INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

Landslide Hazard Assessment & Mitigation

DML – 502 Lecture - 2

Subject Code : DML-502
Course Title: Landslide Hazard Assessment & Mitigation

"To understand the mechanisms, mapping, and hazard assessment techniques of landslides for disaster mitigation."

S. No 1

Definition; **overview of Hazard assessment techniques on regional, semi detail and detailed scales and their application for planning purposes**; Terrain classification and mapping methods, use of RS and GIS.

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Scale: range of analysis for landslide studies

Scaling in units of length (m)

Macro scale 10^{-1}

Landslide studies work at these scales

10^{-8} Nano scale

10^{-5} Micro scale

10^{-1} Meso scale

10^{0} Laboratory/experimental scale

10^{1}

10^{2} Slope scale

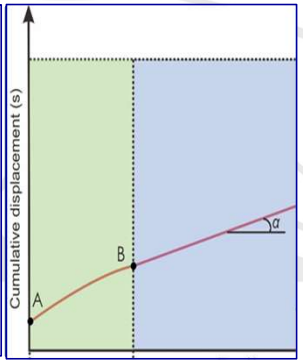
10^{3} Catchment scale

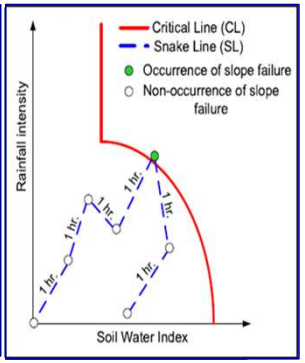
10^{4} Territorial scale

Increased complexity at finer scales with respect to states/phases of matter and dimensions

1. Solid and fluid phases
2. Three dimensions

Meso-scale studies on landslide mechanics & bio geotechnics





Increased complexity ⟷ Reduced complexity

Laboratory experiments

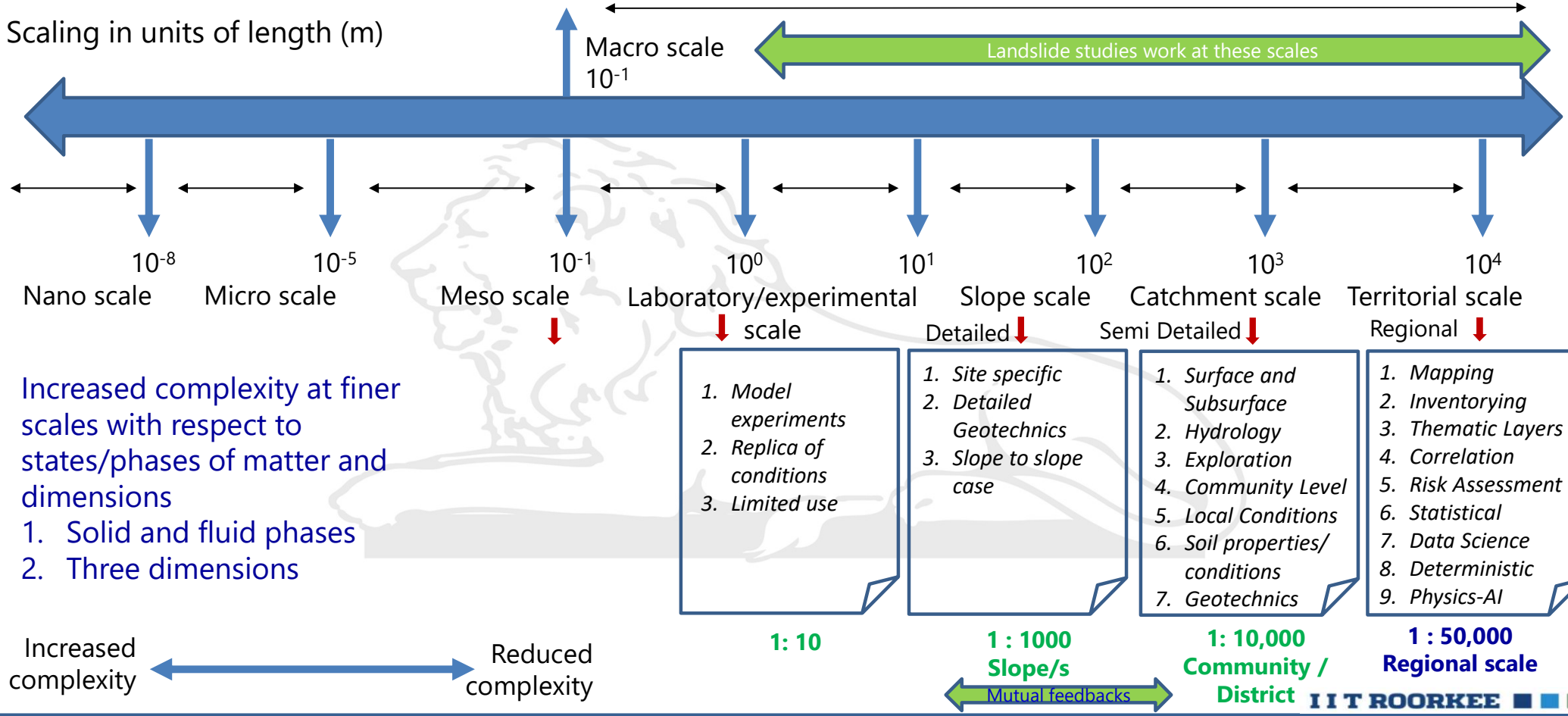
Slope-scale monitoring

Mutual feedbacks

Hydrological boundary

Landslide early warning

Scale: range of analysis for landslide studies



Increased complexity at finer scales with respect to states/phases of matter and dimensions

