

Characterising landslide processes using limited data: case study on East Sikkim, India

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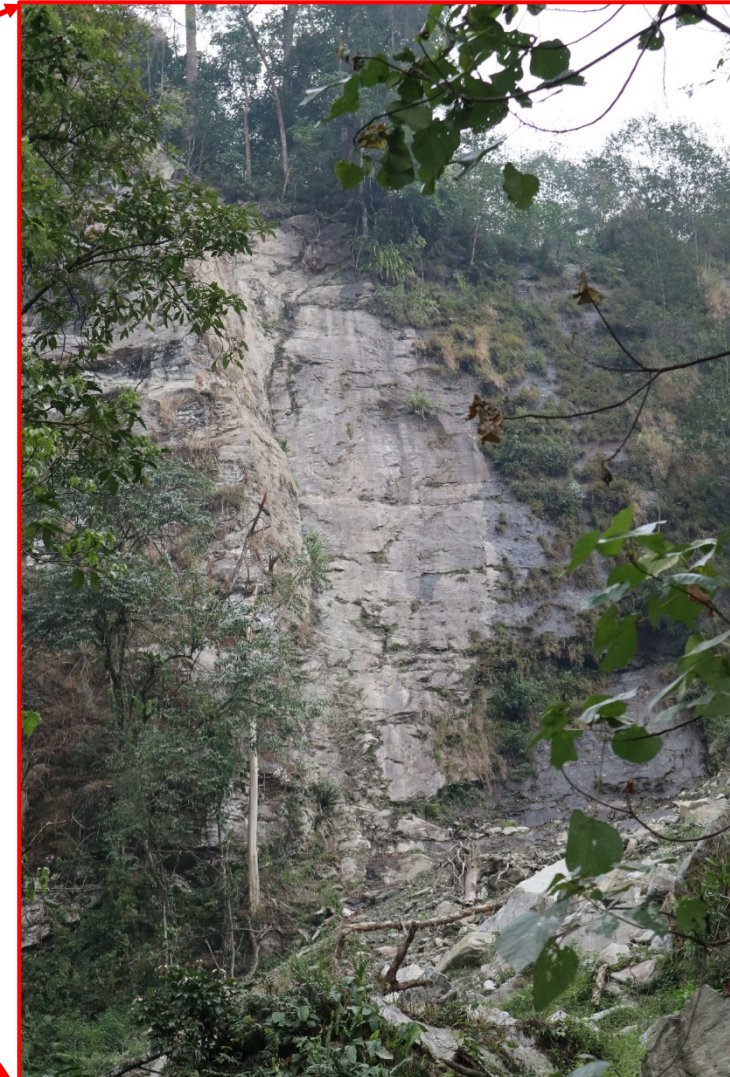
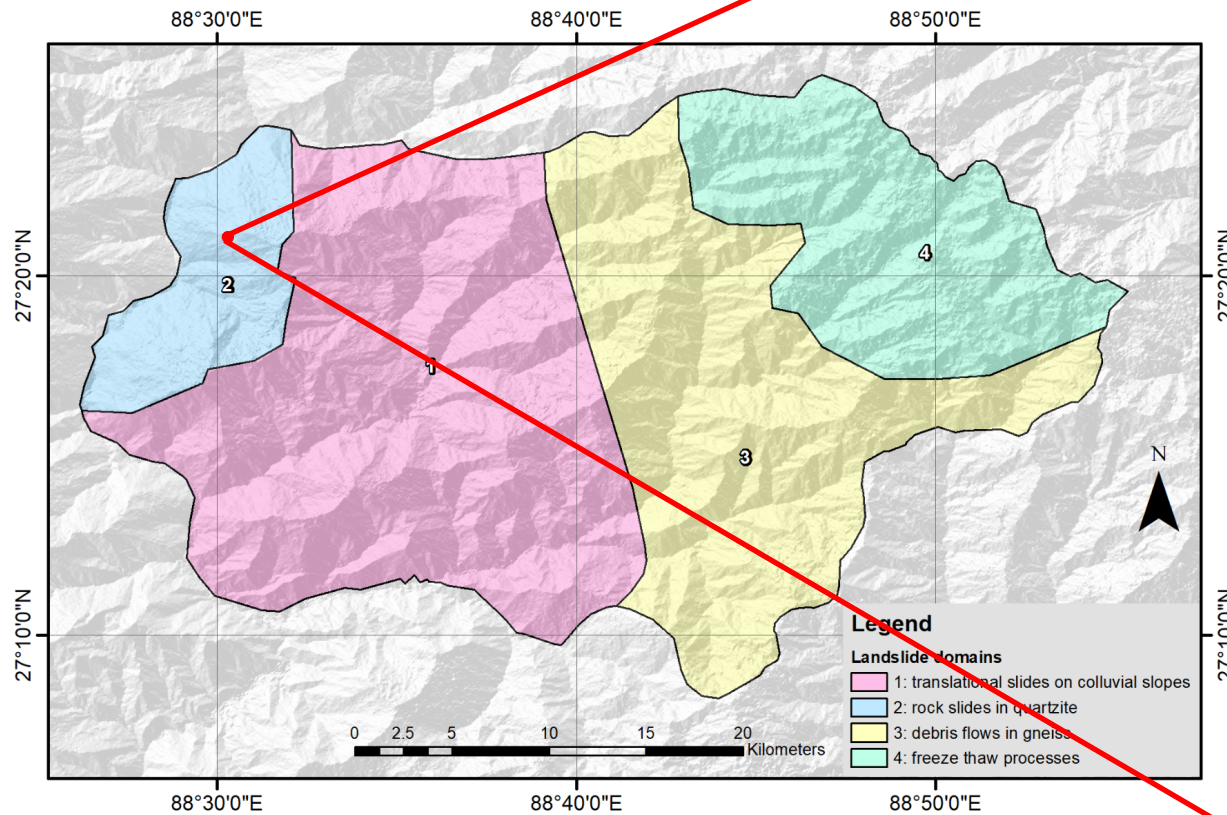
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A. Overview

Main aim

Characterise and map landslide processes in data-poor regions, using locally detailed environmental information in a **landslide domains** framework.

