Topographic Laser Scanning of Landslide Geomorphology System: Some Practical and Critical Issues

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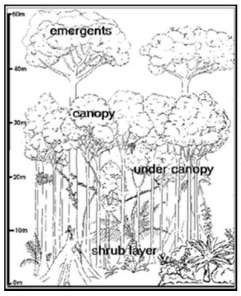
Commission No. 6

Introduction

- Based on UNISDR-CRED international disaster **databases**, landslides are ranked **3rd** in terms of number of **fatalities** among the top ten natural disasters.
- In the past **34 years**, the total economic losses due to landslides in Malaysia are estimated about **RM 3 billion** and without a comprehensive mitigation plan; it will substantially **cost 17 billion** over the next 25 years.

Landslide Mapping in the Tropics: Why it is so difficult?

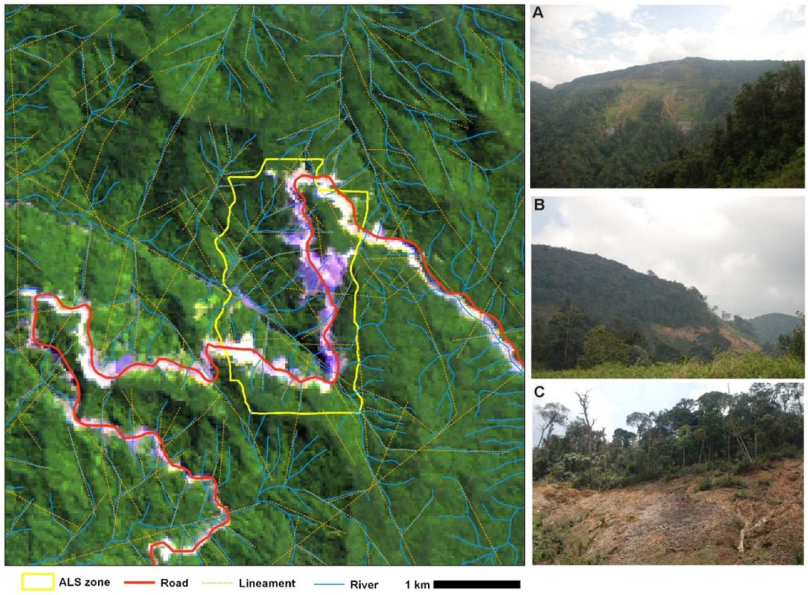
- In the monsoon-dominated regions, landslides occur in areas characterized by steep hillslopes, high rainfall intensities, seasonally dry periods, unstable soils and also under dense vegetation.
- The compilation of **landslide inventory maps** is a tedious procedure due to the fact that each individual landslide has to be mapped and described together with their characteristics.
- Conventional landslide mapping techniques have **limitations in a forested and rugged mountainous environment.**



- **This research provides a new insight into the use of topographic laser scanning system (TLSS) data for characterizing complex tropical landslides.**
- **We highlight some practical and critical issues following the *field to finish* concept of landslide mapping and characterization using laser scanning data in a lowland evergreen rainforest in Malaysia.**