1. Solid and fluid phases
2. Three dimensions

Increased complexity ⟷ Reduced complexity

Hazard assessment

Hazard assessment techniques on *regional, semi detailed and detailed* scales

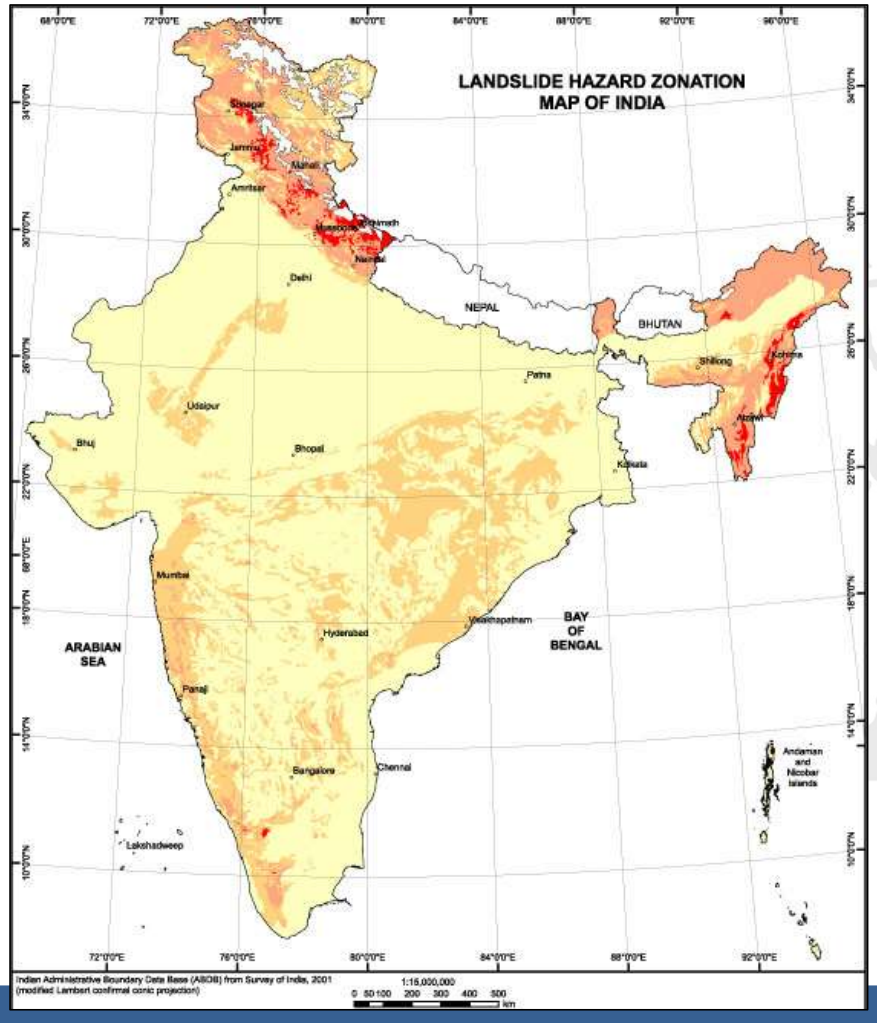
- Mapping is the 1st step in Hazard Assessment.
- Maps are a useful and convenient tool for presenting information on landslide hazards. They can present many kinds and combinations of information at different levels of detail. Hazard maps used in conjunction with land-use maps are a valuable planning tool.
- Commonly, there is a three-stage approach to landslide hazard mapping.
- The first stage is ***regional*** or reconnaissance mapping, which synthesizes available data and identifies general problem areas. This regional scale mapping is usually performed by a Provincial, State, or Geological Agencies.
- The next stage is ***semi-detailed community-level mapping, which is*** a more detailed surface and subsurface mapping program in complex problem areas.
- Finally, ***detailed*** **scale** site-specific large-scale maps are prepared. If resources are limited, bypassing regional mapping and concentrating on a few known areas of concern may be more prudent.
- We discuss three types of general mapping; (1) ***regional***, (2) ***semi detailed*****-**Community level, and (3) ***detailed*** **scale-**site specific.

