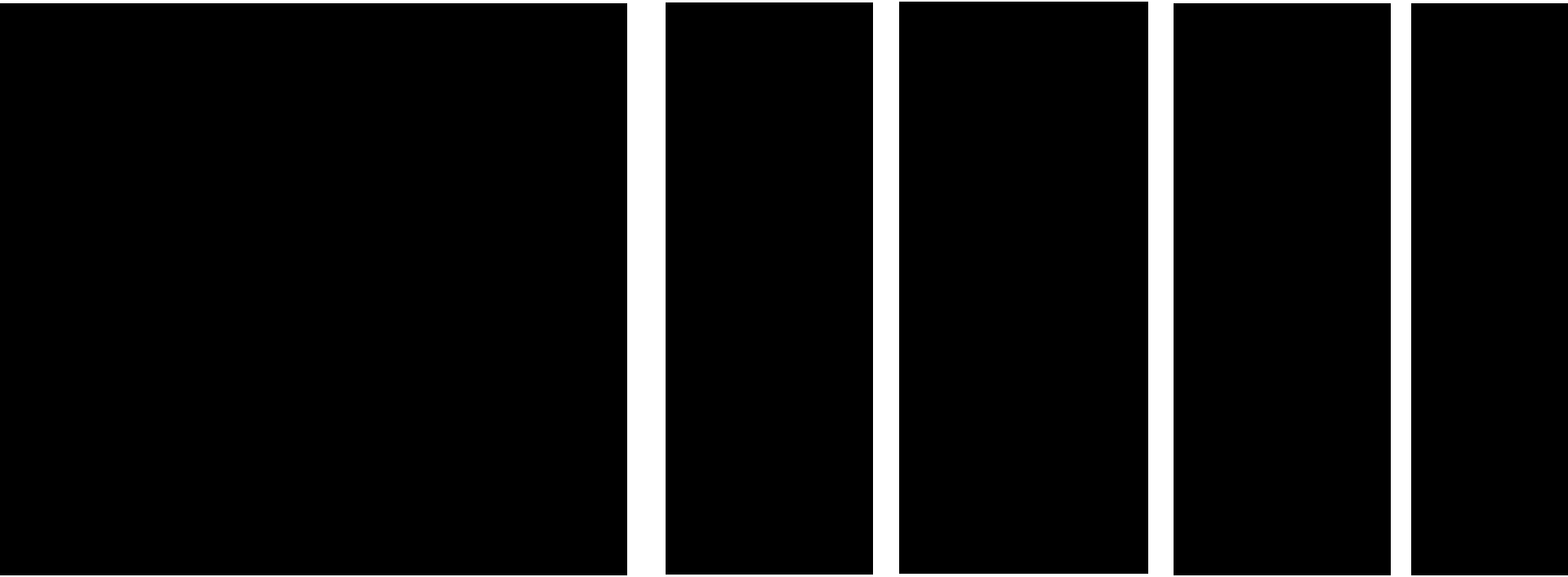


Figure 3 - Regolith Units Overlain on an Oblique Photograph (MFJV, 2002)

What is the gap?



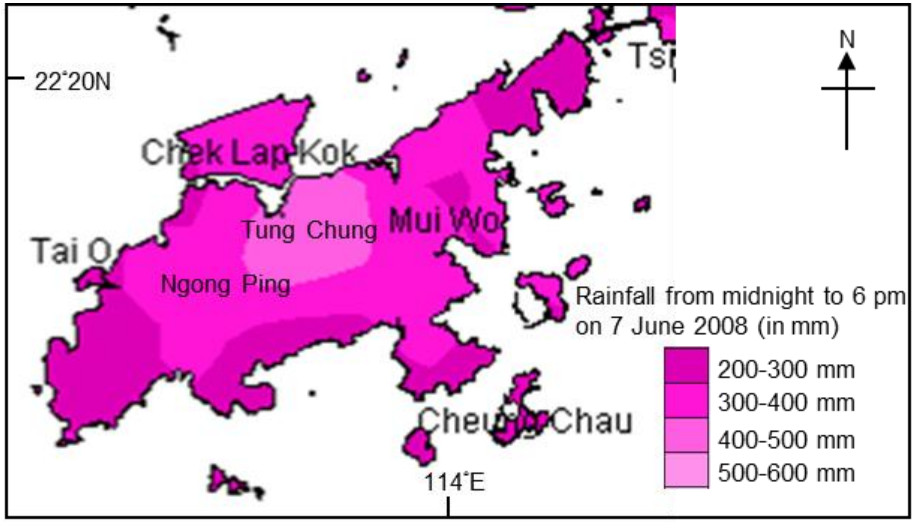
Is it possible to apply **quantitative** geomorphology to assess landslides?

An Application of Quantitative Geomorphology

An opportunity comes up …

June 2008 landslides

- > 1,600 landslides were triggered by heavy rainstorm in June 2008
- 845 landslides on W. Lantau
- Rainfall intensity: 145 mm in an hour (Return period: 1000 years)



Source: Hong Kong Observatory

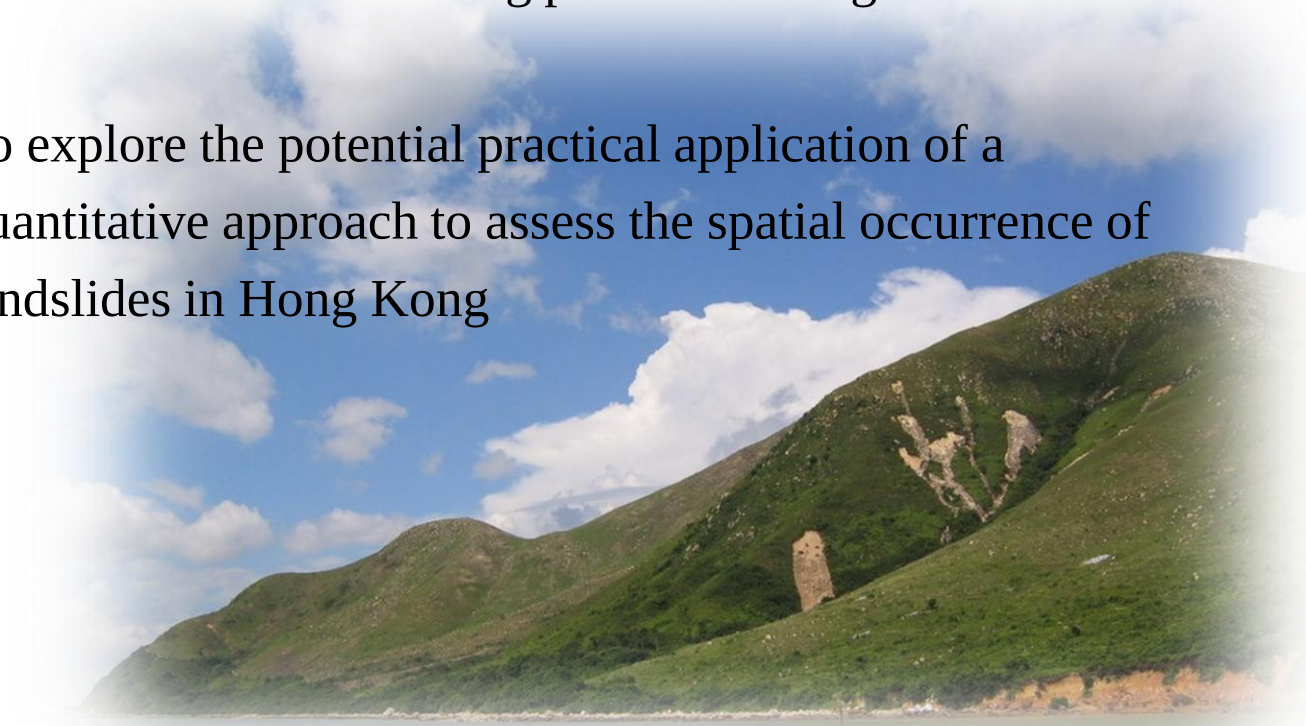
Shallow debris slides and flows

An Application of Quantitative Geomorphology

Aims of Study

- To quantify the relationship between the geomorphological parameters and landsliding process in a regional scale

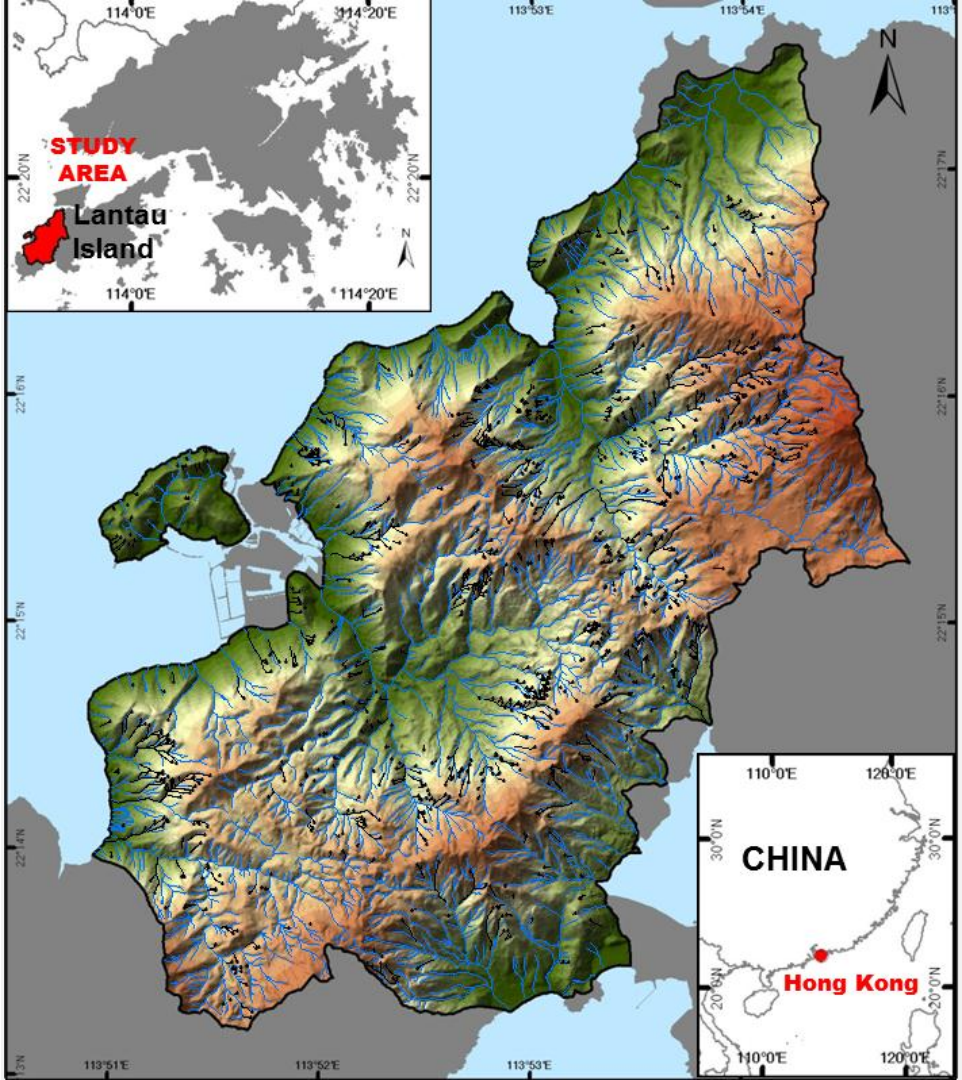
- To explore the potential practical application of a quantitative approach to assess the spatial occurrence of landslides in Hong Kong