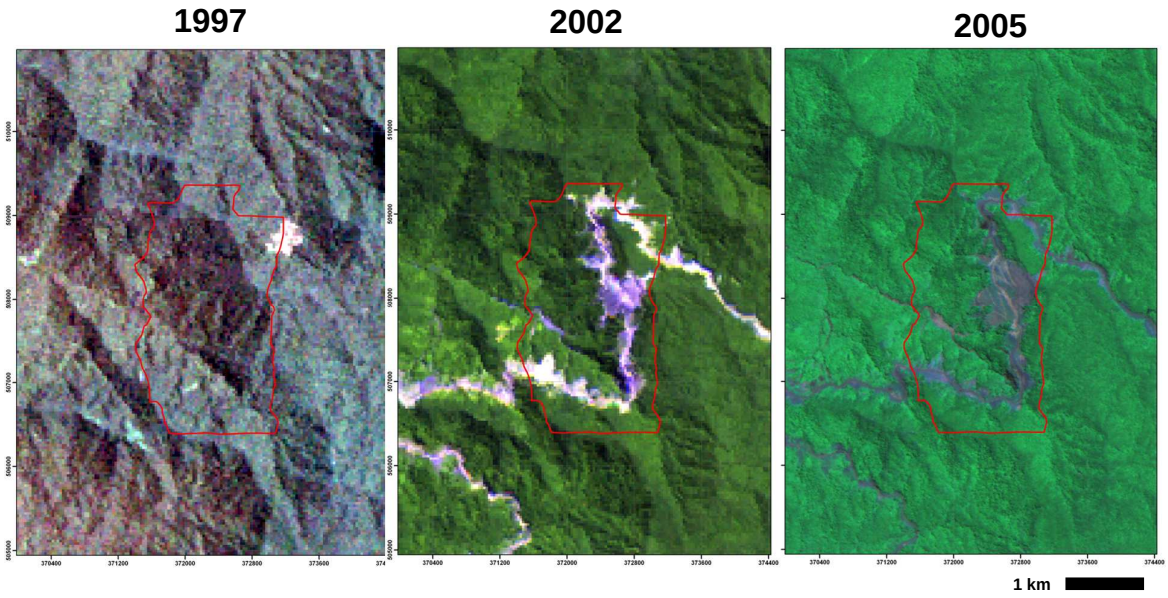
Billions of 3D point clouds across landslide affected terrain

Complex Landslides, Gunung Pass Perak



- Elevation range between 930 and 1600 m msl
- The annual rainfall is between 2500 and 3000 mm per year.
- Geologically, it is dominantly covered by metasedimentary schists.

Land-use changes from space

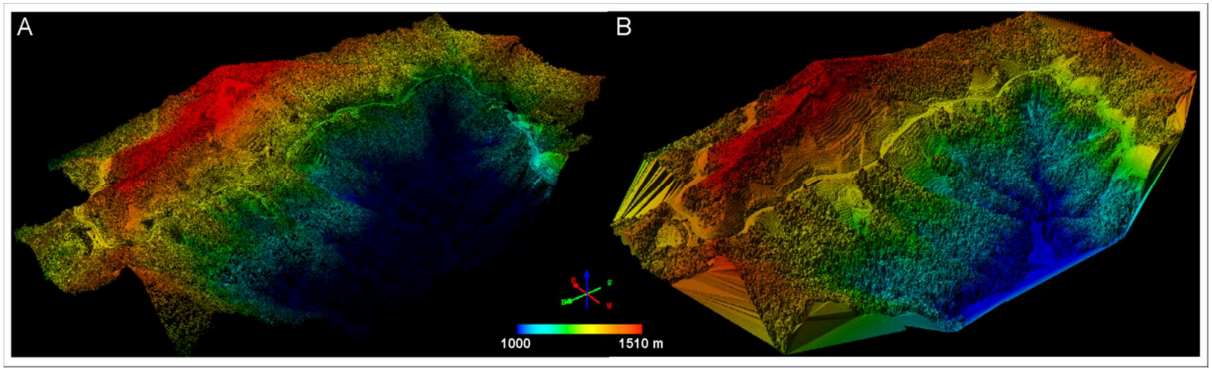


MULTISENSORS LASER SCANNING DATA FOR TROPICAL LANDSLIDES

- ALS & TLS systems and intensive field campaigns.
- Point cloud- and image based processing.
- Optimal DTM for tropical landslides.
- TLSS-derived landslide mapping and classification.
- Morphological and vegetation characteristics associated to complex landslides.
- Some recommendations and possible near-future research.

Methods:
A lidar helicopter-based approach

- In this study, we used a point cloud of about 17.2 million points with a mean point density of 4.31 points m^{-2}.
- The ALS data was acquired using RIEGL LMS-Q560 system.