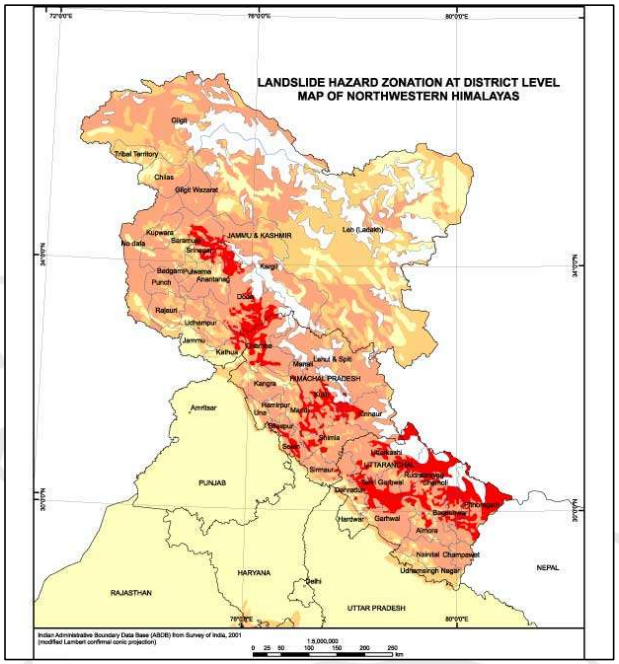
Hazard assessment/mapping

Regional mapping

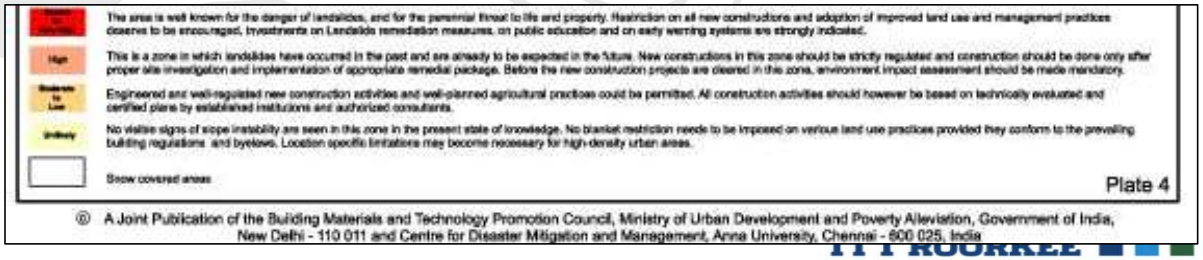
- Regional or reconnaissance mapping supplies basic data for regional planning by providing baseline information for conducting more detailed studies at the community and site-specific levels and for setting priorities for future mapping.
- Such maps are usually simple inventory or susceptibility maps and are directed primarily toward the identification and delineation of regional landslide problem areas and the conditions under which they occur.
- They concentrate on those geologic units or environments in which additional movements are most likely. The geographical extent of regional maps can vary from a map of a State or Province to a national map, which delineates an entire country.
- Such mapping relies heavily on photogeology (the geologic interpretation of aerial photography), reconnaissance field mapping, and the collection and synthesis of all available pertinent geologic data.
- Map scales at this level are typically at scales ranging from 1:10,000 down to 1:4,000,000 or even smaller.