Study Area

- West Lantau Island
- 31 km^2 (refined catchments)

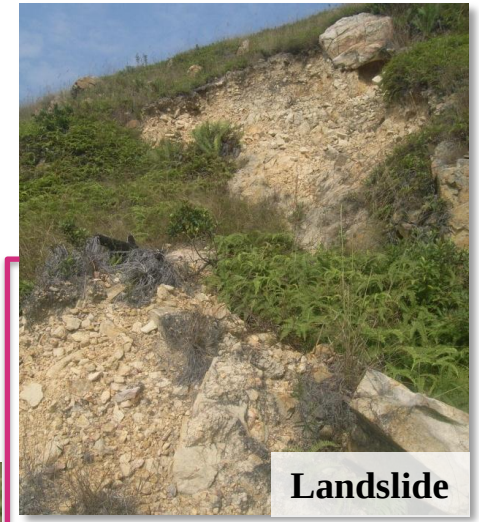
Geomorphology	Key Characteristics
Form	Steep terrain up to 750 mPD
Processes	Fluvial dissected hillslopes; mass movements
Materials	Weathered volcanic ash tuff; colluvium

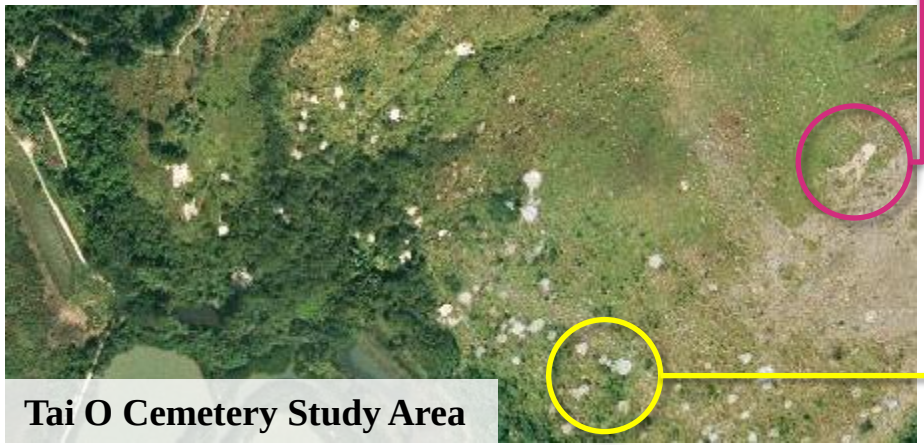


Methodology

Use of API & Field Verification

- To confirm presence of streams and study area
- To identify / verify June 2008 landslide locations



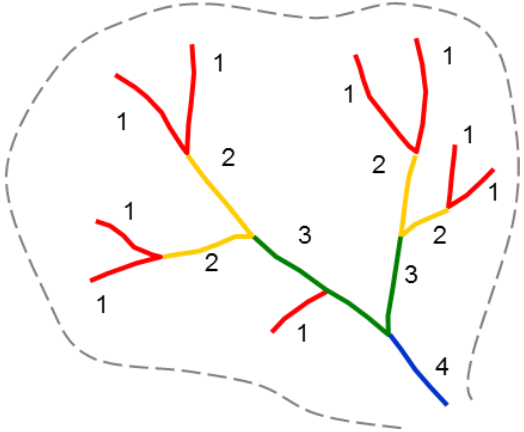


Methodology –

Drainage line delineation and classification

Stream Ordering

- Strahler's ordering system can be adopted to classify natural streams and the associated catchment



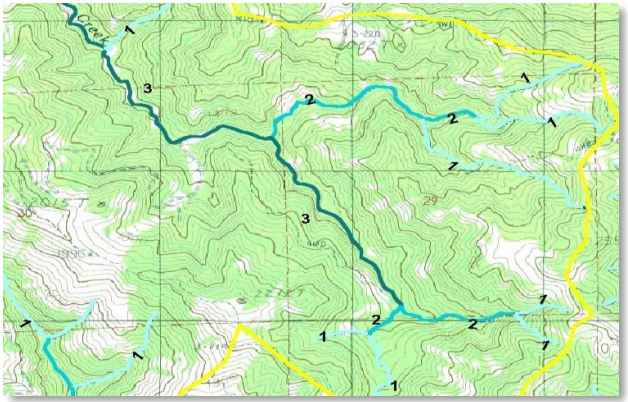
Lower-order stream

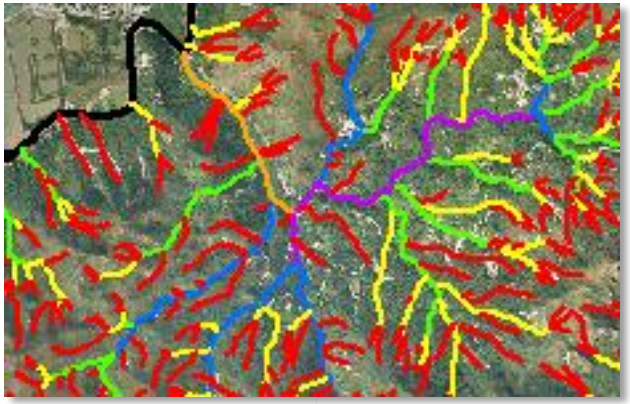
Higher-order stream

How to delineate a drainage line?

- 1:1,000 scale topographic maps
- API
- Field Verification

Increasing certainty



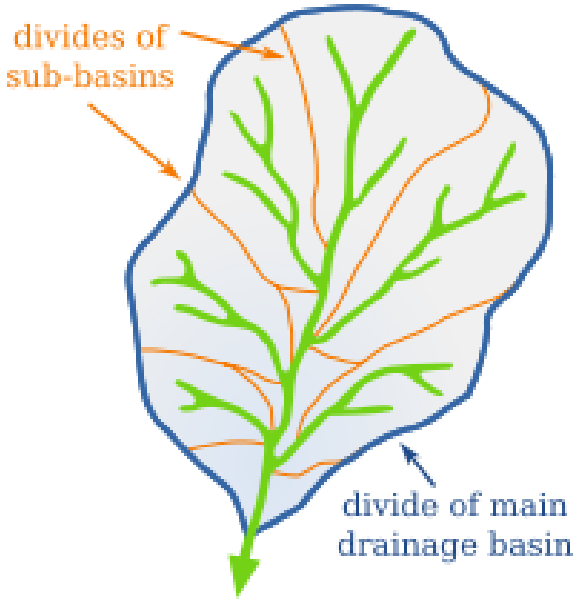


Methodology –

Measurement of Parameters to characterise Drainage Basin Morphometry

Linear Parameters

- Drainage order (No. / order)
- Drainage length (km)



Areal Parameters

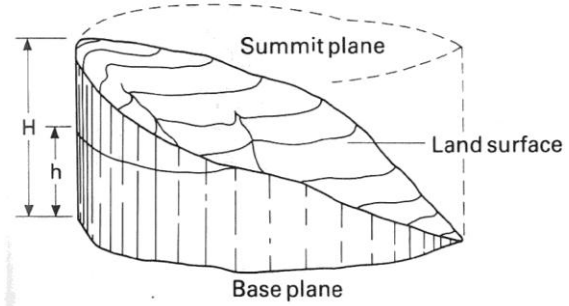
- Drainage area (km^2)
- Drainage density (km/km^2)

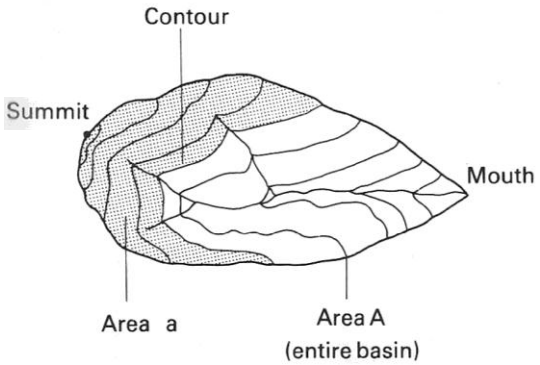
Relief Parameters

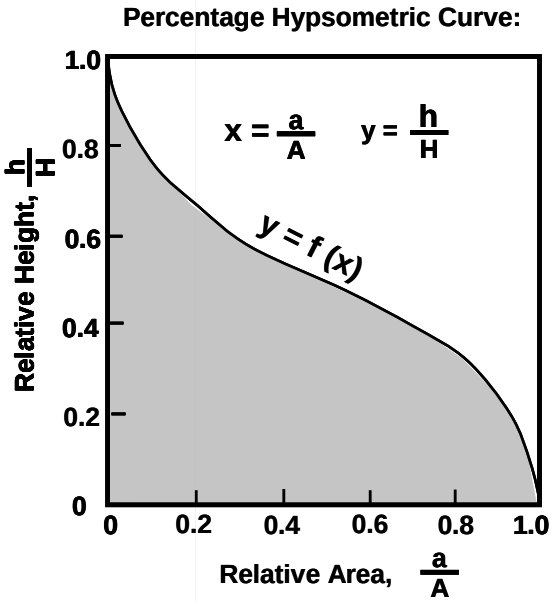
- Drainage gradient (ratio or degrees)
- Hypsometric Integral

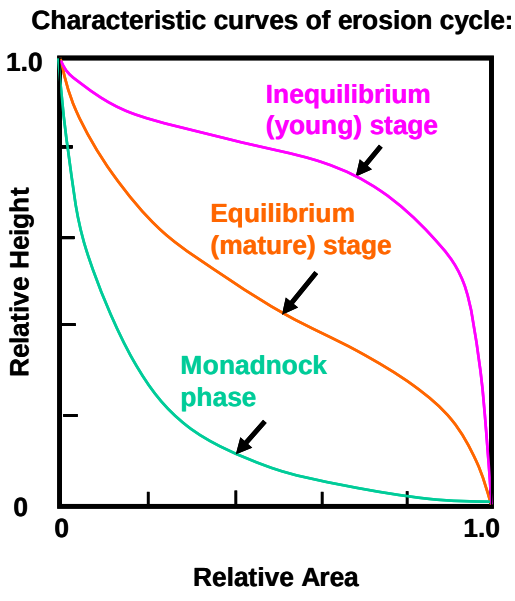
What is Hypsometric Integral?