Recommendations: Airborne LiDAR of forested landslides

	Airborne segment	Ground segment
PRE-STAGE	**Selection of ALS system** (*Laser scanner; GPS; IMU*) **flight platform** (*helicopter*) **Data collection schedule** (snow-free and inclement weather condition) **Determination of flight planning parameter** (*point density; flight altitude; swath width; overlapping area*)	**GPS reference station** (*number; location*) **Calibration area** (*method: non-coordinated points*)
DURING-STAGE	**Guidance flight system** *(need software states the pilot the flight course and elevation during flight)* **Data handling and synchronization** (hardware and data integration)	**GPS reference station** *(technique of sending correction - differential; CORR; data handling)*
POST-STAGE	**Data Processing** *(registration and calibration; strip adjustment; ALS filtering, DTM generation)* **Data Visualization** *(point cloud- and image-based technique)*	**Data Management** *(types of data; data format)* **Quality of data** *(ALS error budget)*

Methods: Ground based laser scanning system

Two set of laser scanners; RIEGL VZ1000 and Leica ScanStation C10 for measuring 3D landscape data over the instability slopes.

Gunung Pass, Perak

Important issues: Ground based laser scanning system

- For **best practise** in gaining reliable topographic data associated landslides, we recommend to put efforts and time on the site evalution (e.g. landslide flow, dimension, diagnostic features, geomorphic processes and recent activity).

- The **planning** of a laser scanning survey can be useful with the help of **preliminary low-resolution data** over the area of interest. This leads to a proper survey design, e.g. determine the number and correct position of laser scanner, and approximate time required to complete the survey and also the quality of 3D registration.

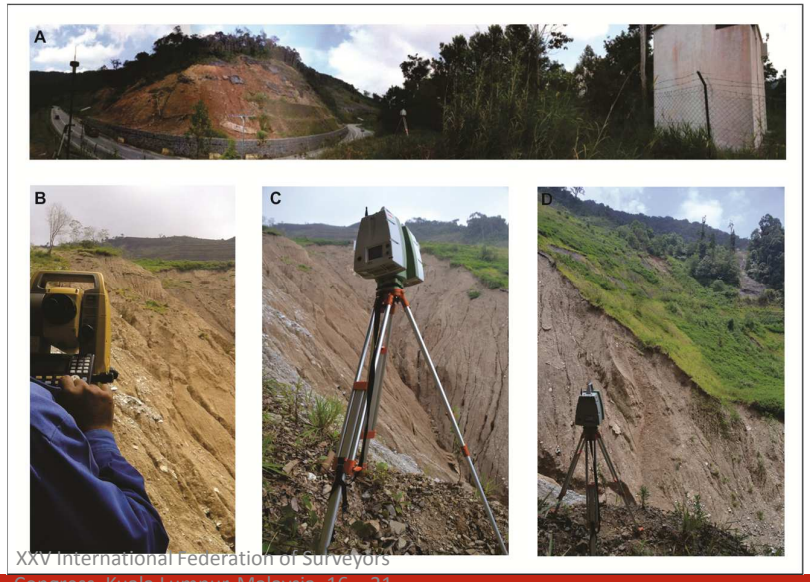
- Evaluation of **complexity** of the sites and **local morphology** of the scanning area.

