Multi-criteria analysis of landslide susceptibility, Afghanistan

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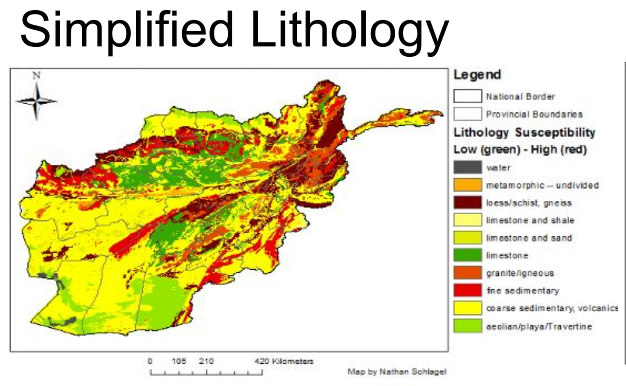
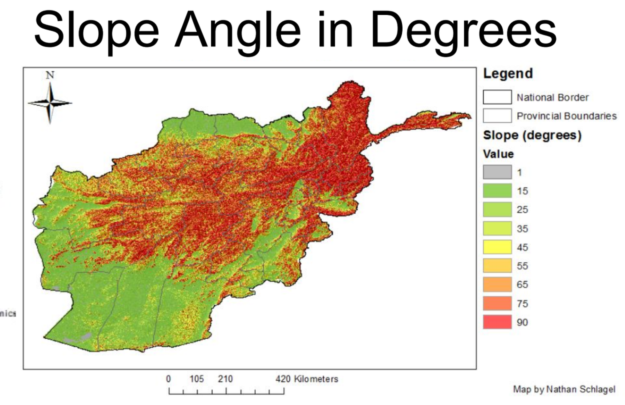
Abstract

Landslides are among the most destructive forces of nature. Estimating susceptibility through modeling is an essential tool for planning and mitigation efforts. Some regions, however, are too dangerous or lack the capacity to develop extensive inventories for rigorous analyses. Remote sensing and GIS allow for initial risk assessment and hazard planning. Data derived primarily from remote sensing, or developed before and during war efforts of the last few decades were used for this study of landslide susceptibility in Afghanistan.