- Calculation of area-altitude distribution of drainage basin

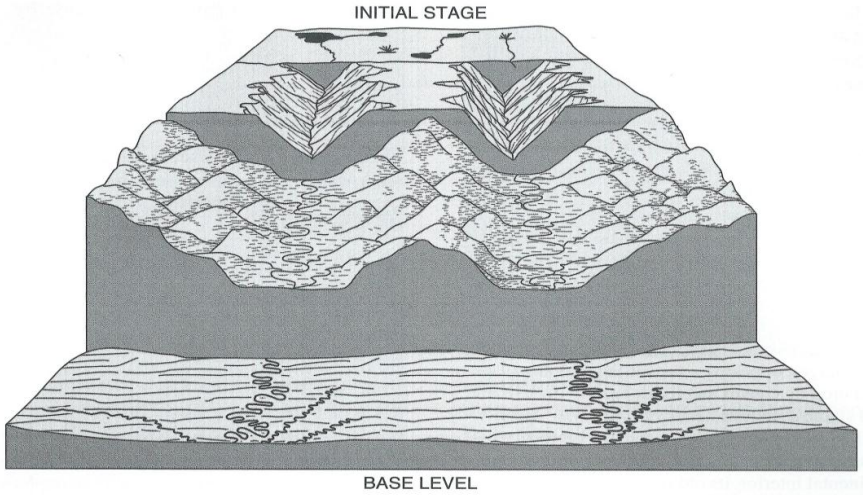








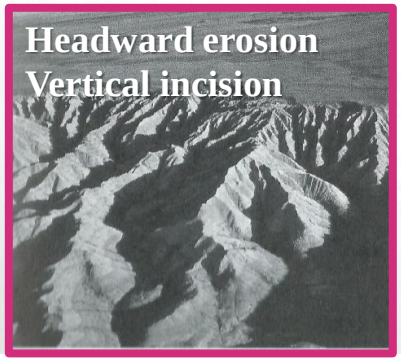
Fluvial Landform Evolution

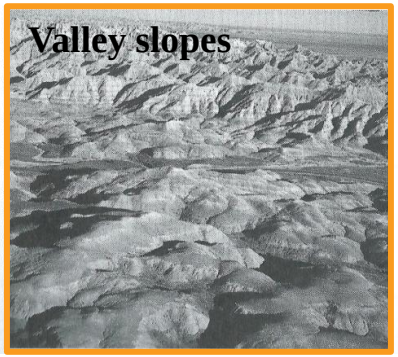


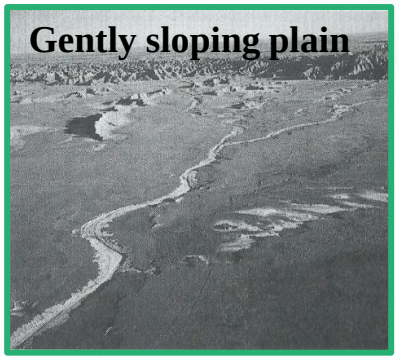
Early stage

Mature stage

Old stage







Easterbrook (1999) Figure 6-35

Work in progress…

Study Area (refined)

GIS

Geomorphology references

Topographic maps

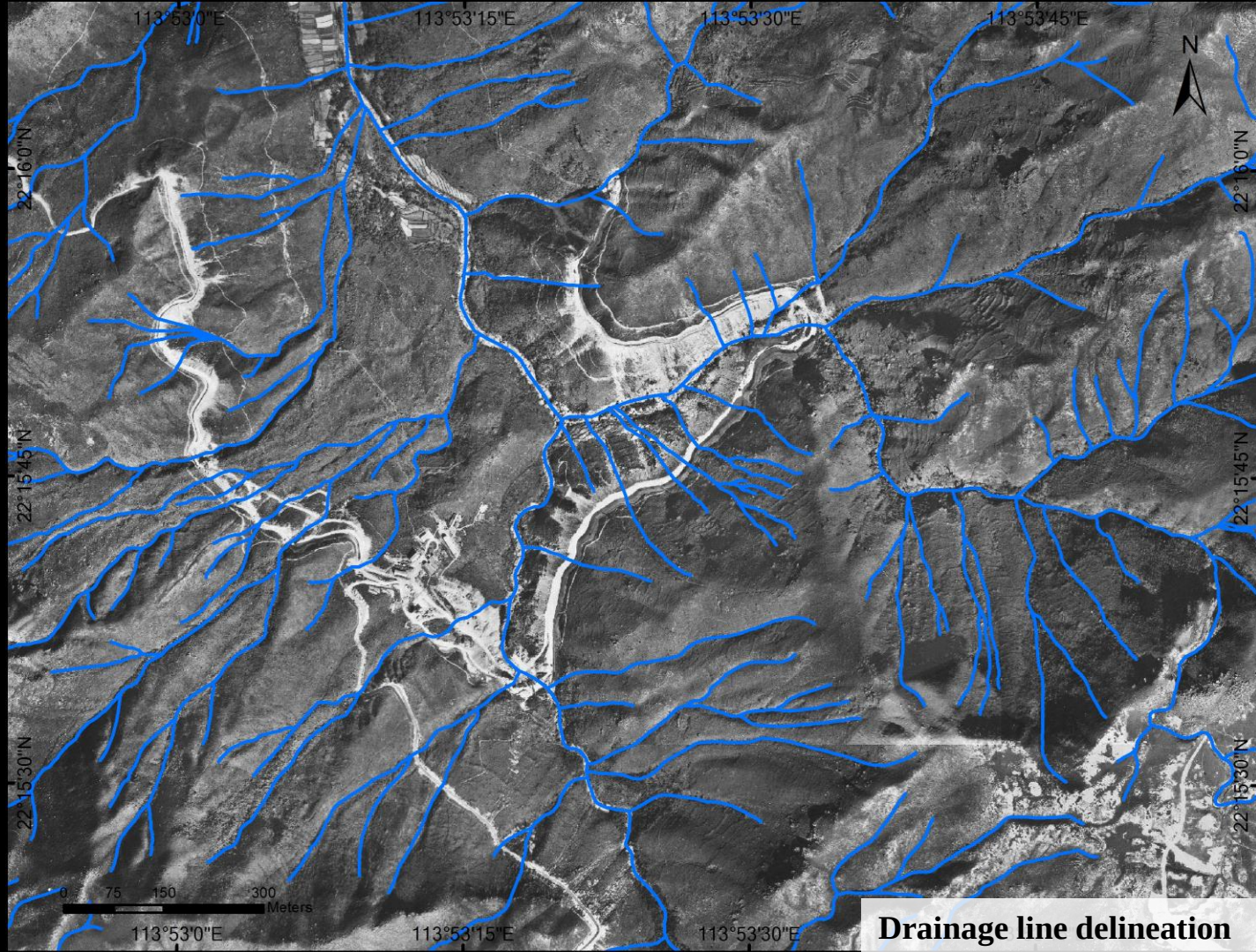
Field verification

API

How it works?

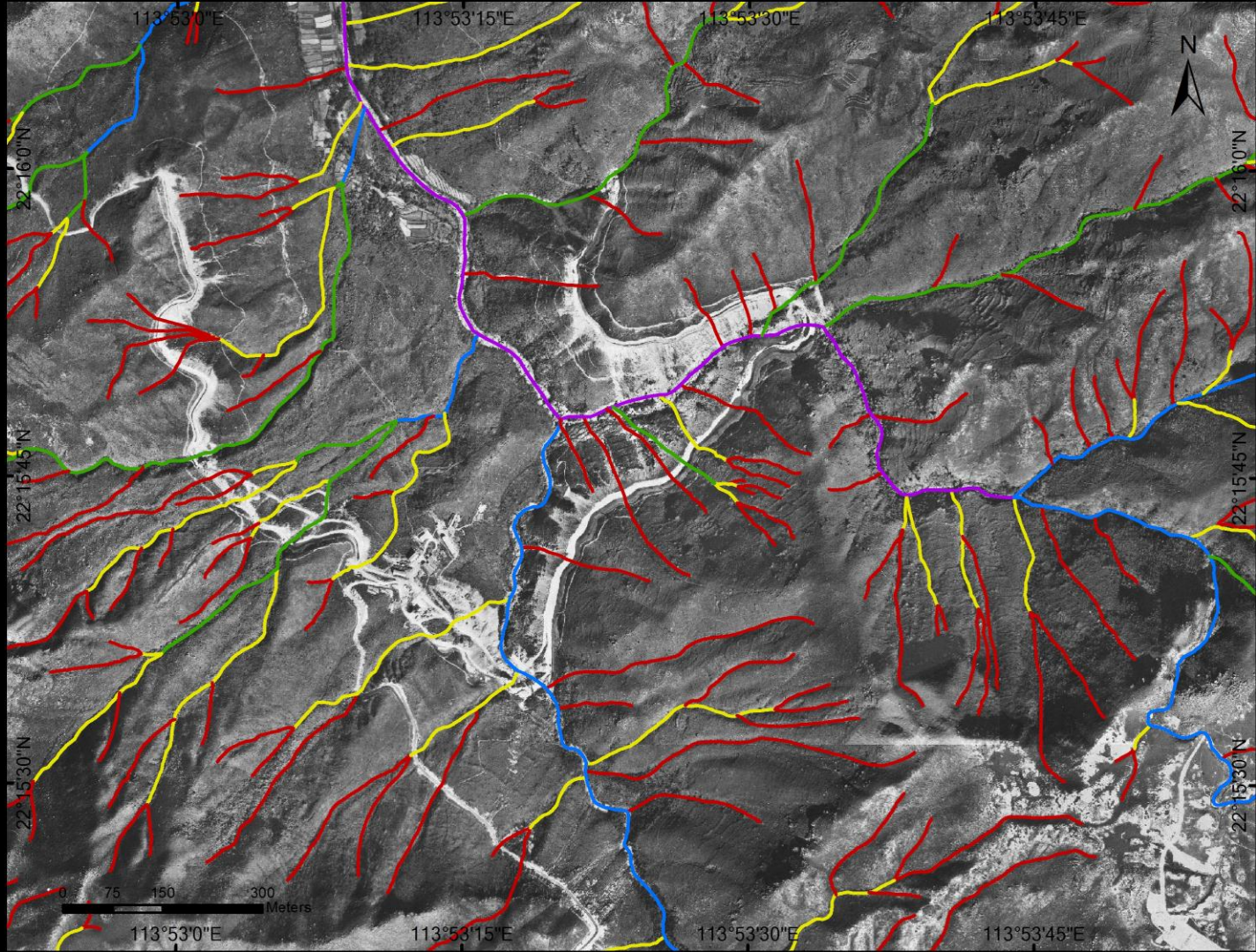
API (1963)