New tools for an old problem

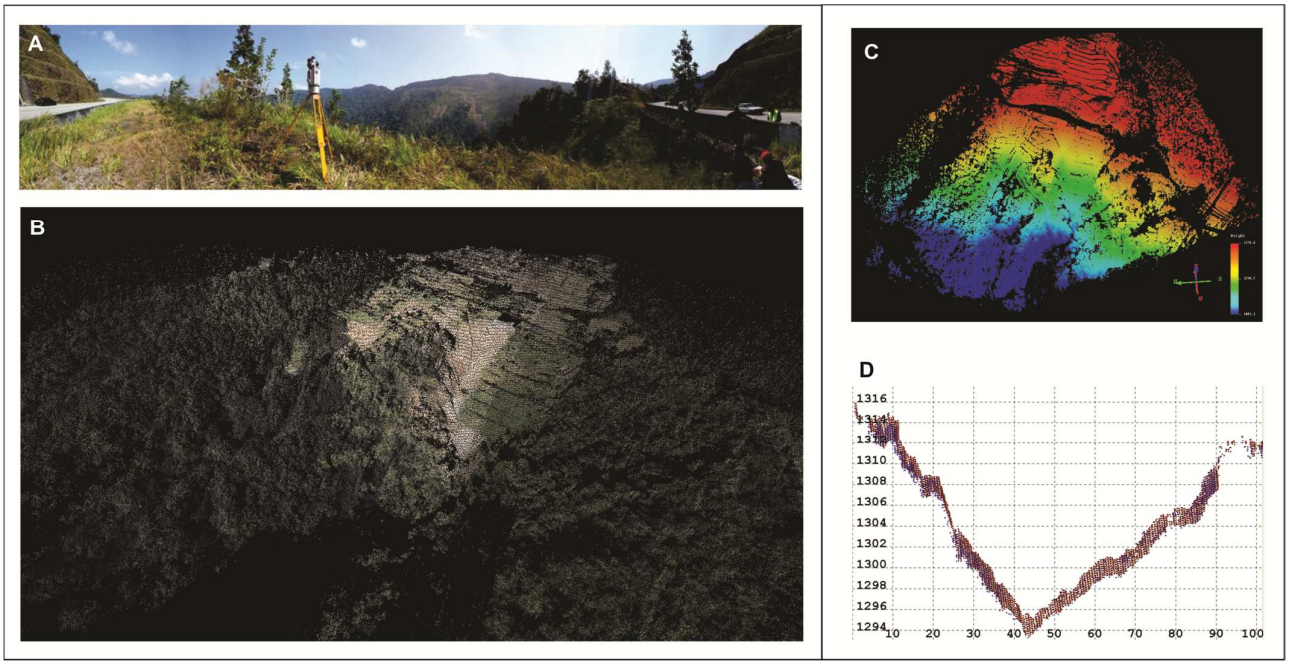
- Topographic laser scanning system: ALS + TLS
- Existing landslide monitoring system: Robotic Total Station – JKR.
- For comparison, a reflectorless total station (RTS) was used.

RTS vs TLS

- 700 points collected over 6 hours of data collection – only on the profiles.