Overview of presentation:

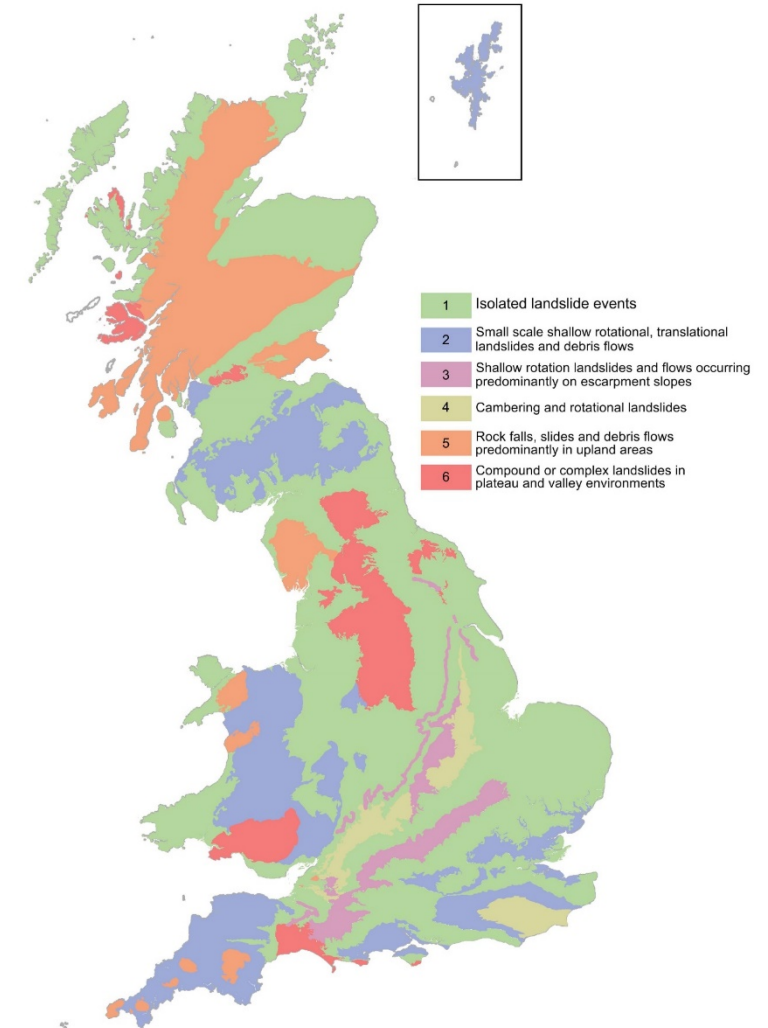
- B. Landslide domains background and framework
- C. Study area
- D. Landslide mapping
- E. Landslide domains
- F. Application example
- G. Summary

B. Landslide domains background [1/2]

“Areas of similar physiographic, meteorological, climatic and geological characteristics that shaped the style of landsliding.”

Dashwood et al. (2017)

- Mapping environmental characteristics that drive landslide processes,
- Use detailed landslide process information about a small part of the region to fill in data-poor parts with similar environmental characteristics,



The Landslide Domains Map of Great Britain. Figure from BGS (2018).