API – Drainage line Identification

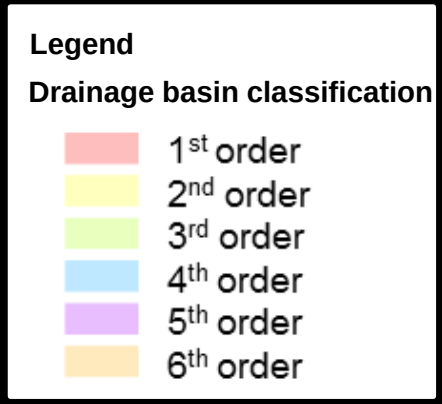


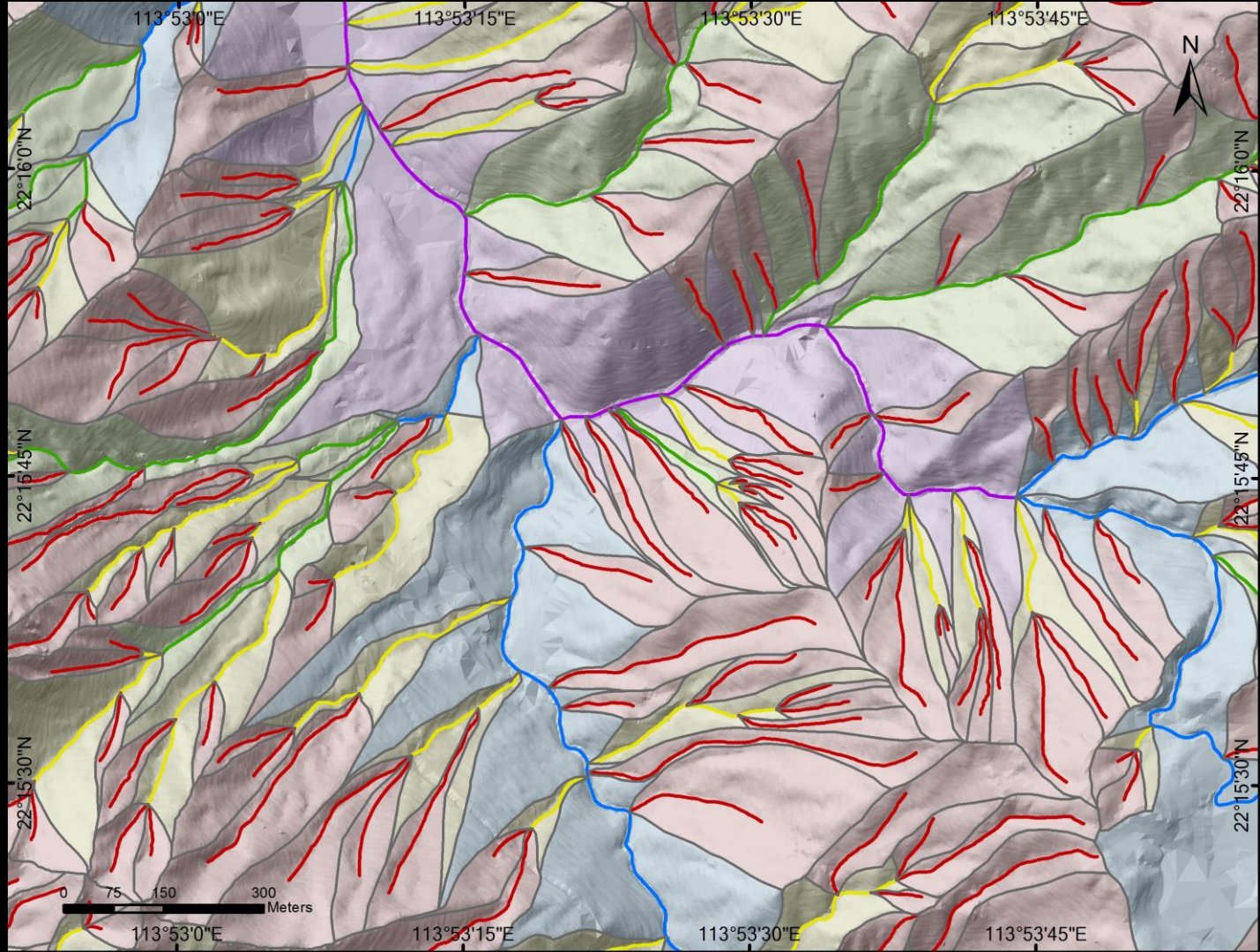
Drainage line delineation

Drainage line classification using Strahler's Order



Drainage basin classification using Strahler's Order



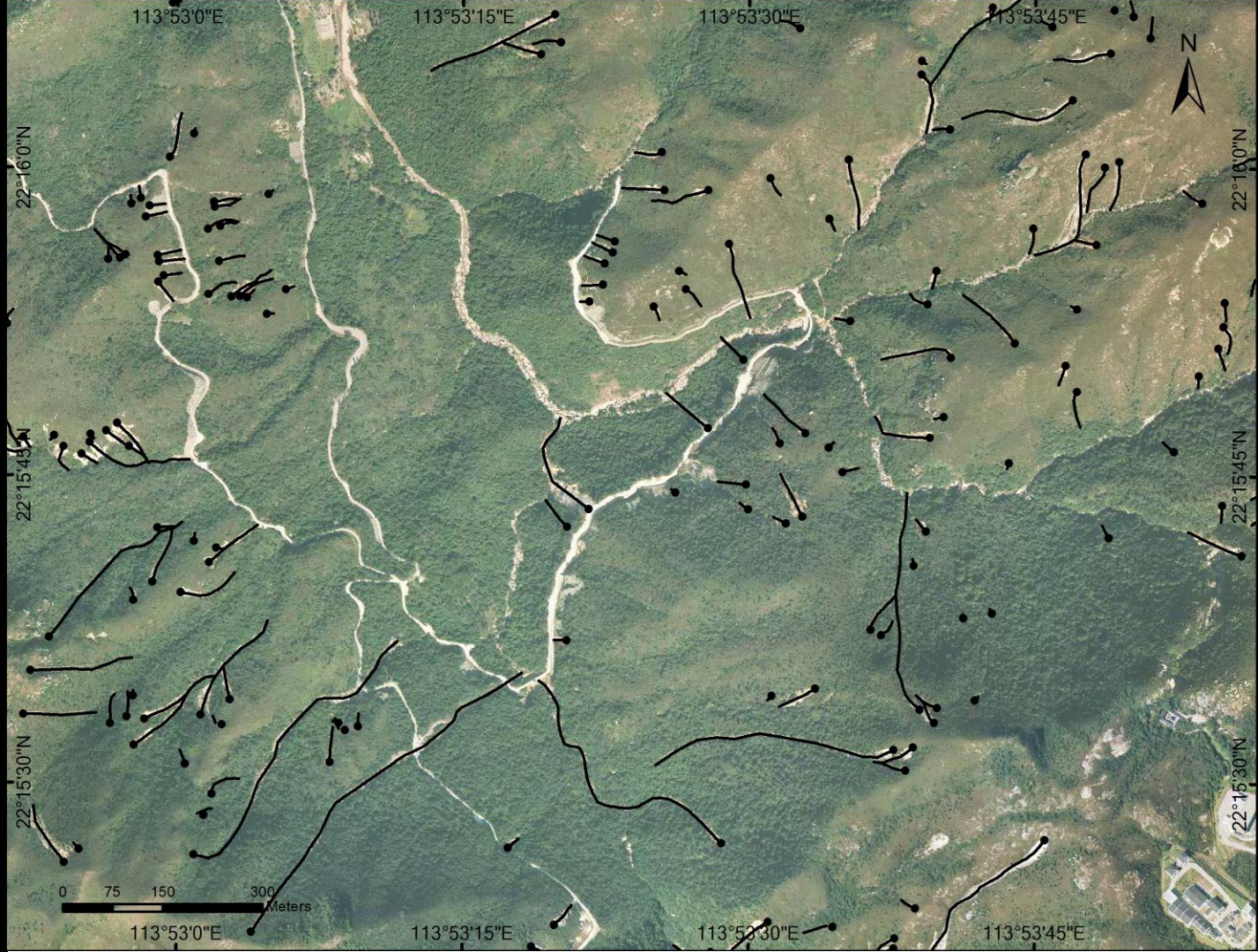


API
(before June 2008 rainstorm)

API
(after June 2008 rainstorm)