- 86 million points over the entire mountainous.



Practicable Approach: A long range TLS



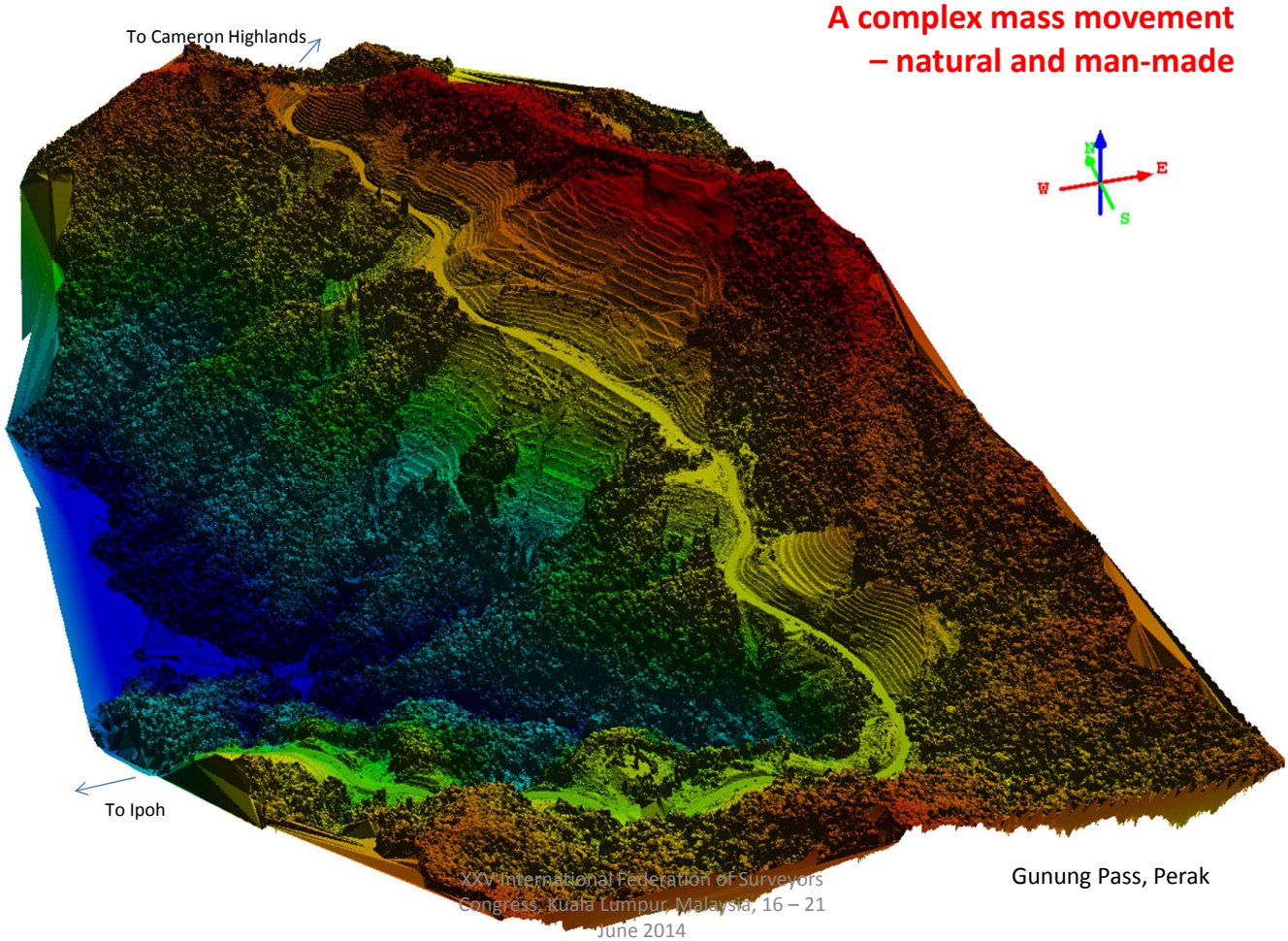
- A cross section analysis revealed main scarp depth was up to 30 m.
- Volume of displaced materials of debris flow resulted in 190260 m^3