A. Over-
view

B. Back-
ground

C. Study
area

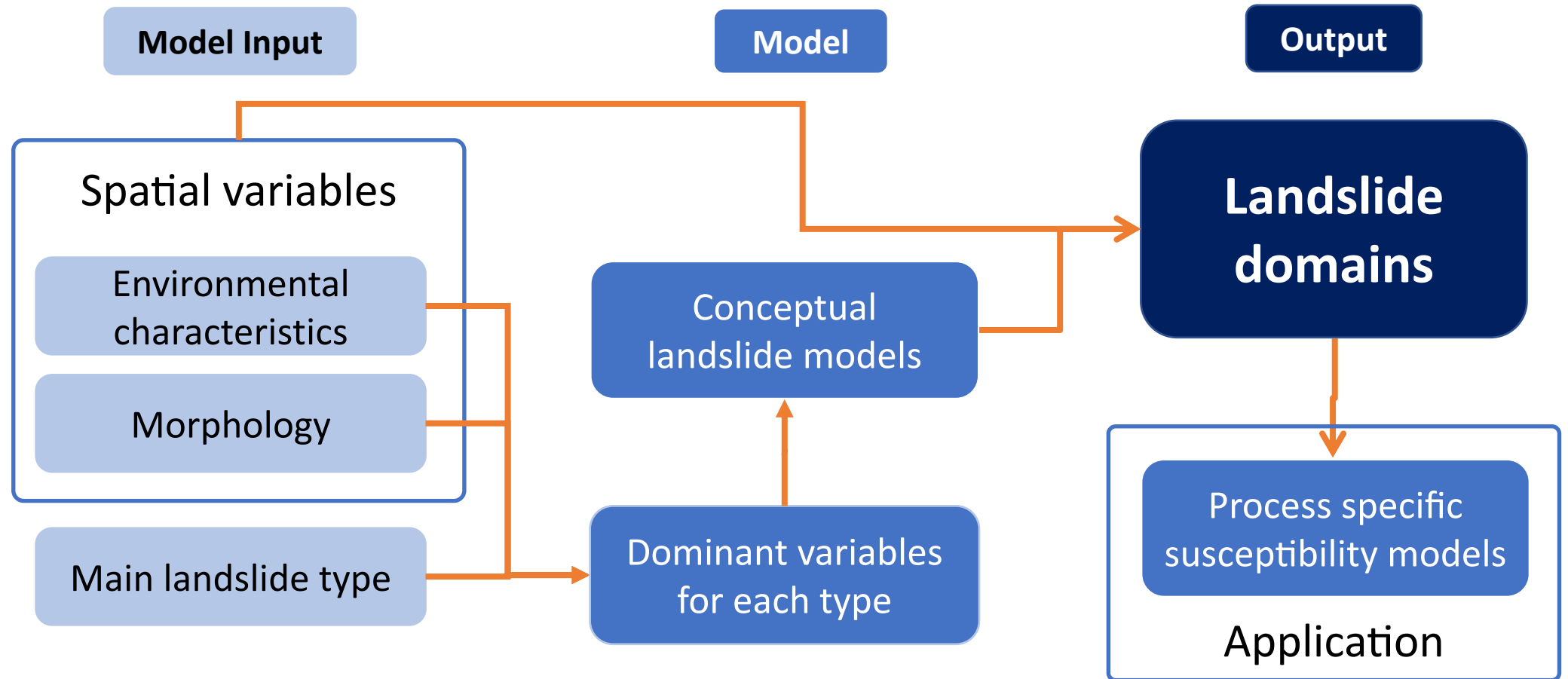
D. Landslide
mapping

E. Landslide
domains

F. Application
example

H. Summary

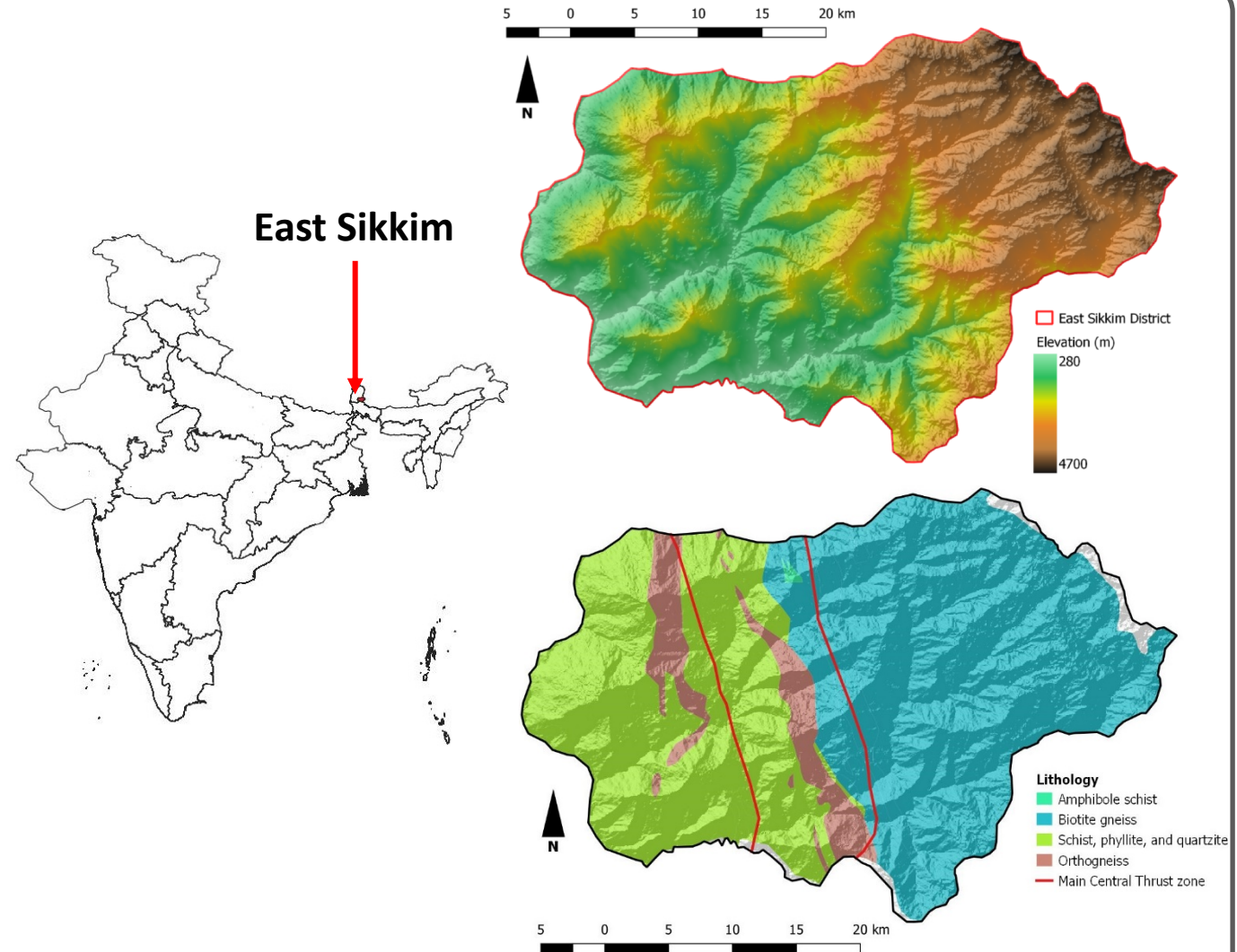
B. Landslide domains framework [2/2]



C. Study area [1/2]

District of East Sikkim in India:

- Lesser and High Himalaya,
- On the Main Central Thrust zone which acts as a boundary between weak phyllites and mica schists, and hard gneiss.