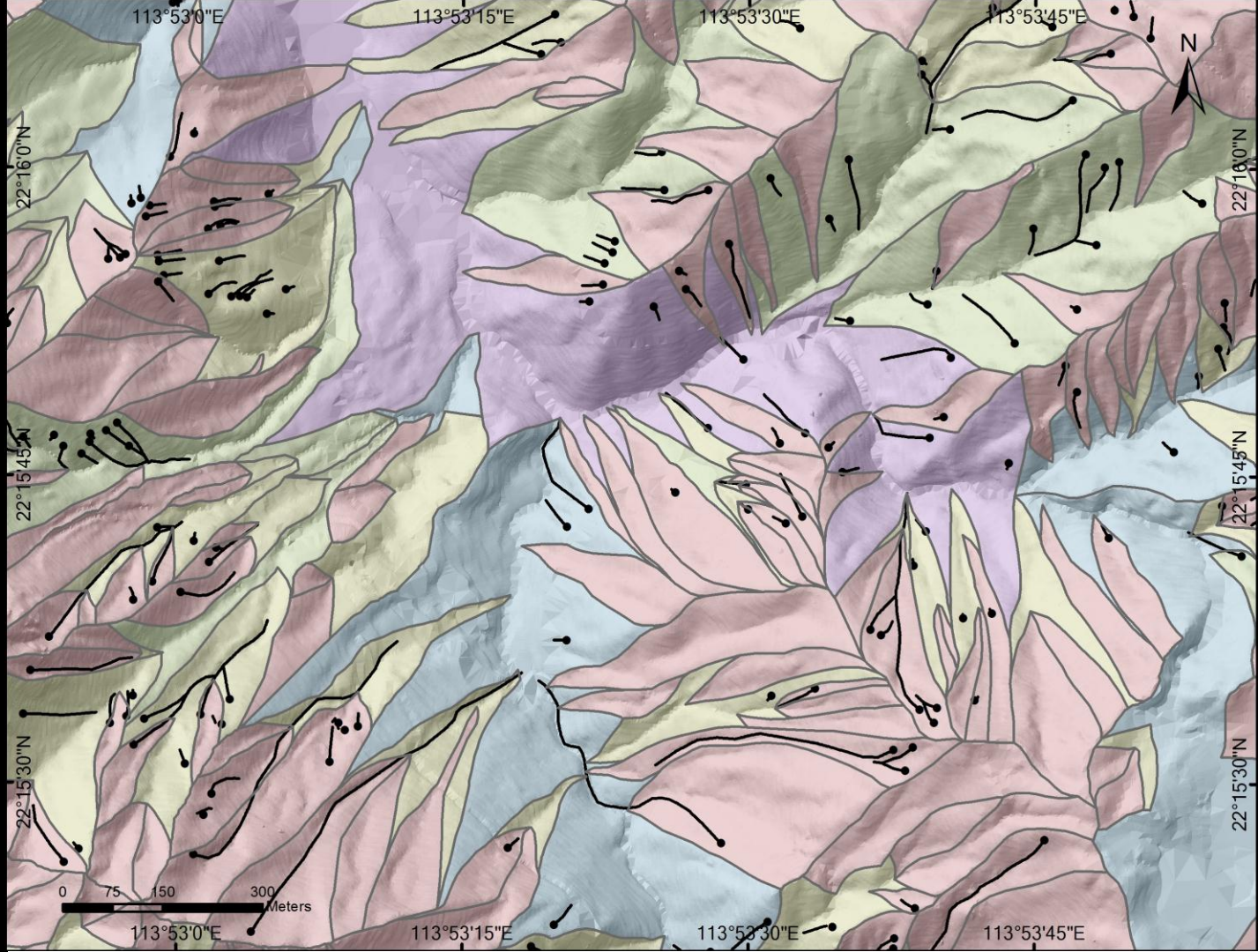
API

Identification of landslides triggered by the June 2008 rainstorm



GIS Analyses

Landslides &
Drainage basin
Morphometry

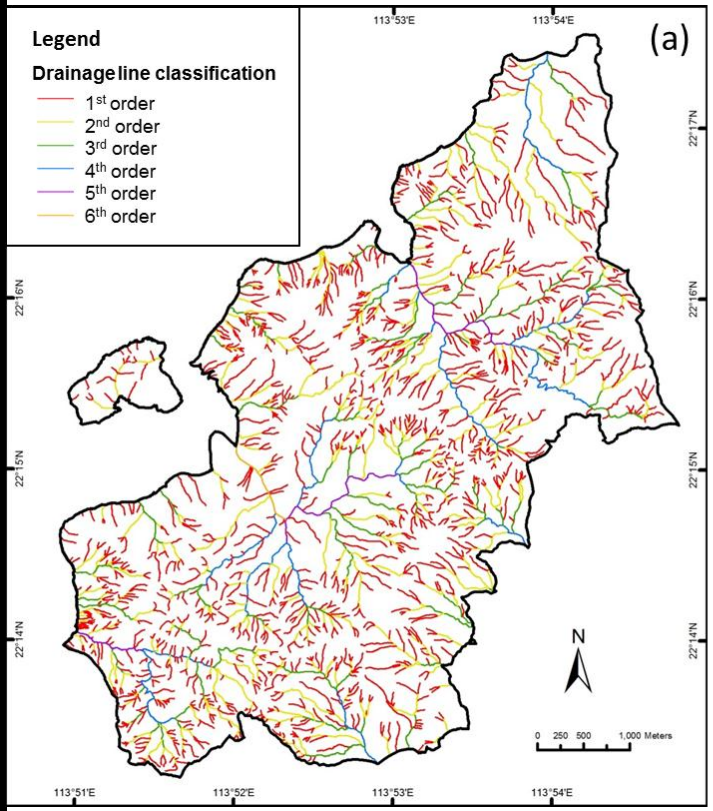


Results

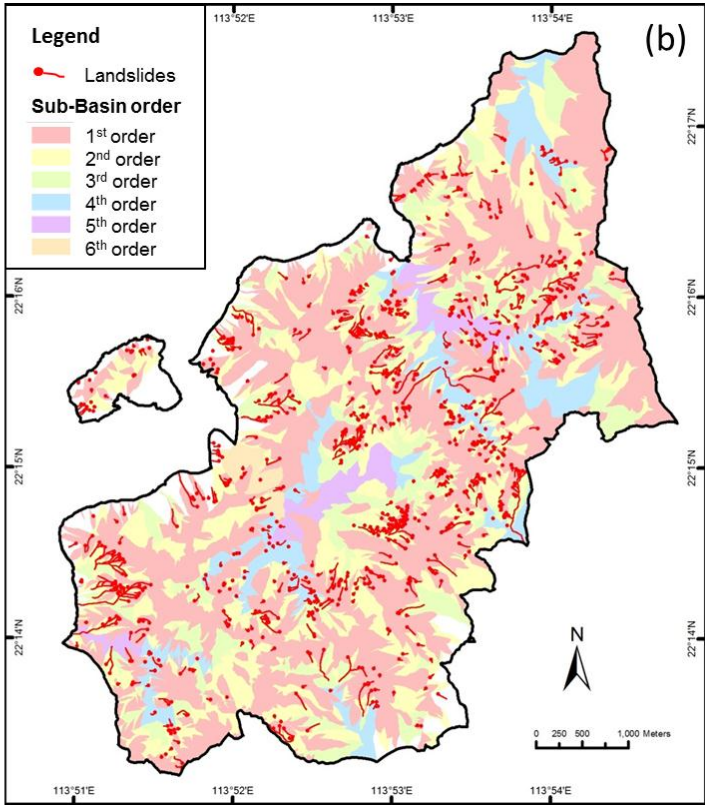
Which geomorphic location is most susceptible to landslides?

Key Findings –

Spatial Distribution of the June 2008 Landslides in West Lantau



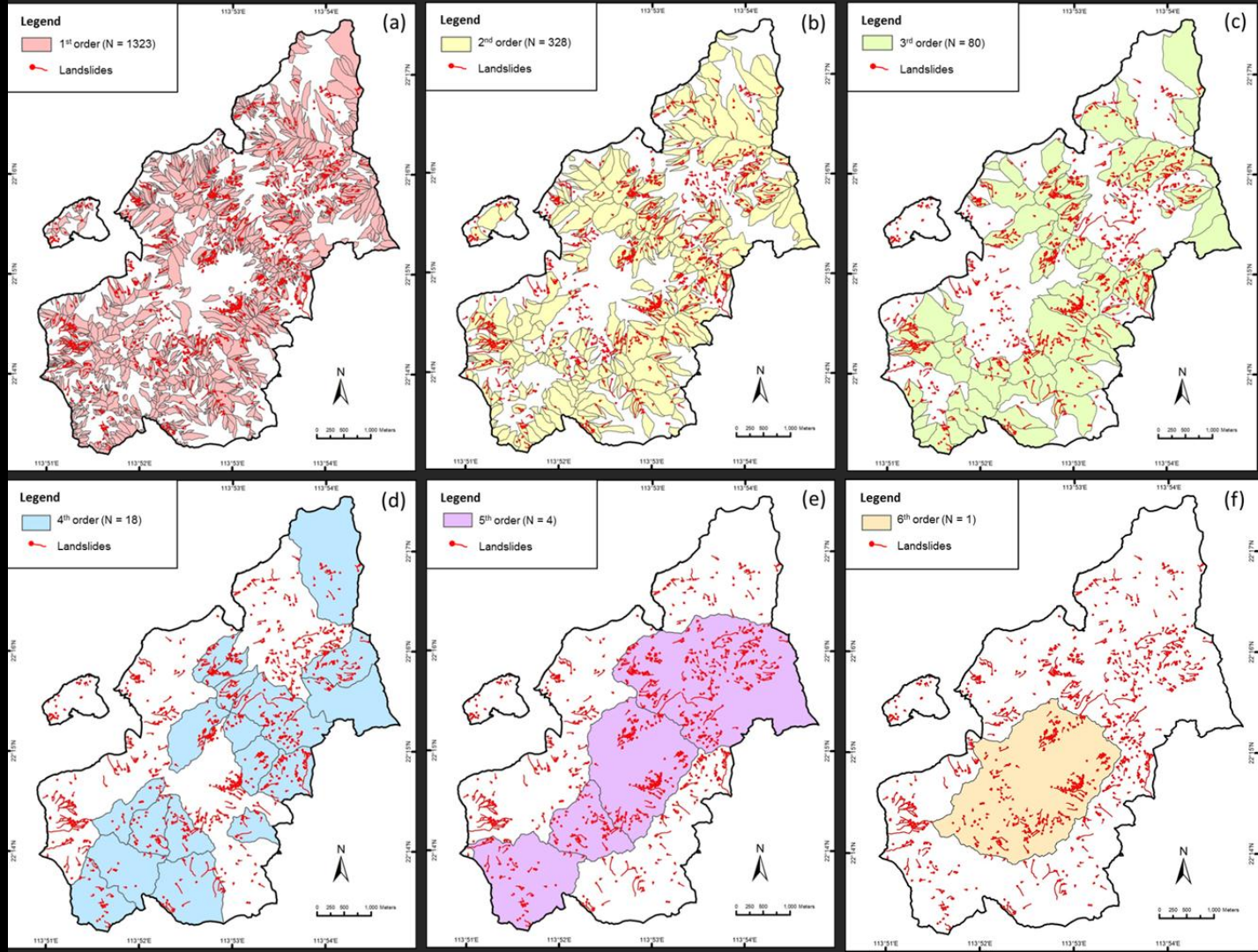
Drainage network system in Strahler's order