TLSS Derivatives Landslide Products

As a result of modern geospatial tools, many landslide derivatives products can be generated (e.g. unstable and stable zone, profiles, length, width, and micro & macro-morphology features).

Landslide inventory - susceptibility - hazard – risk assessment

A complex mass movement – natural and man-made



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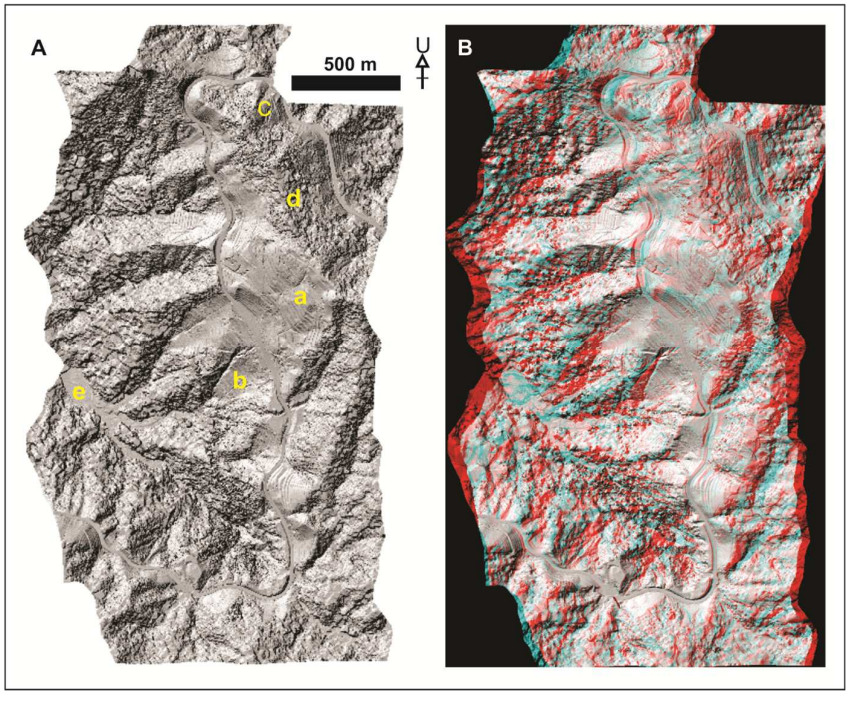
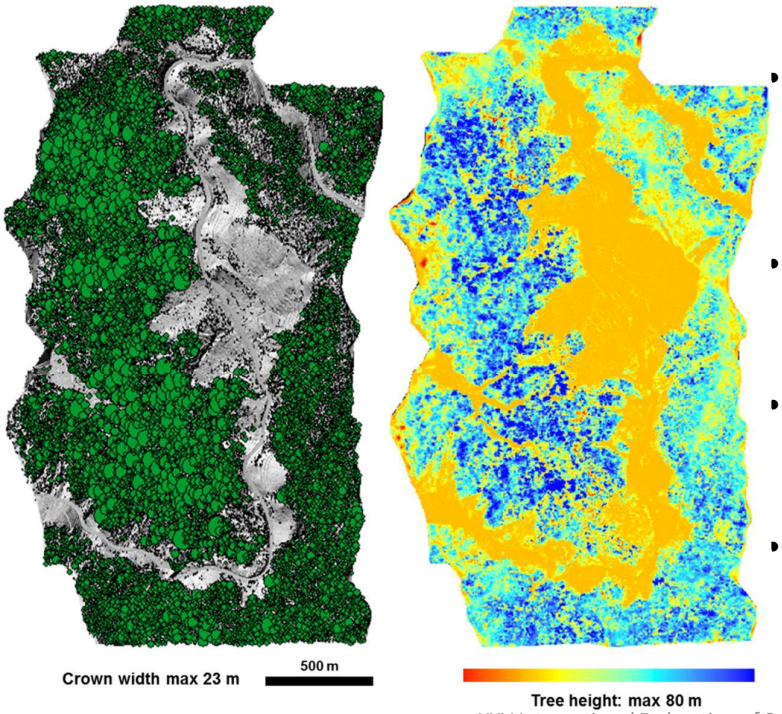
Morphology of tropical landslides

- Multi-scale visual analysis of stereoscopic TLSS images and expert knowledge driven approach
  - the stable and unstable areas were critically identified, including several landslide morphological features and relative activity.

- **Rockslide**: slope facing south
- **Debris flow**: downslope
- **Rotational landslide** with a retrogressive style



Individual tree detection, tree height and crown width



- Single tree detection and height estimation was carried out using the variable window filters (VWF) algorithm.
- We used allometric relationship (slope=-0.27; intercept=23.54; r2=0.23).
- Results: i) Single trees 40500 trees, ii) Tree height and crown width are up to 80 and 23 m.
- Analyze the tree growth anomalies: TLSS-geoindicator