Location in India (left), and elevation model (above) and lithology map (below) of East Sikkim

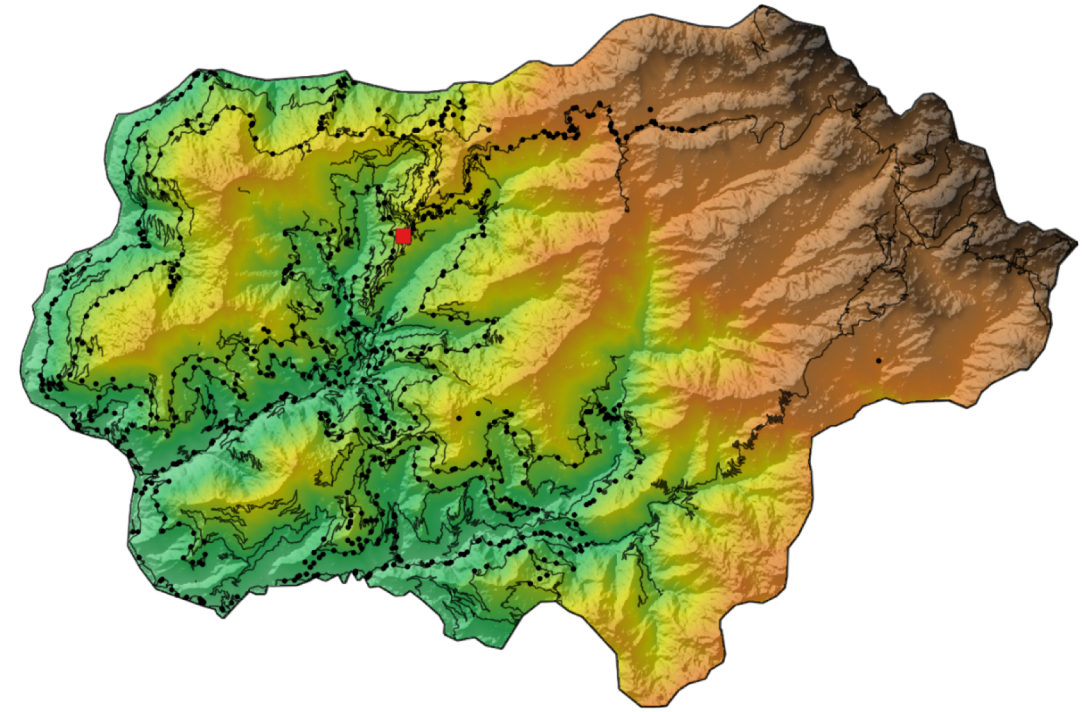
C. Study area [2/2]

In many data-poor areas:

- systemic information on **landslide occurrence** is **rarely** available, other than near roads and towns;
- data about **environmental characteristics** is **sparse**.

We have supplemented the Geological Survey of India inventory (see section **D. Landslide mapping**).

5 0 5 10 15 20 km

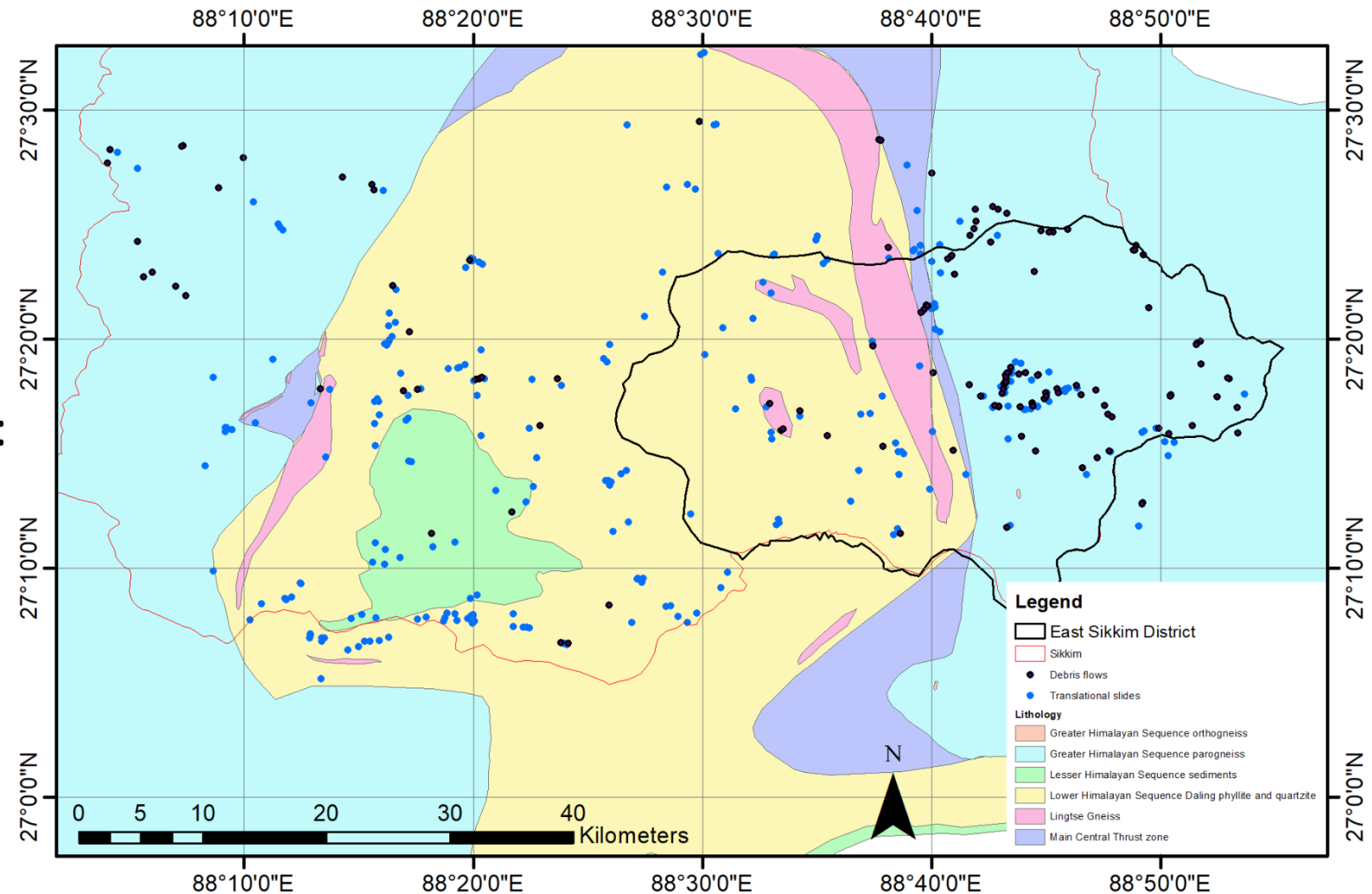


Elevation model of East Sikkim, low (green) to high (brown), with capital (red), roads (black) and GSI landslide inventory (black dots).