The geomorphic position of landslides within sub-basins

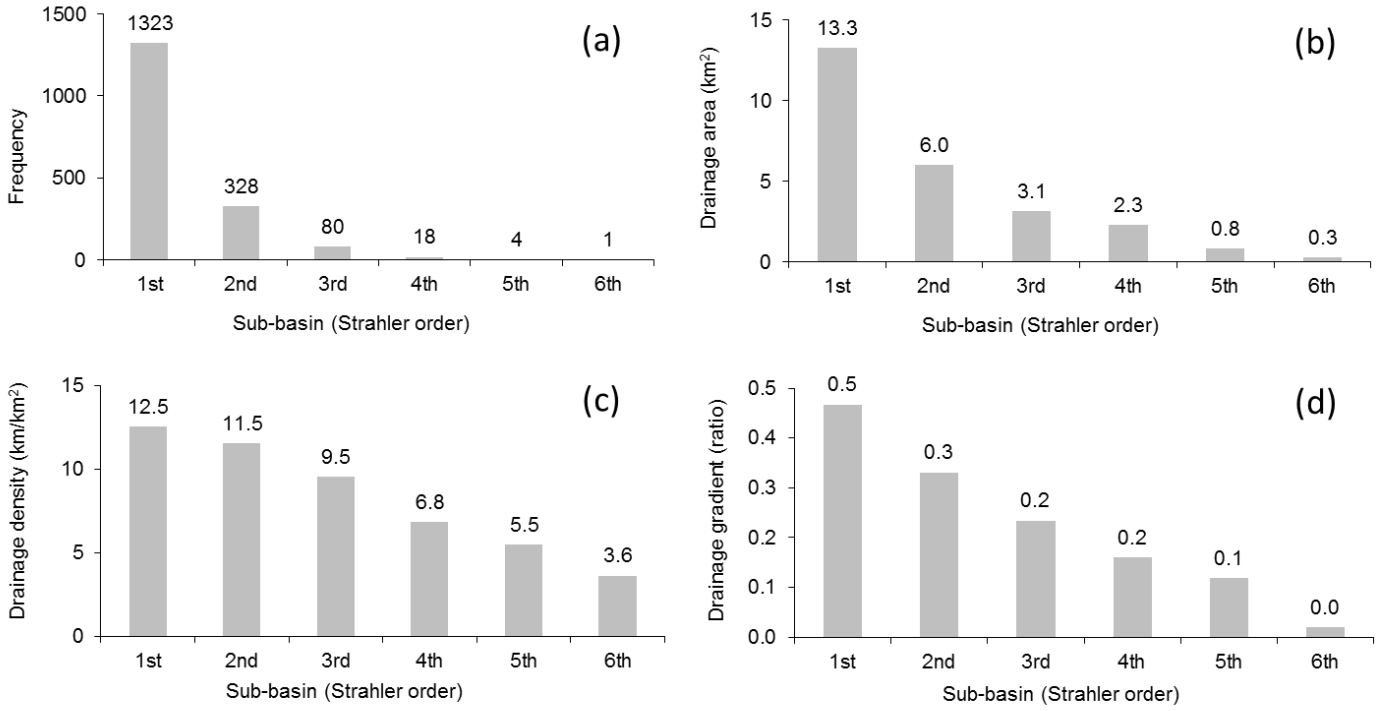
Key Findings –

The Geomorphic Position of Landslides



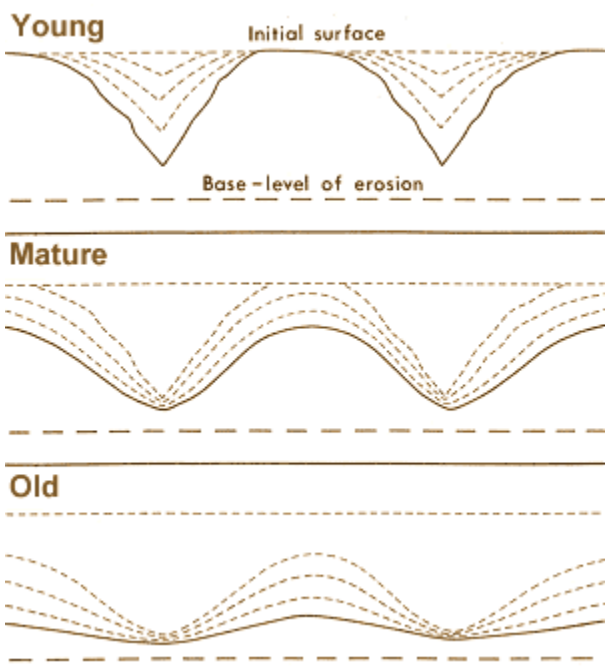
Key Findings –

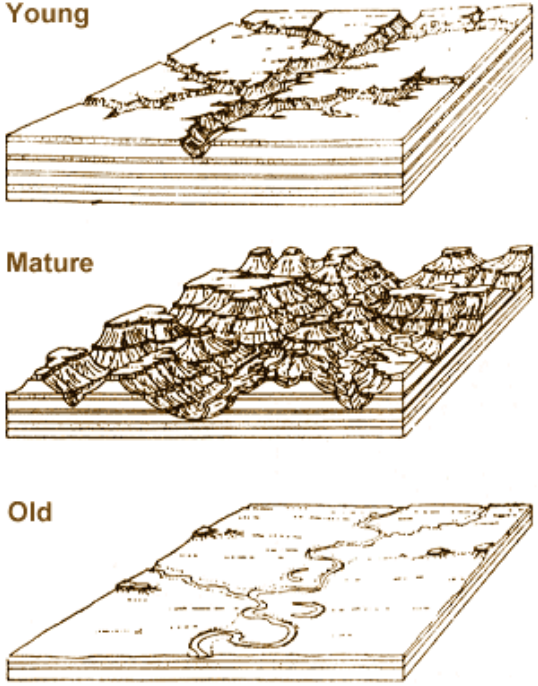
Drainage Basin Morphometry

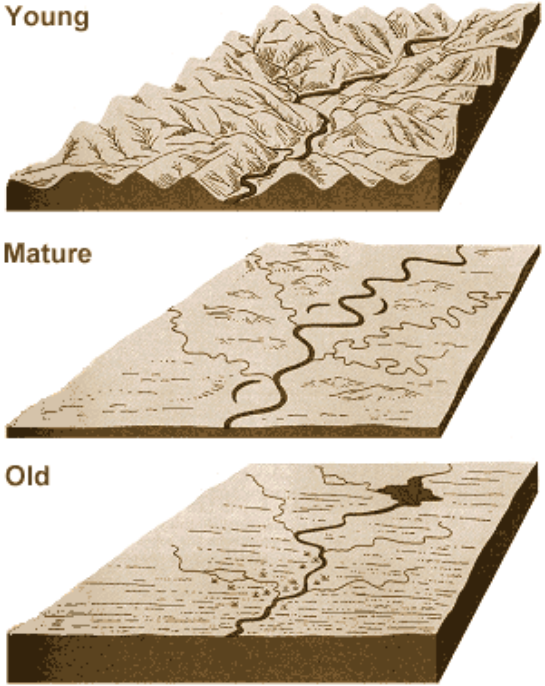


Systematic Distribution of Morphometric Parameters in Strahler's order

Which Stage of Landform Evolution?