Hazard assessment/mapping

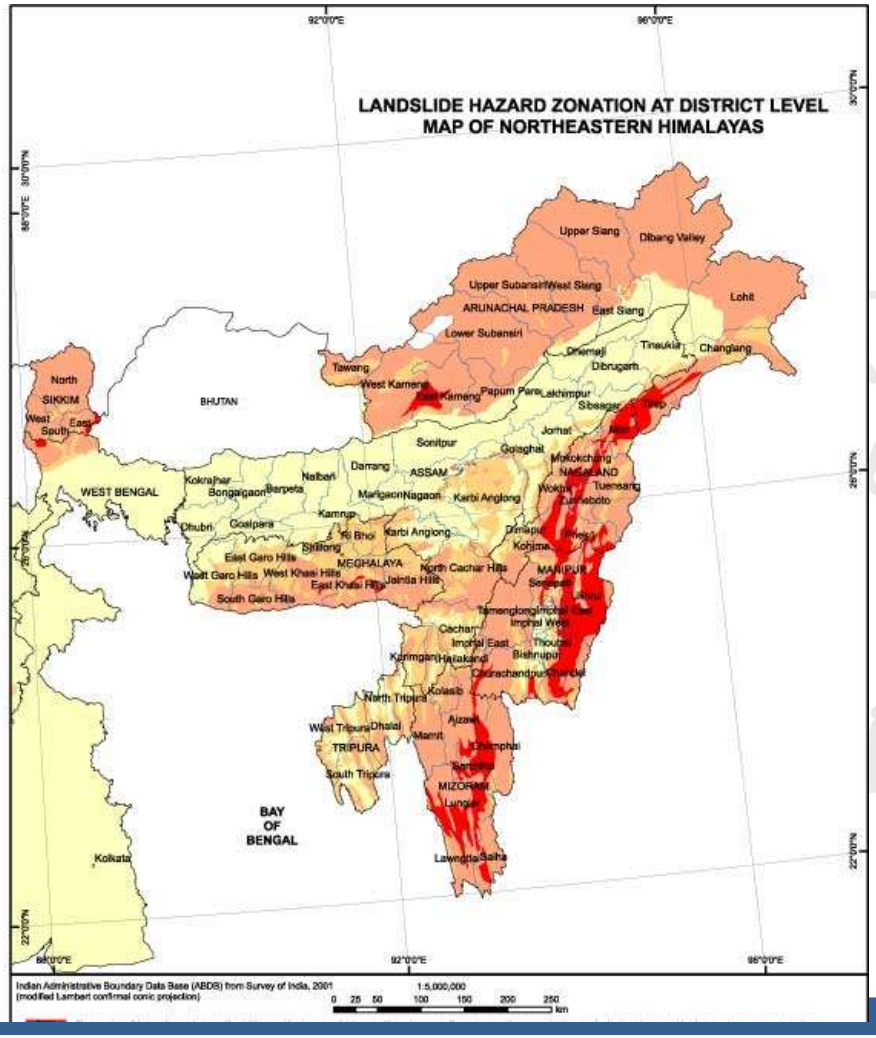


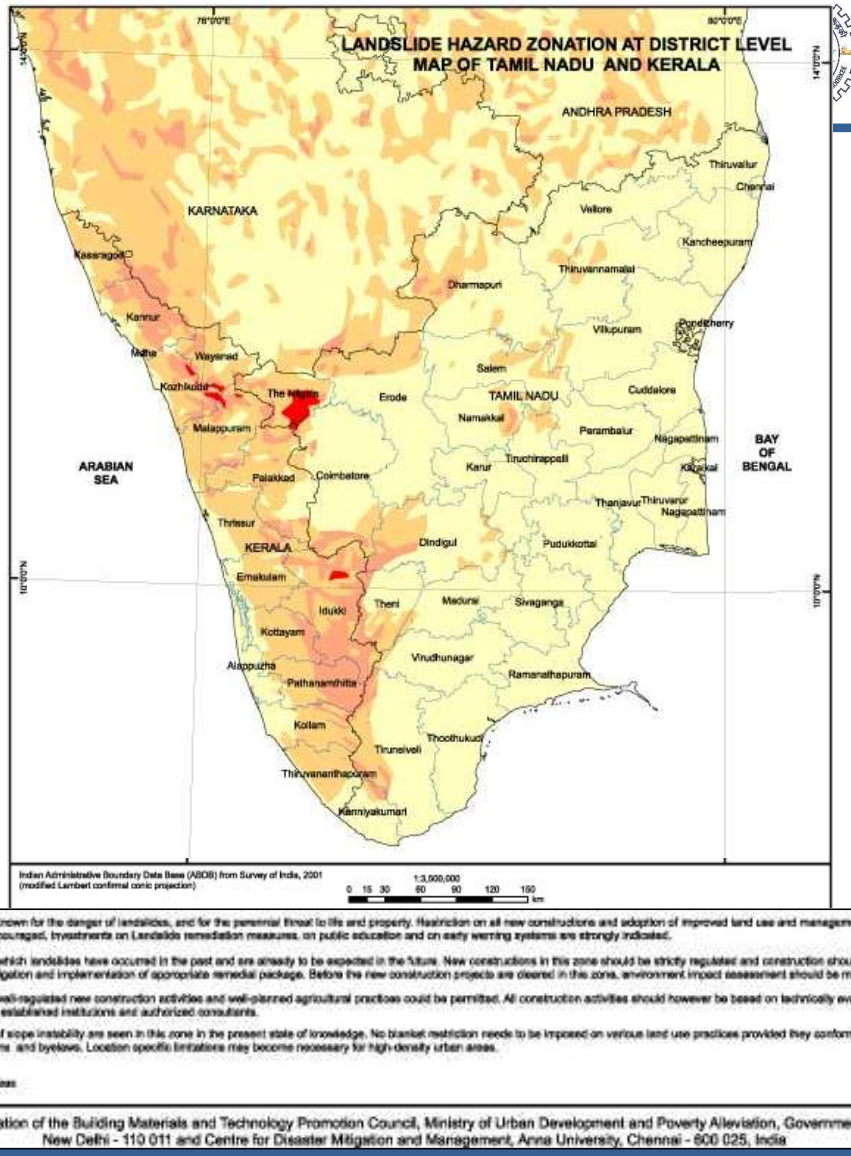


Source: Vulnerability Atlas of India (Earthquake, Windstorm, Flood, Landslide, Thunderstorm Maps and Damage Risk to Housing) 3rd Edition March, 2019



Hazard assessment/mapping





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Hazard assessment/mapping

***Semi detailed,* Community-level mapping**

- This type of mapping identifies both the three-dimensional potential of landsliding and considers its causes.
- Guidance concerning land use, zoning, and building, and recommendations for future site-specific investigations also are made at this stage.
- Investigations should include subsurface exploratory work in order to produce a map with cross sections.
- Map scales at this level typically vary from 1:1,000 to 1:10,000.

Site-specific mapping

- Site-specific mapping is concerned with the identification, analysis, and solution of actual site-specific problems, often presented in the size of a residential lot.
- It is usually undertaken by private consultants for landowners who propose site development and typically involves a detailed drilling program with downhole logging, sampling, and laboratory analysis in order to procure the necessary information for design and construction.
- Map scales vary but usually are about 1:600 or 25 mm equal to 16 m.