D. Landslide mapping [1/3]

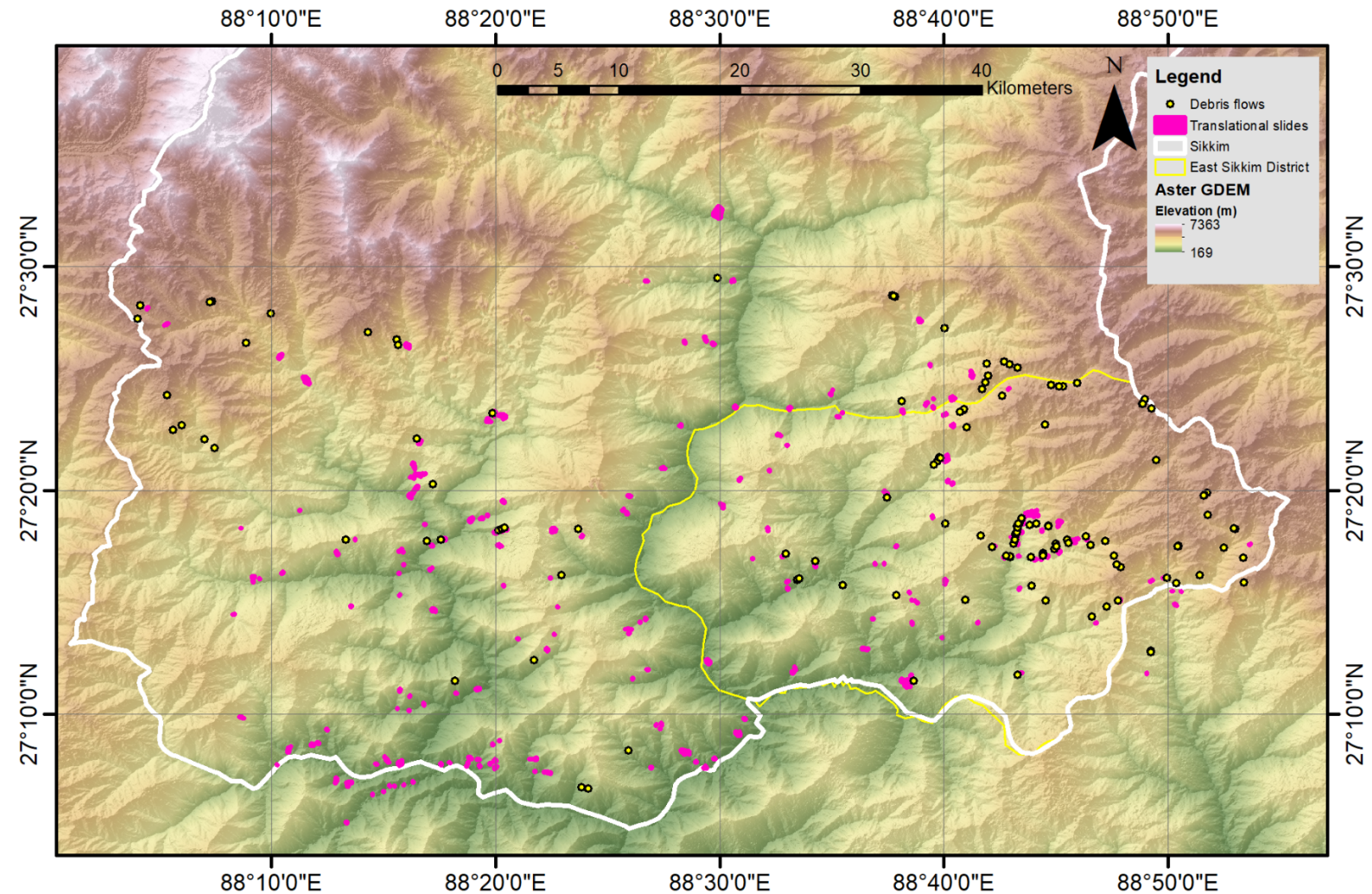
Using open-source Google Earth 3D we mapped in whole of **southern Sikkim, India**:

- Similar geology West and East,
- Results in similar landslide processes,
- Increased data.



D. Landslide mapping [2/3]

- 167 landslide mapped in **East Sikkim**, India,
- 389 features mapped in **southern Sikkim**:
 - 256 translational landslides,
 - 133 debris flows.
- Ground-truth through fieldwork February 2019



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D. Landslide mapping [3/3]