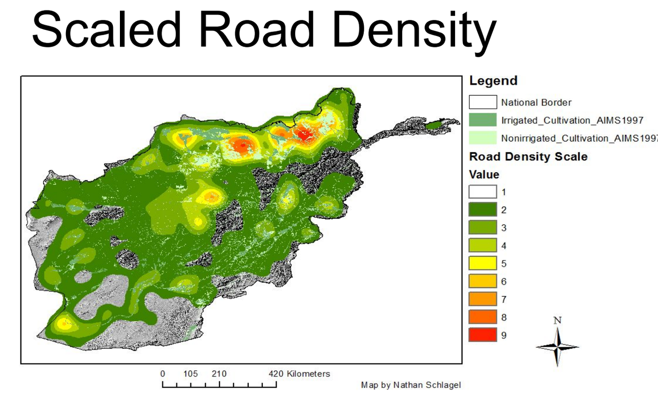
Simplified Lithology



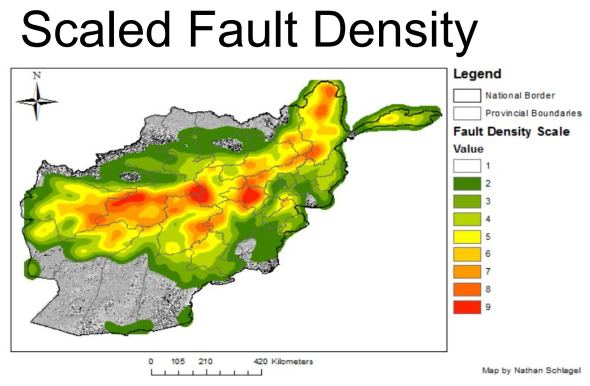
Slope Angle in Degrees



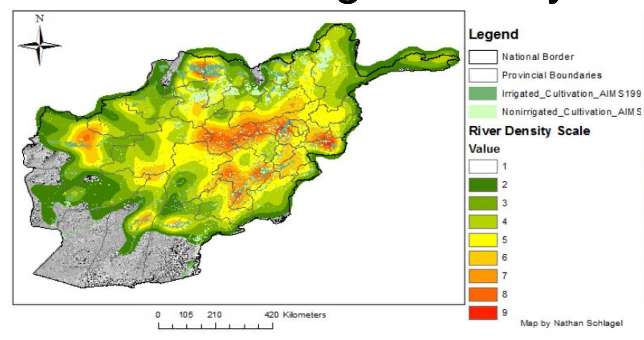
Scaled Road Density



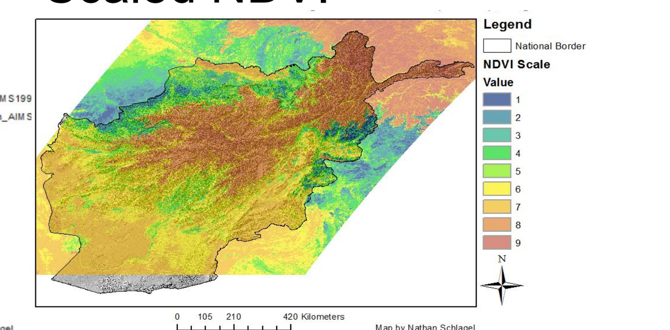
Scaled Fault Density



Scaled Drainage Density



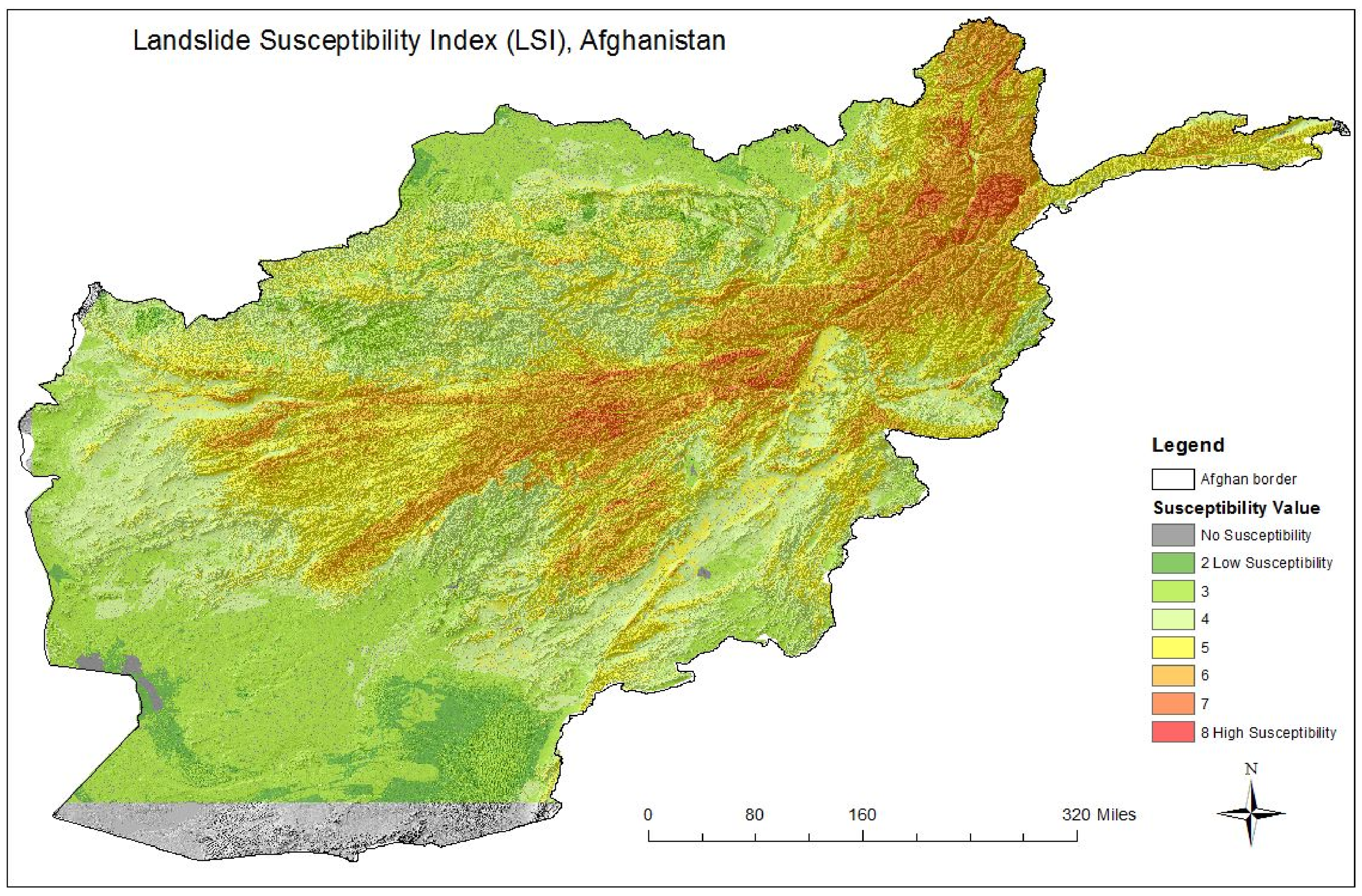
Scaled NDVI



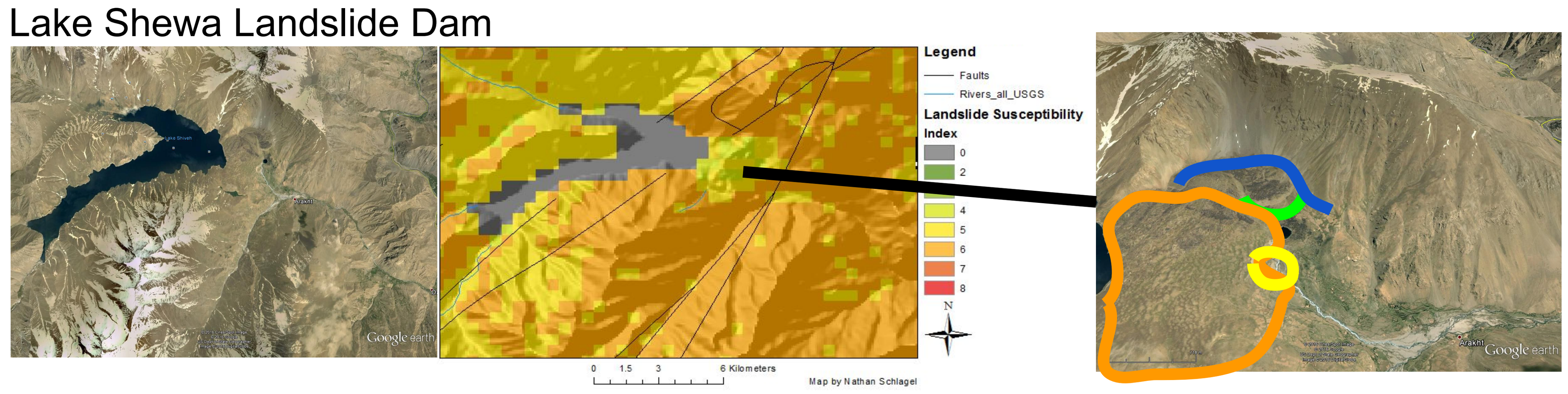
Methods

Lithology, fault, river, and road data compiled by the USGS were derived from both pre- and mid-war sources of varying detail. A 10 year subset of earthquake data was used to reduce processing time; earthquake density was weighted by magnitude. An NDVI tile was used as vegetation data covering most of the country. Slope and aspect data were derived from 90m SRTM. Aspect and earthquake density diagrams not included because of their small scale features.

Each factor was assigned weights for their own min-max range, and expected contribution to landslide susceptibility relative to each other developed through literature review. Layers were combined as a weighted overlay to create a landslide susceptibility index (LSI). Published studies of known landslides and corresponding Google Earth imagery were compared to same locations in the landslide susceptibility map.