Hazard assessment/mapping

Three Important Criteria for Landslide Maps

The three types of landslide maps most useful to planners and the general public are

(1) landslide inventories,

(2) landslide susceptibility maps, and

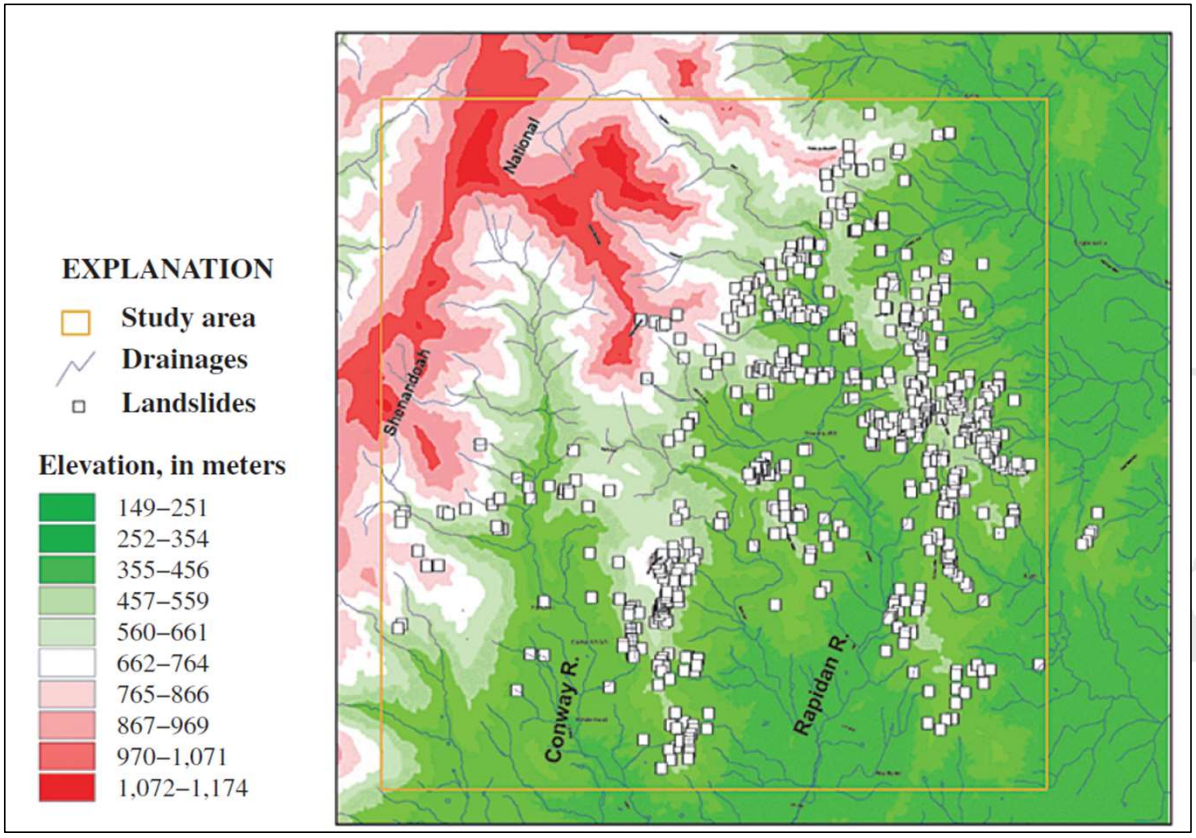
(3) landslide hazard maps.

(1) Landslide inventory maps

- Inventories denote areas that are identified as having failed by landslide processes.
- The level of detail of these maps ranges from simple reconnaissance inventories that only delineate broad areas where landsliding appears to have occurred. Complex inventories that depict and classify each landslide and show scarps, zones of depletion and accumulation, active and inactive slides, geological age, rate of movement, and (or) other pertinent data.
- Simple inventories give an overview of the areal extent of landslide occurrence and highlight areas where more detailed studies should be conducted. Detailed inventories provide a better understanding of the different landslide processes operating in an area and can be used to regulate or prevent development in landslide-prone areas and to aid the design of remedial measures.