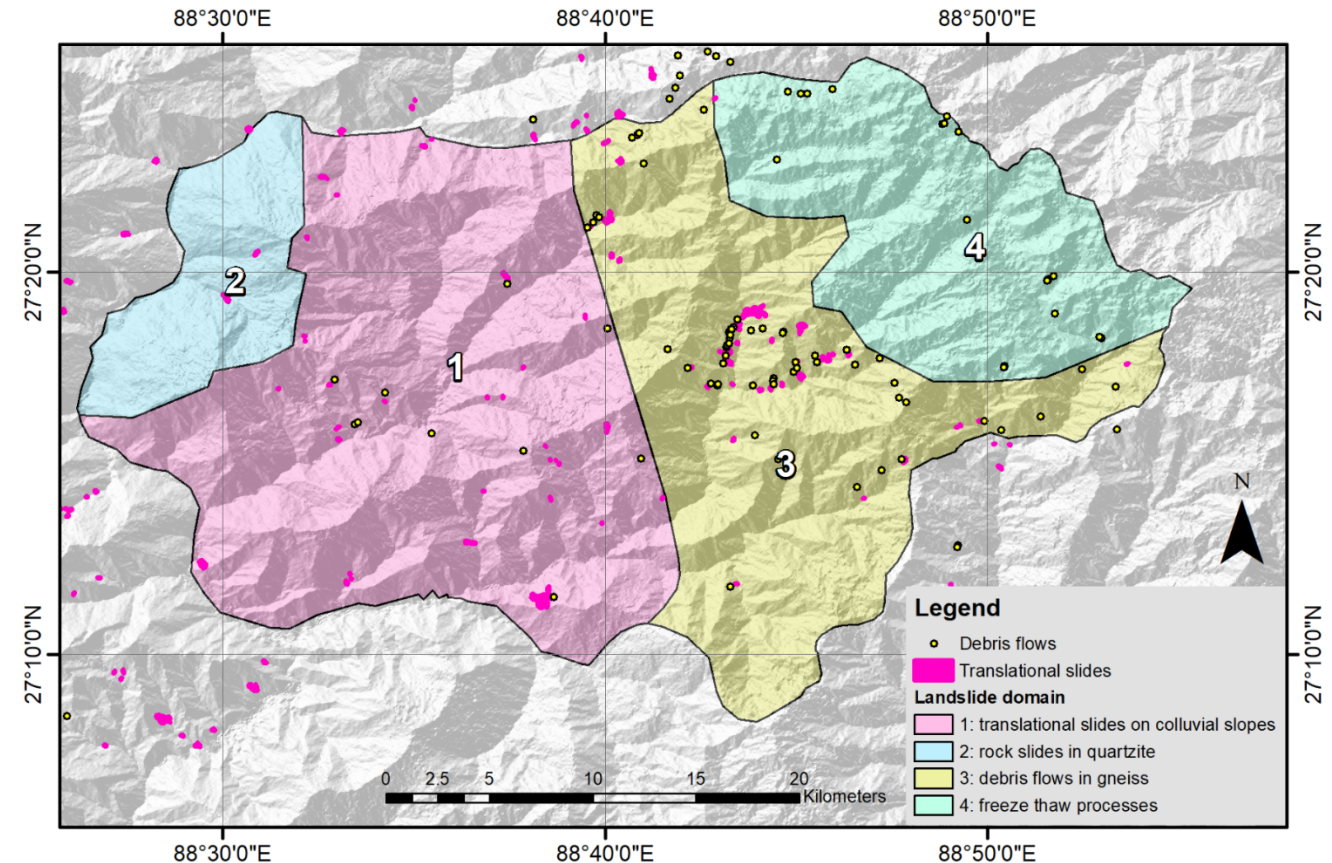
- Main landslide types and processes that occur in Sikkim, India
 - **Translational slides**, with sub-types:
 - Rotational rock slide
 - Translational rock slide
 - Debris slide
 - Debris slide into debris flow
 - **Debris flows**
 - **Rock falls**
- Where material type could not be determined, the main type was used.

E. Landslide domains [1/5]

4 landslide domains mapped:

1. Translational landslides mostly found on colluvial slopes
2. Rock falls on upper parts of slope, debris slides on lower parts of slope
3. Debris flows
4. Rock falls and slides driven by frost-thaw processes

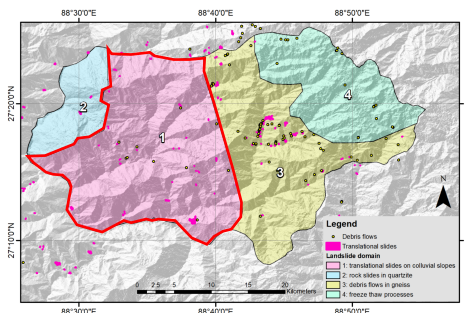
Dominant variables for each process discussed in next slides.



E. Landslide domains [2/5]

Landslide domain 1

- Relatively soft phyllites,
- Colluvial slopes with creep observed and more active debris slides,
- Based on and delineated by **lithology**.



Near Gangtok, East Sikkim, Renée Heijen

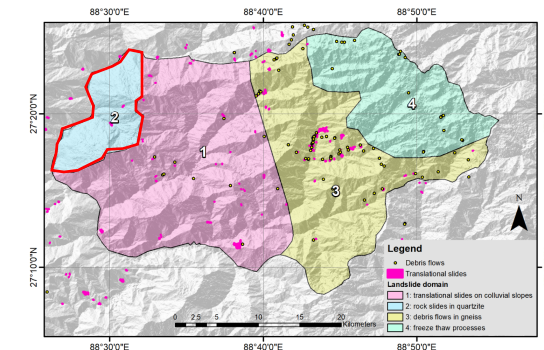
E. Landslide domains [3/5]



Near Dikchu, East Sikkim, Renée Heijen

Landslide domain 2

- Relatively hard quartzites,
- Rock falls and slides observed at the top of slopes,
- Predominantly wedge failures
- Based on field observations, delineated by **lithology**.