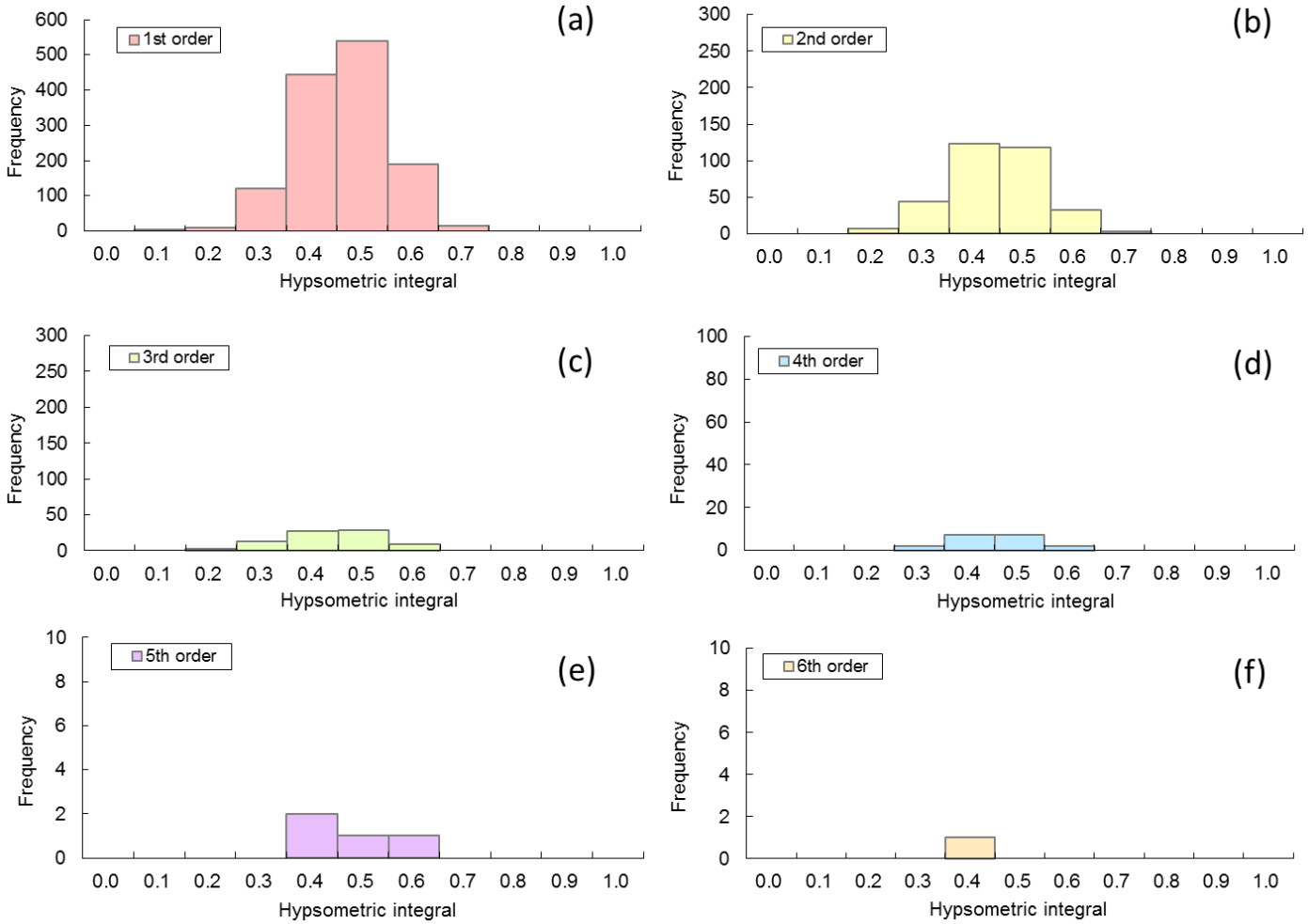






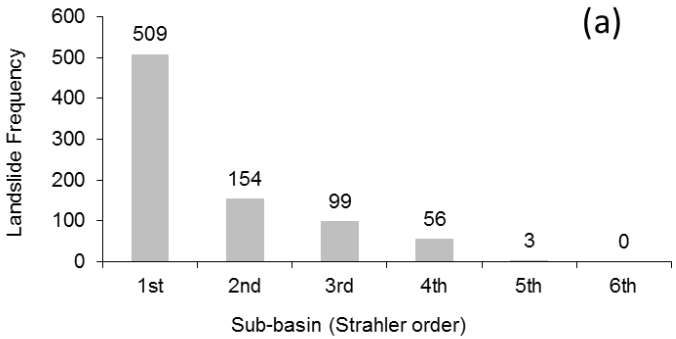
Key Findings –

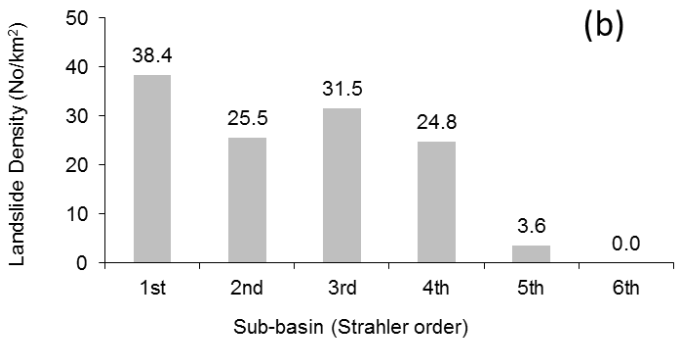
Frequency Distribution of Hypsometric Integral



Key Findings –

Landslide Distribution in Strahler's Order





Discussions

What are the implications for landslide hazard assessment?

Academic Perspective

Landslides and Drainage Network Development

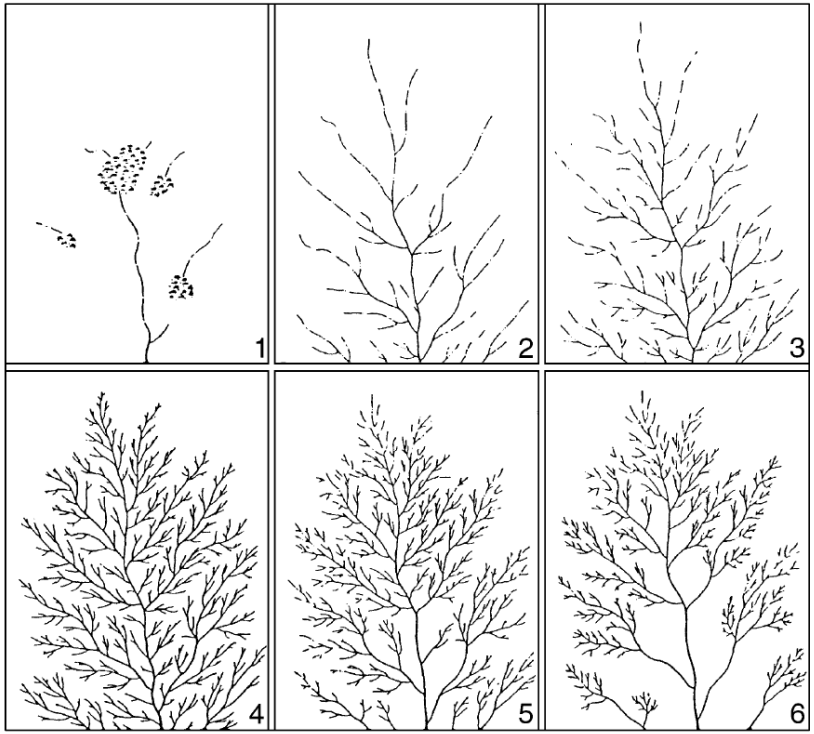
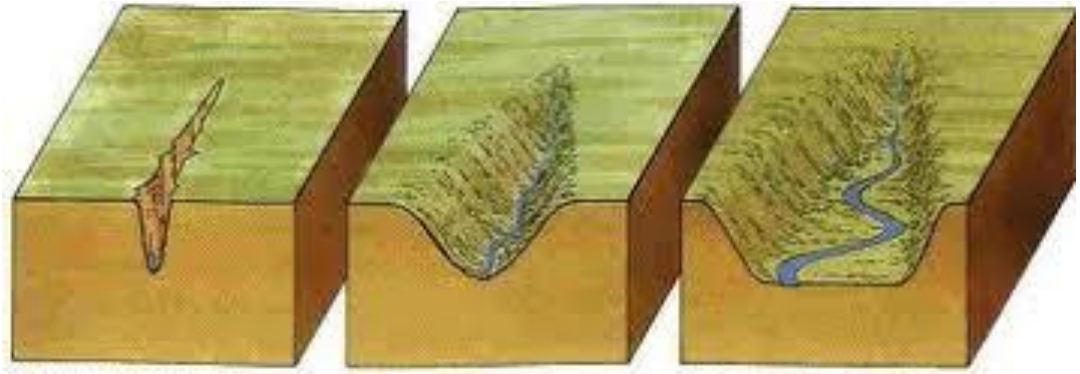


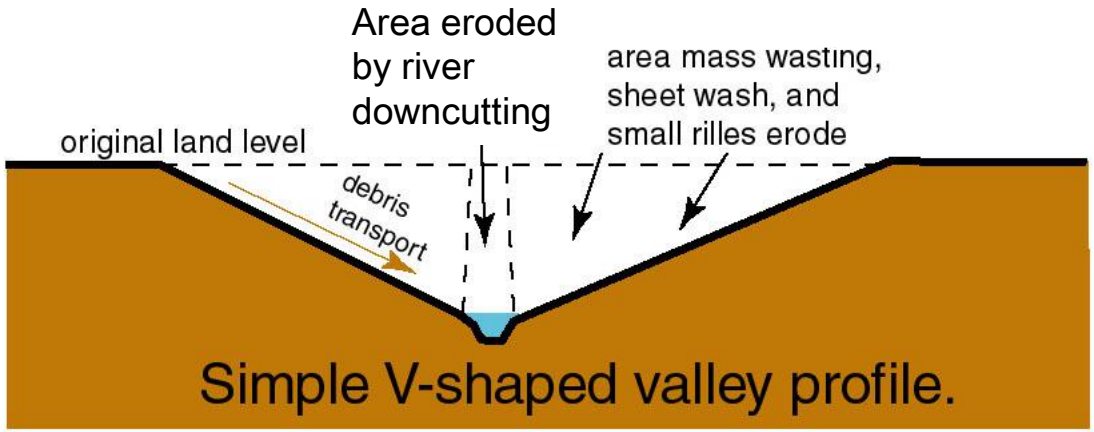
Fig. 1. Drainage network development showing (1) initiation, (2) elongation, (3) elaboration, (4) maximum extension and (5 and 6) integration by abstraction and absoption. (1–4) Drainage network extension and (5–6) drainage network integration (after Glock, 1931).

Ng, (2006) Landslides Locations and drainage network development. *Geomorphology*, 76, 229-239.

Academic Perspective

Interactions of Slope and Fluvial Processes

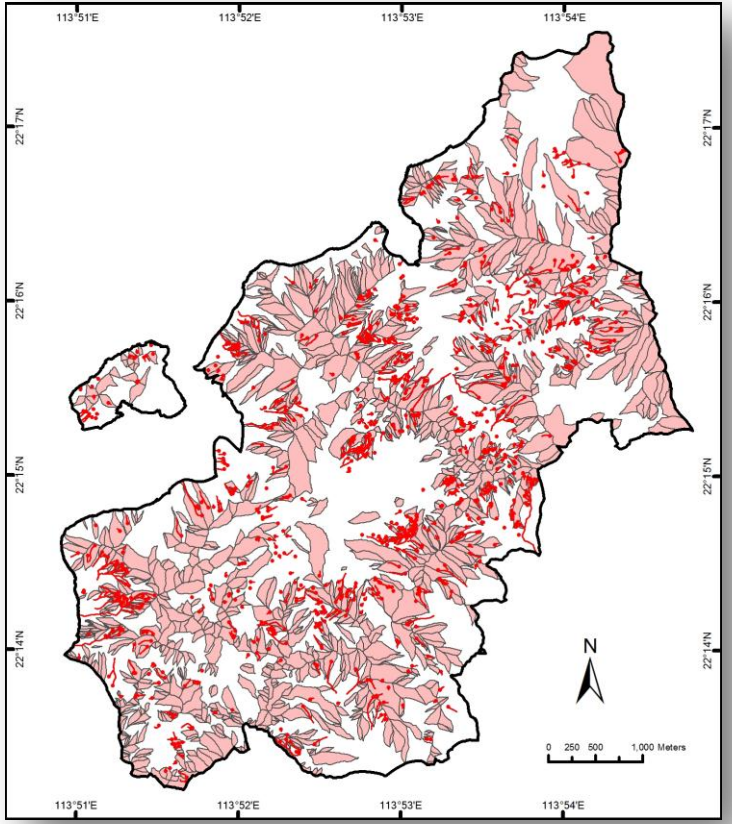




Practical Implications

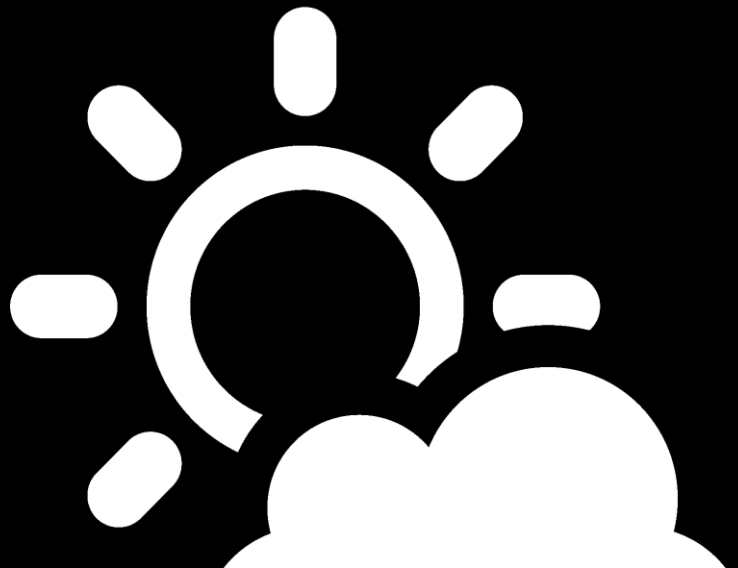
Potential Hazard Zoning at Regional Scale