Hazard assessment/mapping

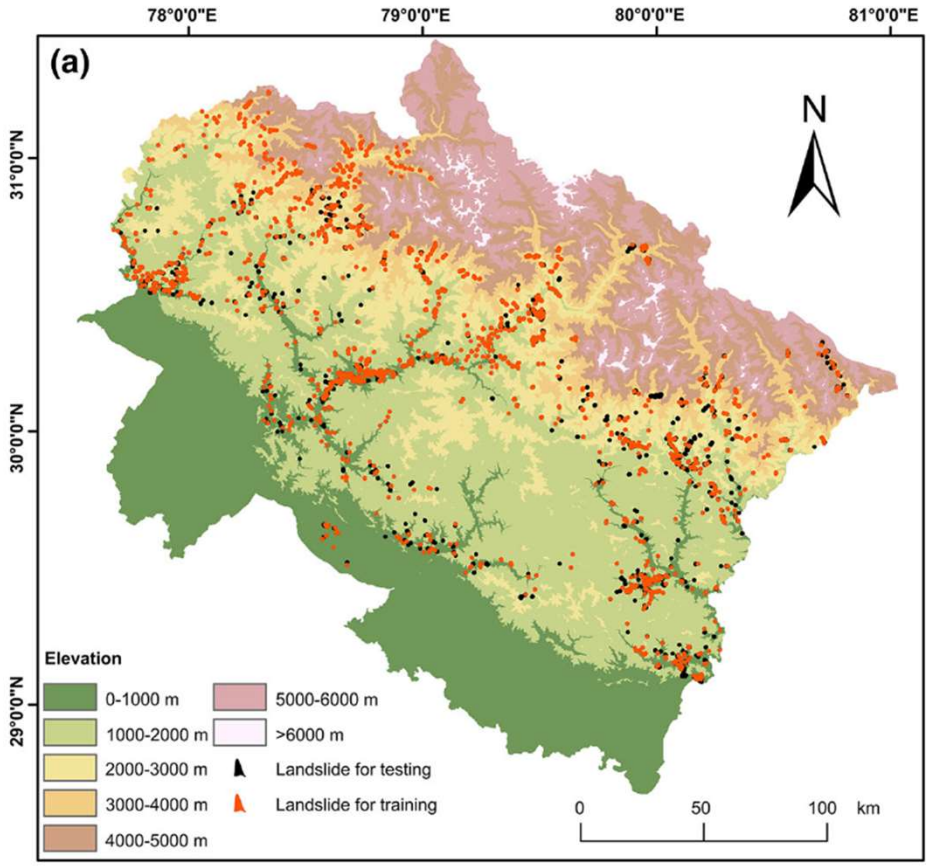
(1) Landslide inventory maps



Example of a landslide inventory map showing the locations of past landslides and including topographical information consisting of elevation (measured in meters) and drainage courses (map from U.S. Geological Survey).

Hazard assessment/mapping

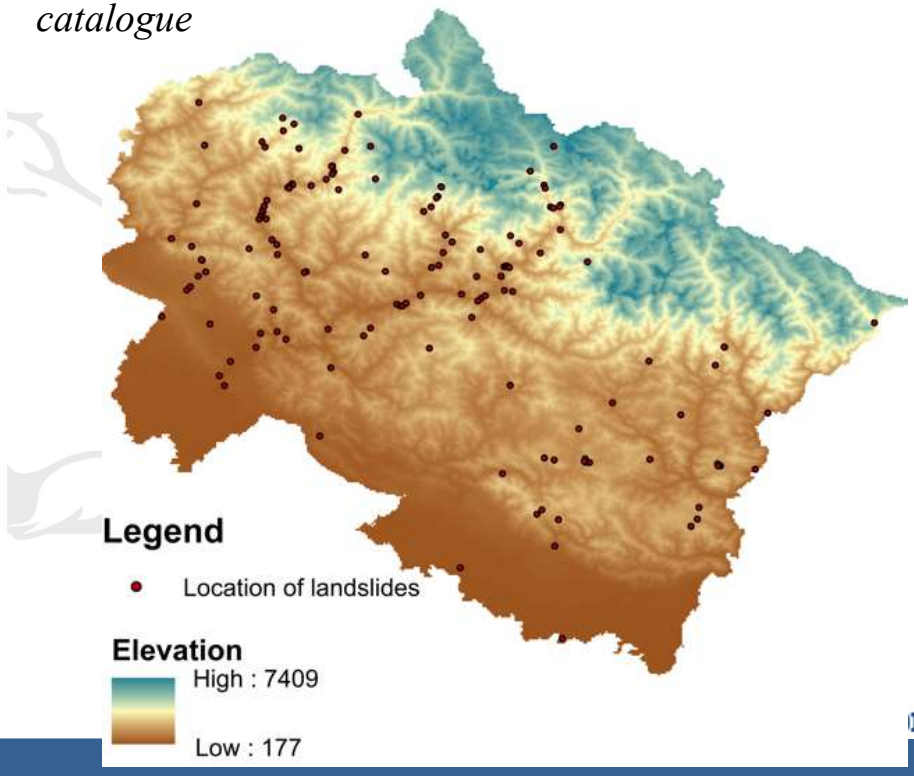
(1) Landslide inventory maps



Example of a landslide inventory map showing the locations of past landslides and including topographical information consisting of elevation (measured in meters)