A. Over-
view

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D. Landslide
mapping

E. Landslide
domains

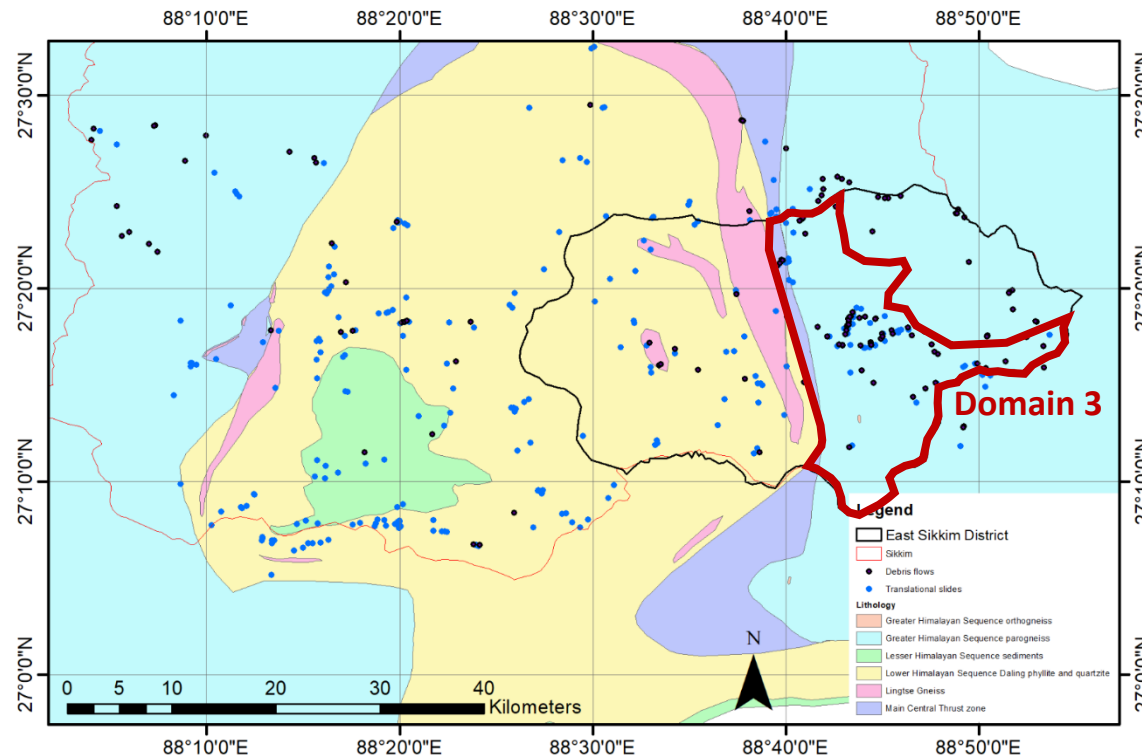
F. Application
example

H. Summary

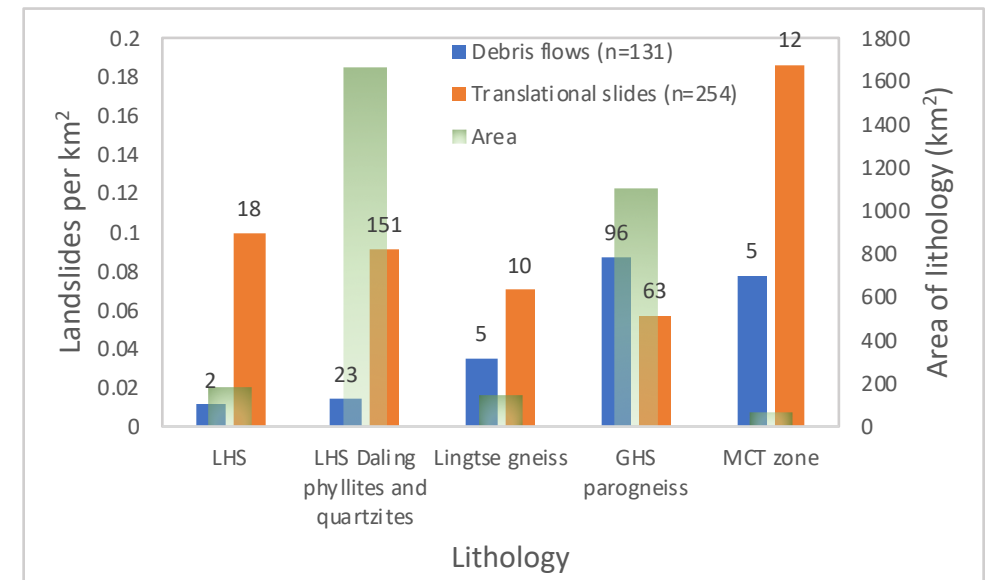
E. Landslide domains [4/5]

Landslide domain 3

Lithology map (Mottram *et al.*, 2014)



- Mix of hard and soft gneisses,
- Shallow vegetation removing rock slides observed on Google Earth,
- Based on **landslide mapping**, delineated by **lithology** and **elevation**.



Area and landslides per km² for each lithology, number above blue and orange bars denote the number of landslides this data is based on.

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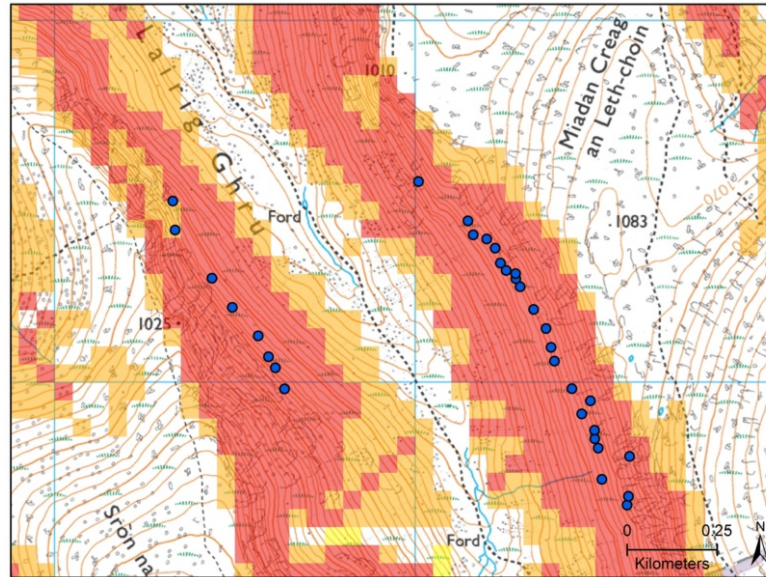
H. Summary