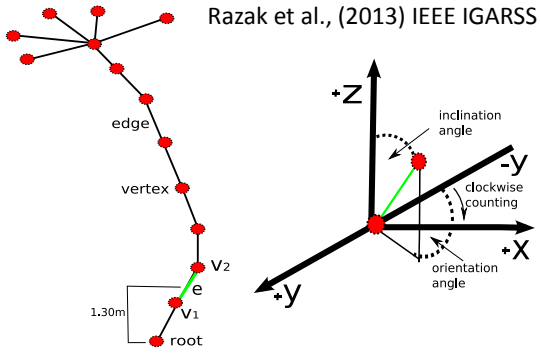
Challenging research works

Forest canopy gaps induced by landslides

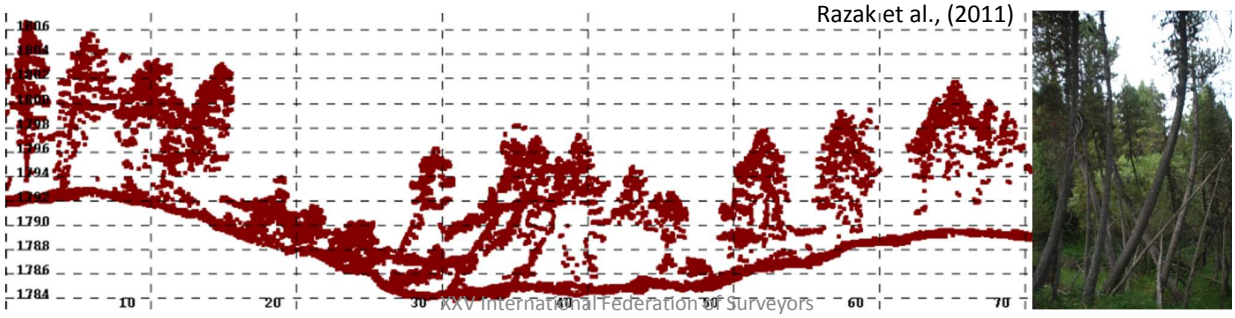
Gode and Razak (2013) Razak (2014)

Single tree irregularity and anomaly

Razak et al., (2013) IEEE IGARSS

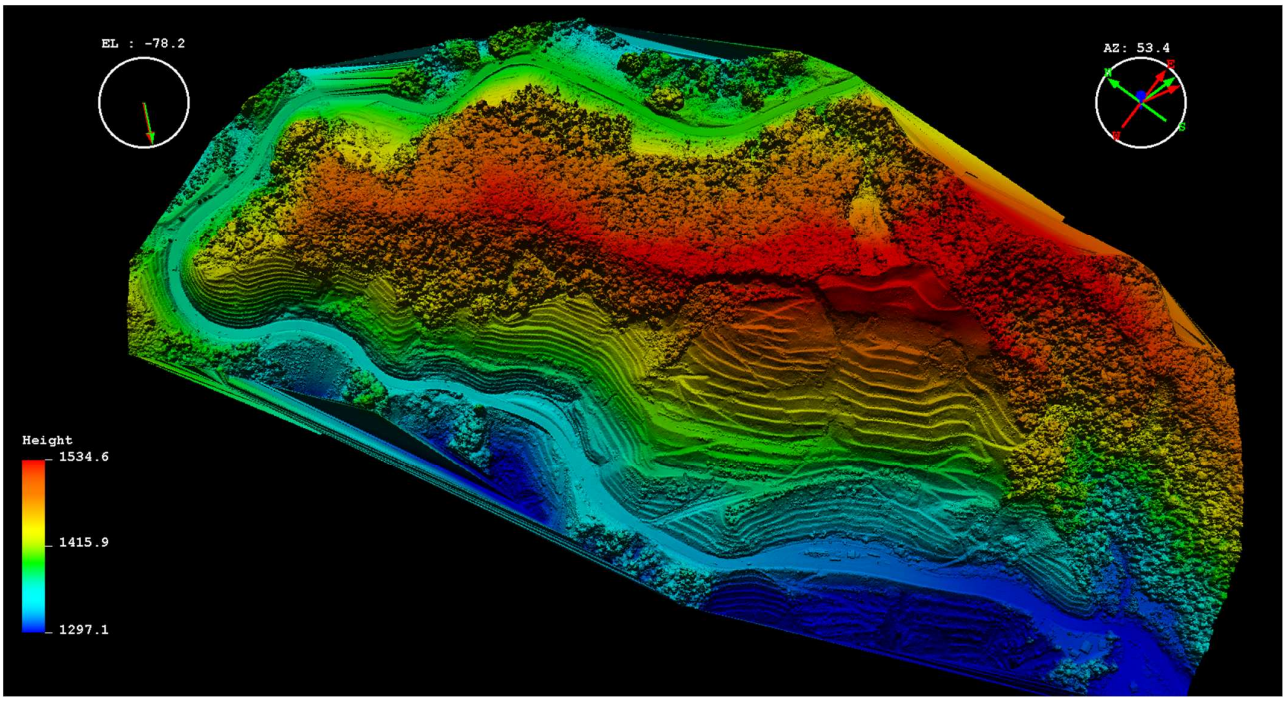


Razak et al., (2011)