Gupta et al. J. Earth Syst. Sci. (2022) 131:2

Locations of landslides sources from NASA's global landslide catalogue



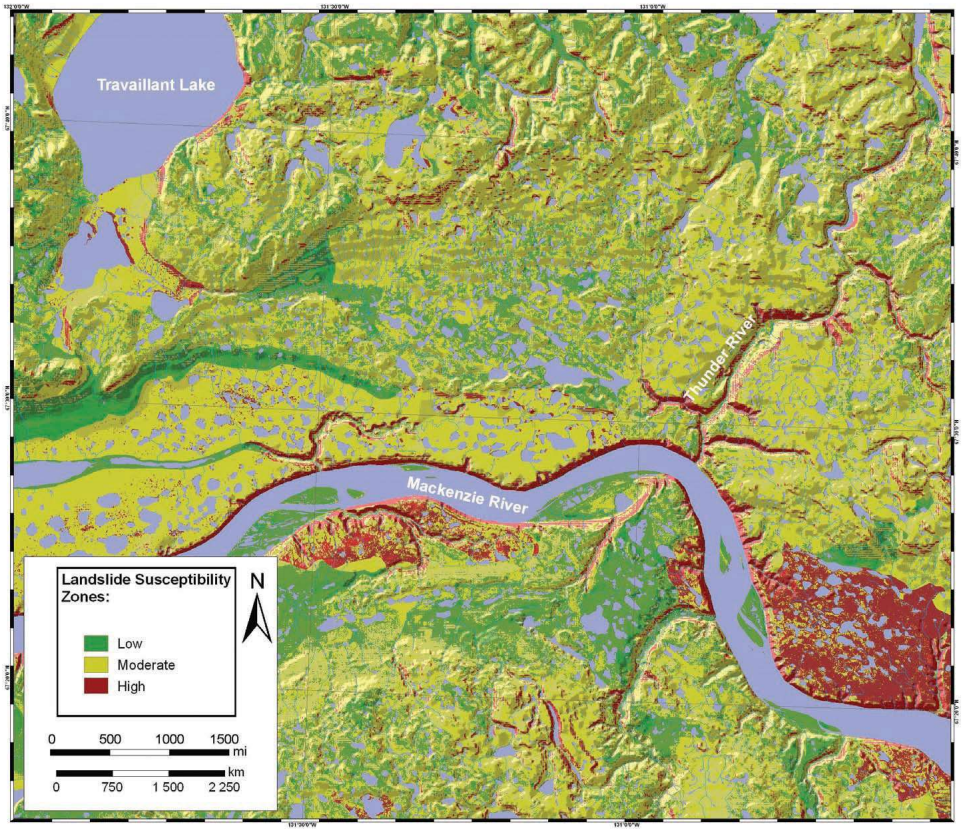
Hazard assessment/mapping

(2) Landslide susceptibility maps

- A landslide susceptibility map goes beyond an inventory map and depicts areas that have the potential for landsliding.
- These areas are determined by correlating some of the principal factors that contribute to landsliding (such as steep slopes, weak geologic units that lose strength when saturated or disturbed, and poorly drained rock or soil) with the past distribution of landslides.
- These maps indicate only the relative stability of slopes; they do not make absolute predictions.
- Landslide susceptibility maps can be considered derivatives of landslide inventory maps because an inventory is essential for preparing a susceptibility map.
- For example, overlaying a geologic map with an inventory map that shows existing landslides can identify specific landslide-prone geologic units.
- This information can then be extrapolated to predict other areas of potential landsliding. More complex maps may include additional information such as slope angle and drainage.

Hazard assessment/mapping

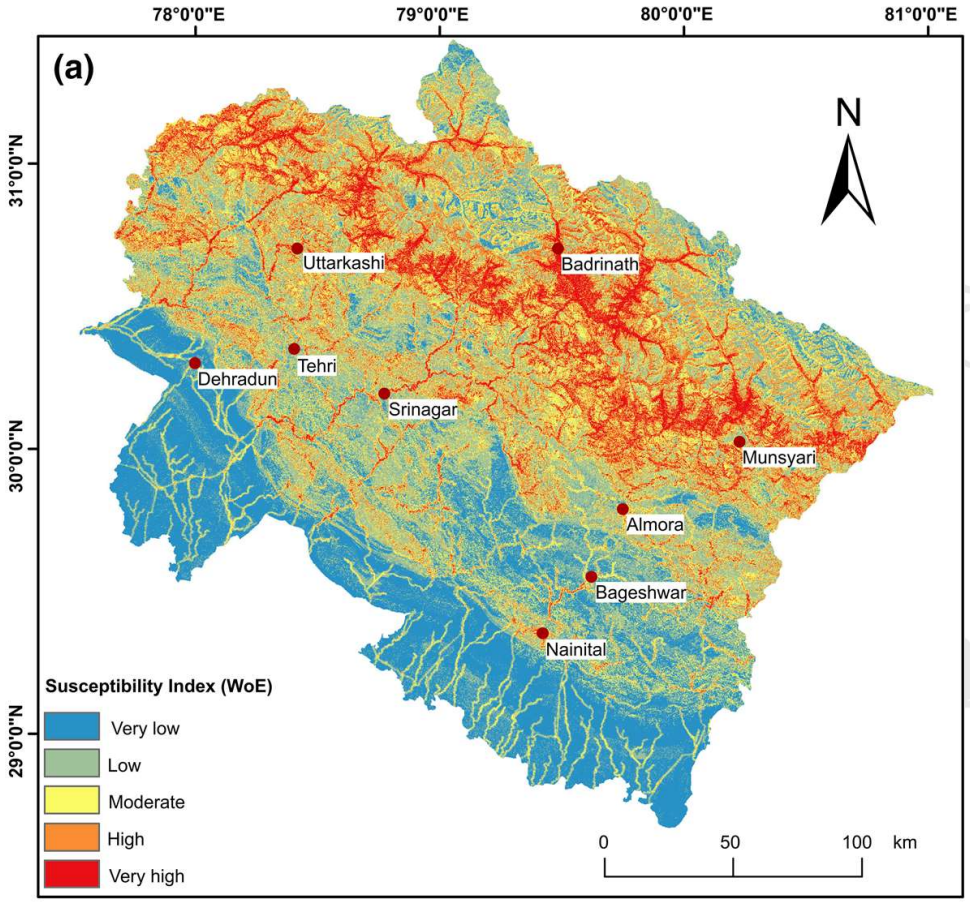
(2) Landslide susceptibility maps



An example of a landslide susceptibility map. This map shows an area in Canada, the Mackenzie River Valley, Northwest Territories. Graphic by Réjean Couture, Geological Survey of Canada.

Hazard assessment/mapping

(2) Landslide susceptibility maps



Landslide susceptibility maps depicting very low, low, moderate, high and very high landslide susceptibility zones using (a) weight of evidence and (b) information value methods.