F. Application example in UK

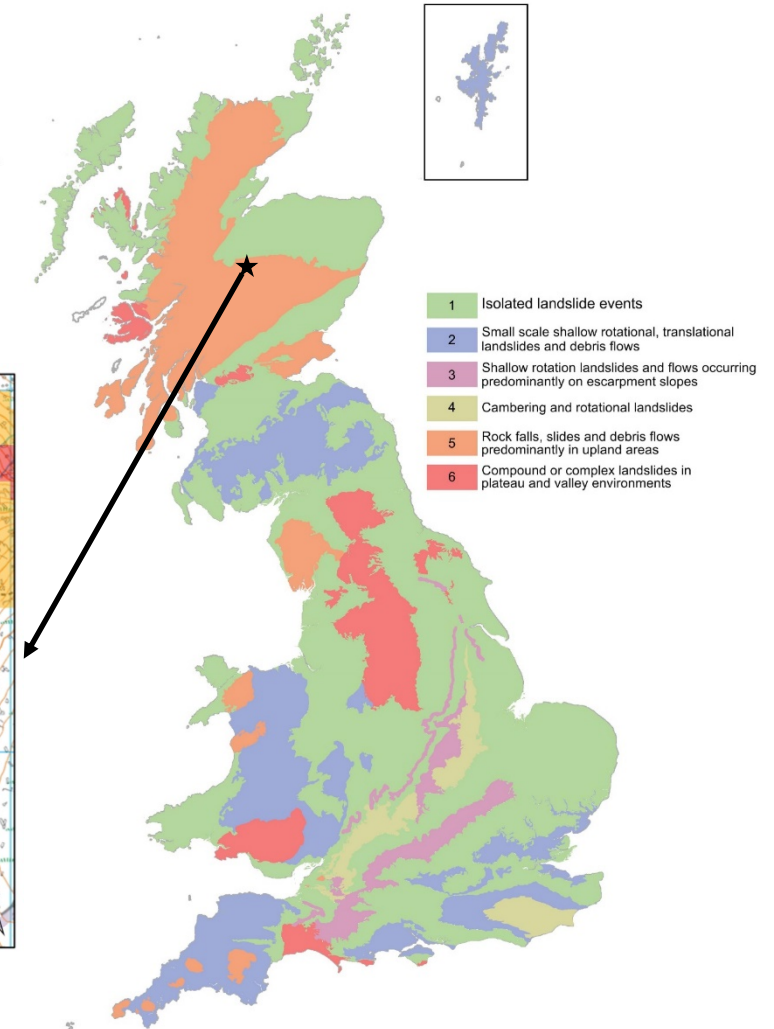
Targeted landslide susceptibility models for relevant domains.



Debris flows in Scotland

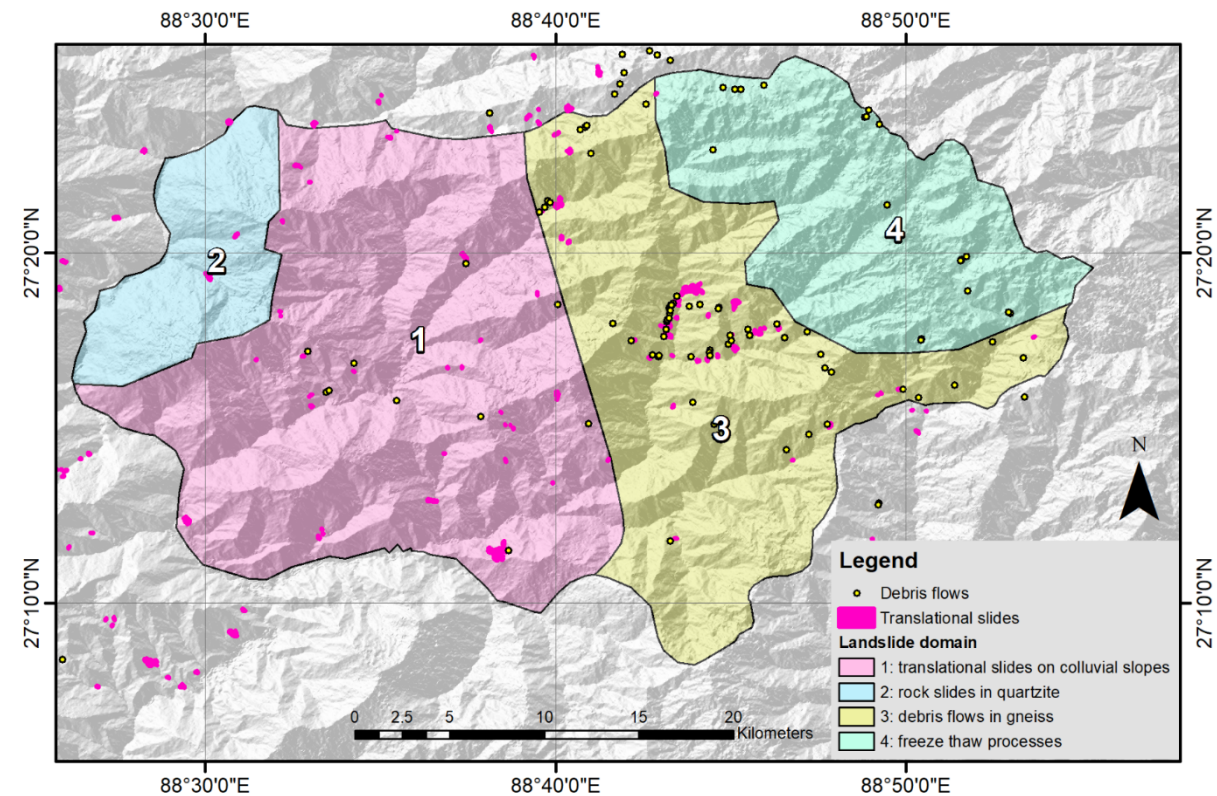


Debris flows found using targeted air photo mapping and outcome of debris flow potential model (Dashwood *et al.*, 2017)



F. Summary

- Using additional data from similar geology East Sikkim (900 km²) can be characterised into **four landslide domains** using **limited data**.
- These four landslide domains define **regions of common processes**.
- Landslide domains in general are an efficient method to categorise landslide processes, leading to **better understanding of landslide susceptibility**.



Landslide domains draft for East Sikkim