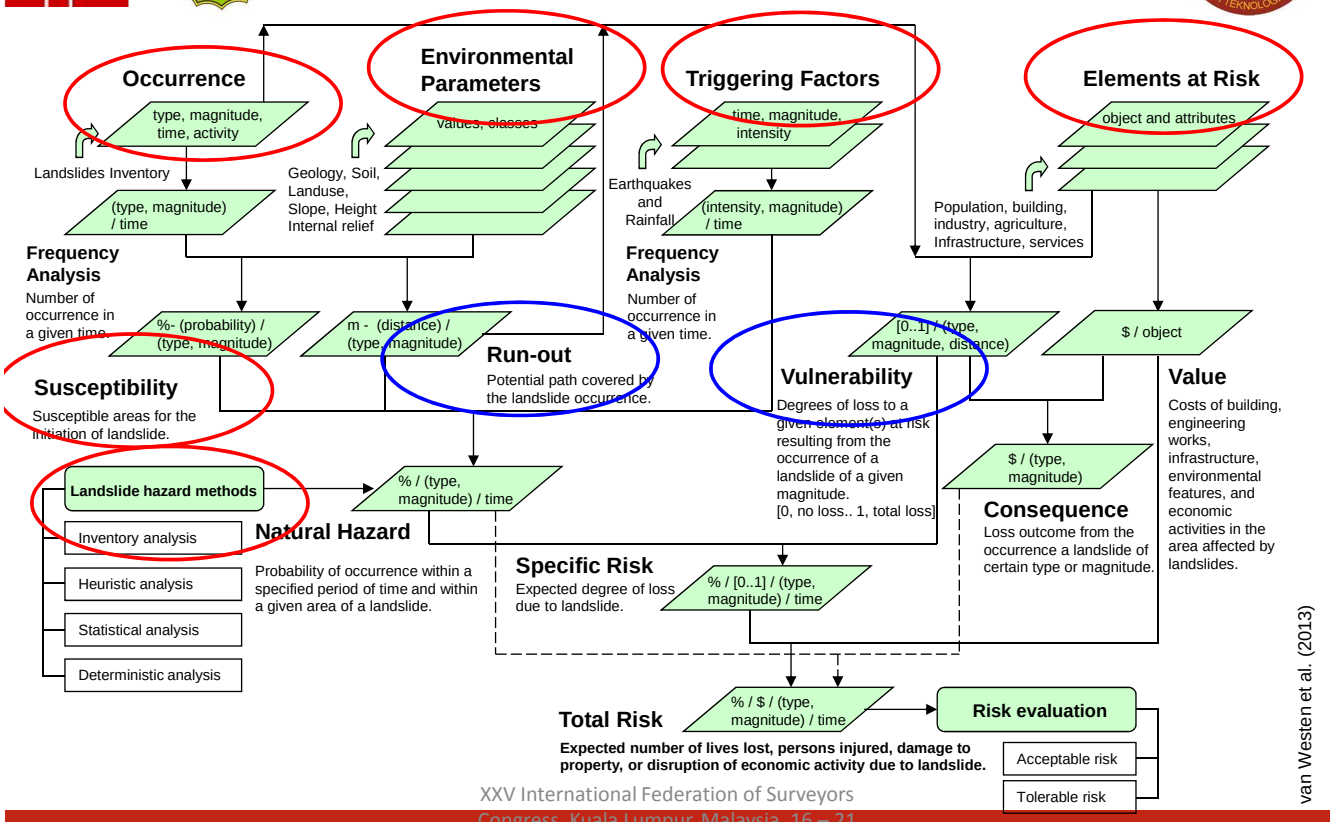


Disrupted vegetation as an indicator to landslide activity in the tropics

ALS tree growth anomalies: Issues and challenges



Geospatializing landslide risk assessment



Acknowledgment

- Financial assistance from Malaysian Land Surveyors Board (LJT).
- Research University Grant, UTM
- Utrecht University, the Netherlands
- University of Twente, the Netherlands

XXV International Federation of Surveyors Congress, Kuala Lumpur, Malaysia, 16 – 21 June 2014

FIG 2014 Congress, 16 – 21 June, Kuala Lumpur #

Thank you for your attention!

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