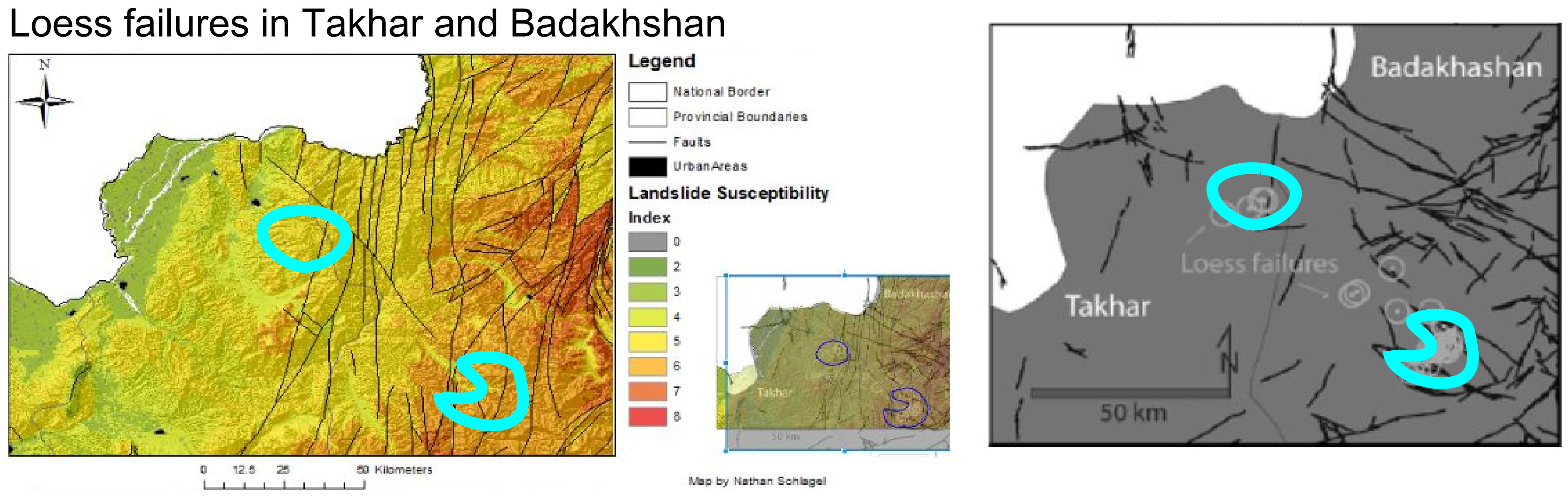


Lake Shewa Landslide Dam



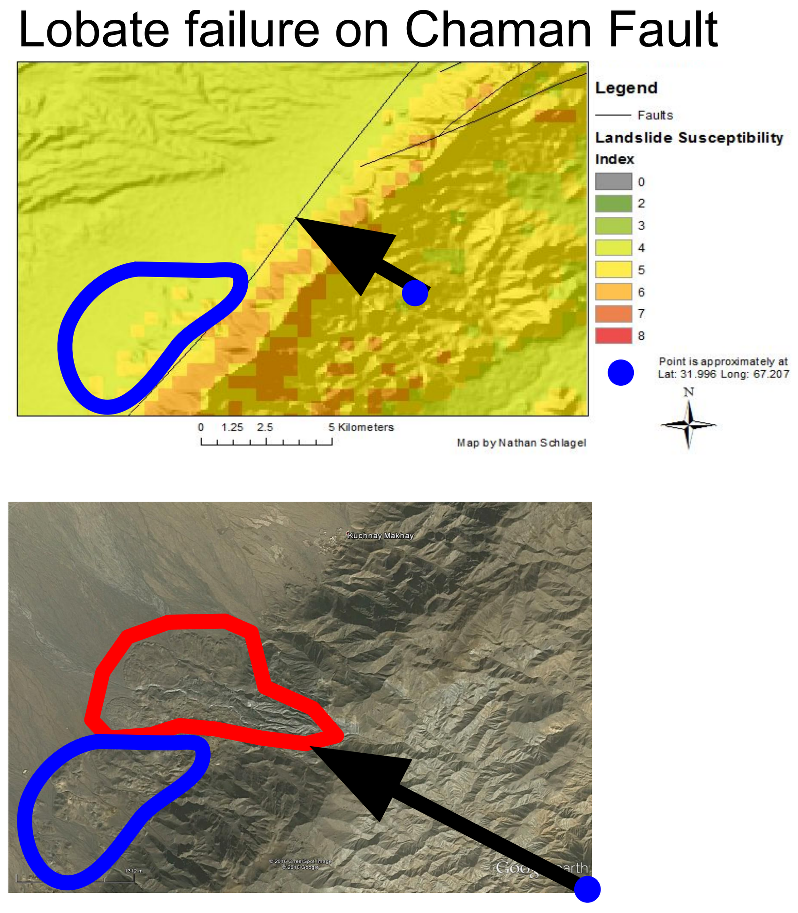
Above: Satellite (left) and LSI comparison (middle). At right, blue outlines the dominant scarp face; green the steep front of a possible rock glacier formed within slide deposits; orange, main slide deposit associated with Lake Shewa Dam; yellow, reactivation of slopes possibly as a result of water flow through the dam. Satellite images from Google Earth.