- Overview of landslide distribution in a geomorphological context
- GIS facilitates the quantification of various morphological parameters for the analyses



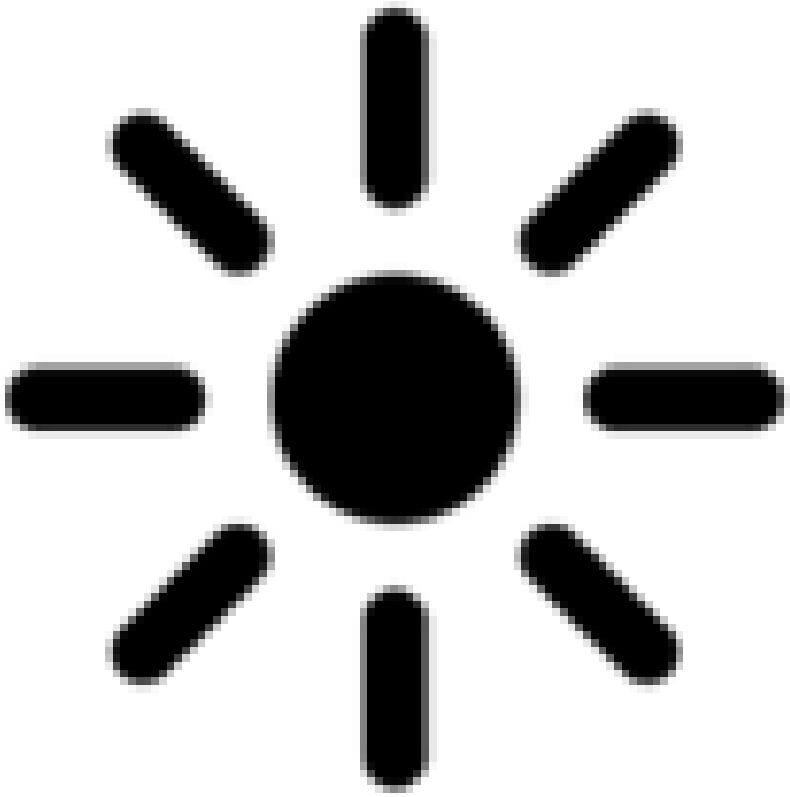
Significance

- Reveal systematic relationship between fluvial morphometric parameters and landslide distribution
- Rapid quantitative geomorphological analyses on ‘where’ landslide occur at a regional catchment scale
- The relative simplicity of Strahler’s ordering system make this approach readily followed and understood by non-specialists



But still there is a gap….

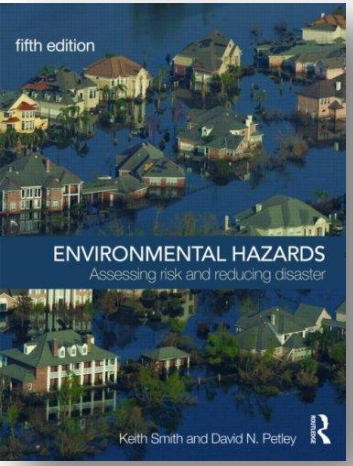
Little is known on **when** and **where** landslide will occur despite advances in research and practice

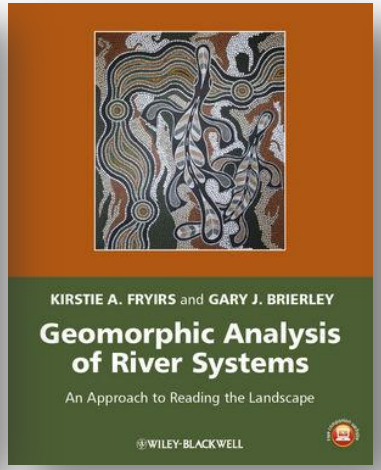


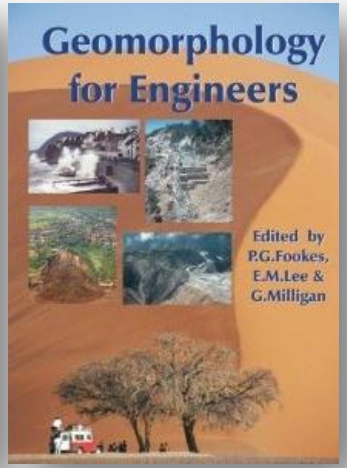
Future Prospects

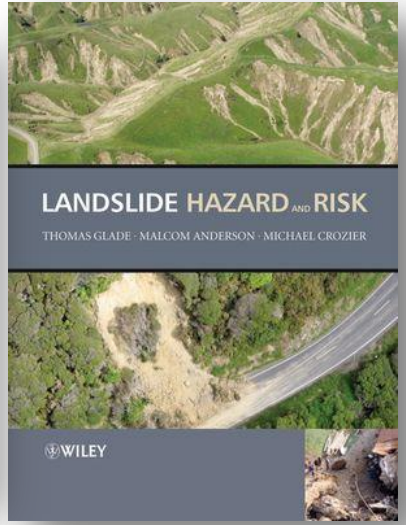
Applied geomorphology in assessing hazard and risk

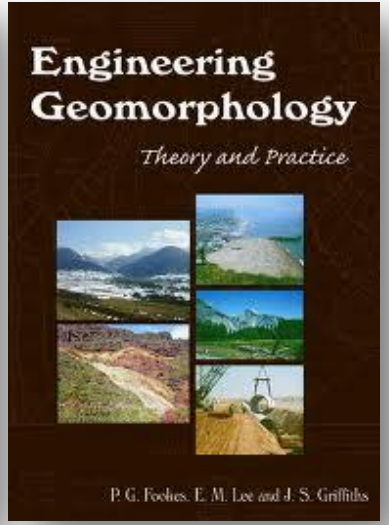
Hazard & Risk Assessment – Applied Geomorphology











- Appreciation of the understanding and practical application of the knowledge

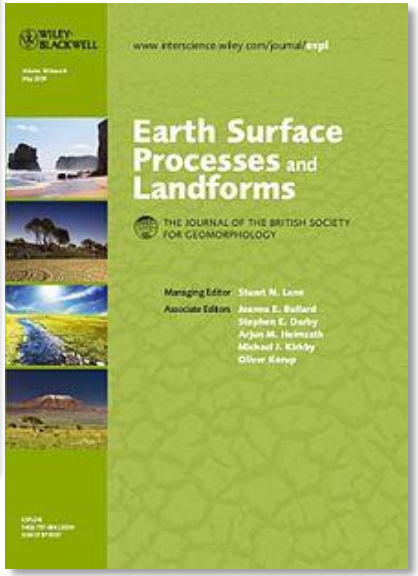
University Education

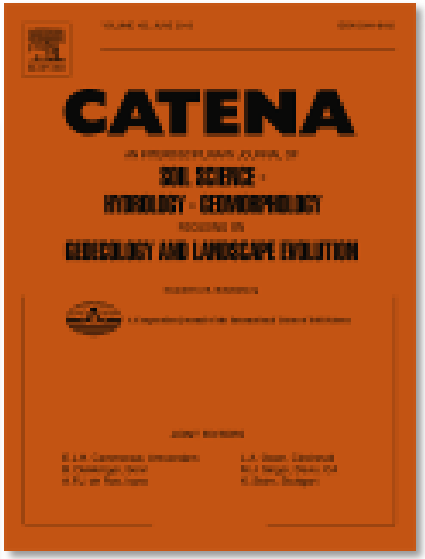
- Geomorphology Courses at HKU, CUHK, HKBU

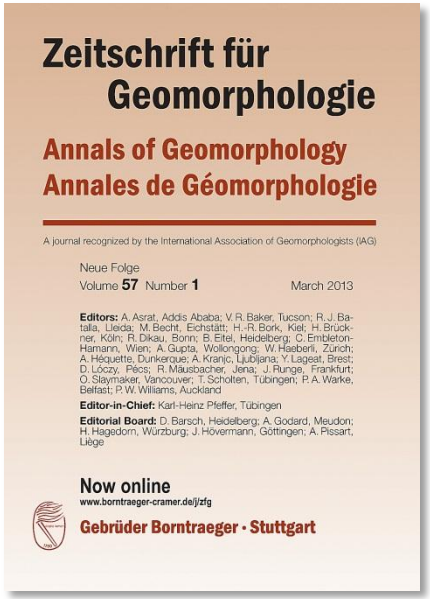
Course Field Trip, 2013

and Research….

- Advance knowledge
- Publish research papers in high impact journals







On-the-Job Training and CPD

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Advancing geography and geographical learning

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- Administered by the Royal Geographical Society (with IBG)
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- About 13% abroad
- Collaborate with the AGI on CGeog (GIS)

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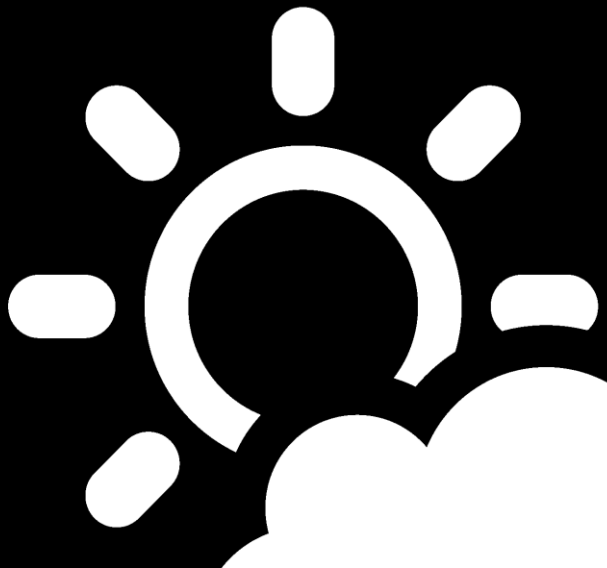
Conclusions



Thank you

June 2008 landslides, Sham Wat