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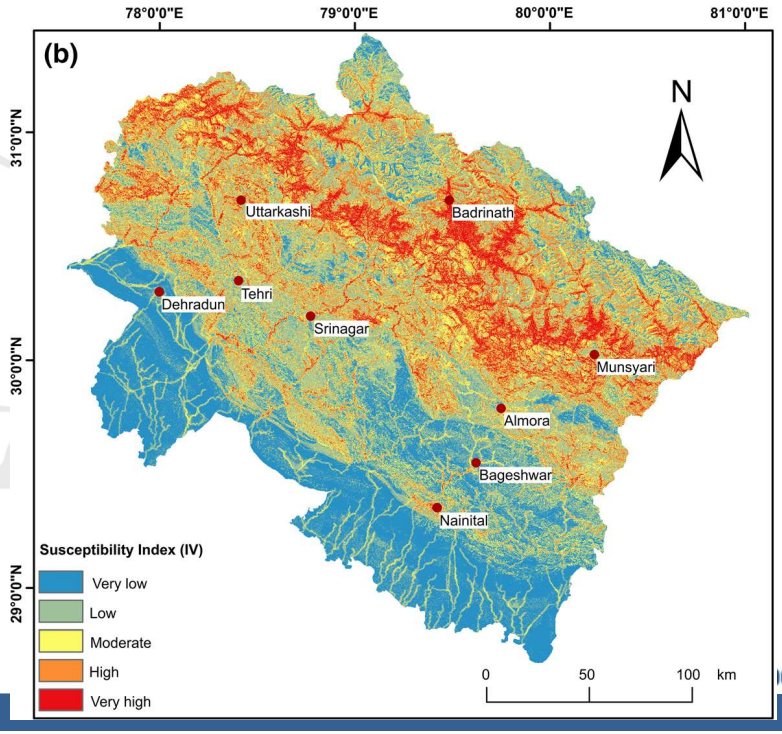


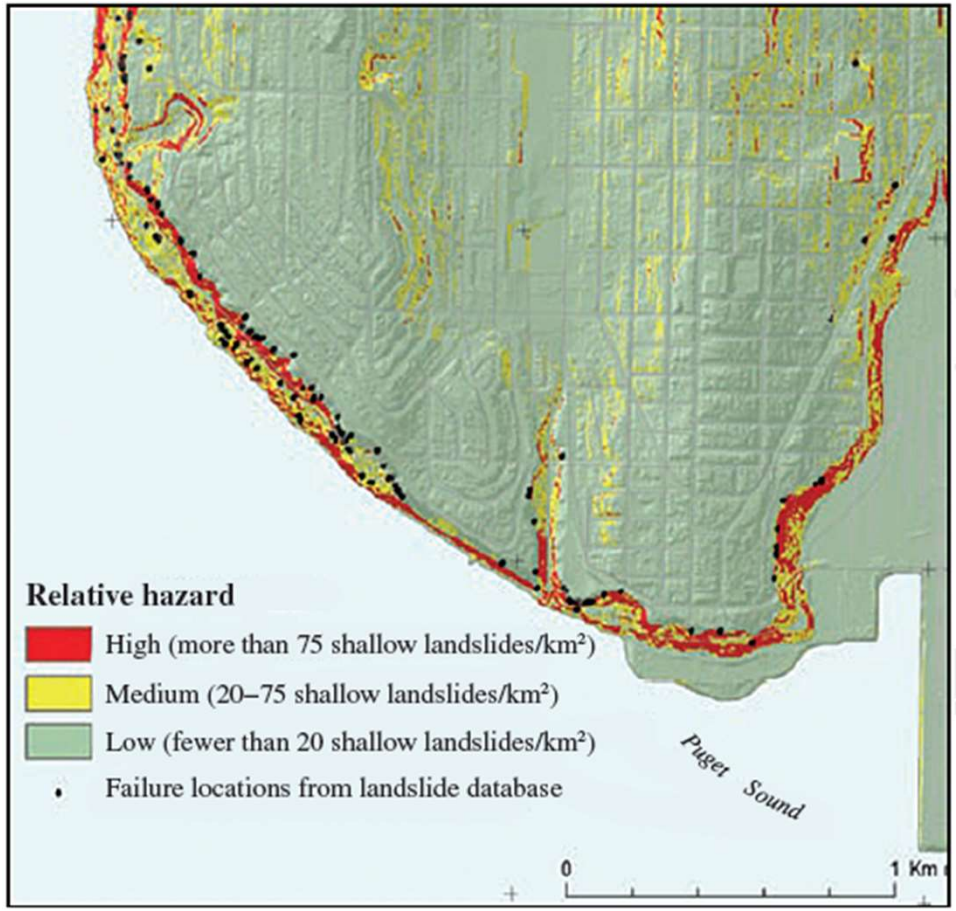
Hazard assessment/mapping

(2) Landslide hazard maps

- Hazard maps show the areal extent of threatening processes:
- where landslide processes have occurred in the past, recent occurrences, and most important, the likelihood in various areas that a landslide will occur in the future.
- For a given area, hazard maps contain detailed information on the types of landslides, extent of slope subject to failure, and probable maximum extent of ground movement.
- These maps can be used to predict the relative degree of hazard in a landslide area.
- Areas may be ranked in a hierarchy such as low, moderate, and high hazard areas.

Hazard assessment/mapping

(3) Landslide hazard maps



Portion of shallow landslide hazard map showing part of the Magnolia area of the city of Seattle, Washington, USA. (km^2 is notation for square kilometers.)

Thank you very much for your kind attention and time!

Question time