Loess failures in Takhar and Badakhshan

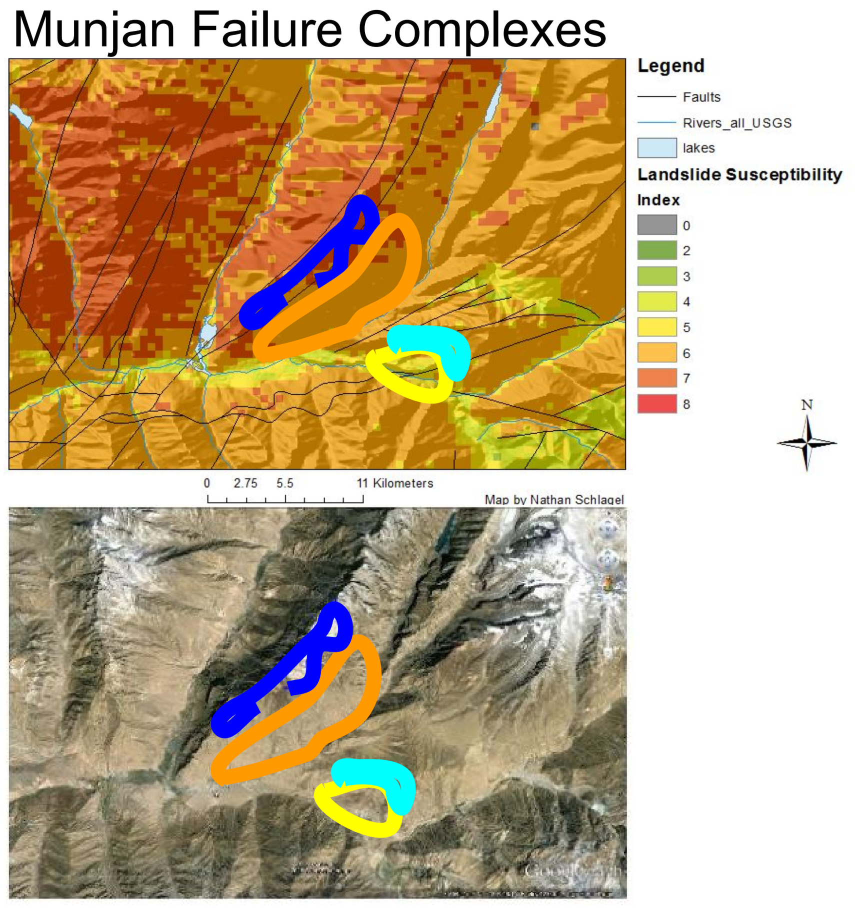


Above: LSI comparison to loess landslides mapped by Shroder et al. (2011a), image at right courtesy of the same. Cyan outlines approximate location of mapped slides by overlapping maps (middle).

Lobate failure on Chaman Fault



Munjan Failure Complexes



Left: Arrow for approximate spatial reference; base at same coordinates. Blue outlines assumed similar features. DEM of insufficient resolution to show debris flow deposit, red outline on satellite imagery. Satellite image from Google Earth.

Right: Blue and cyan show slide-scarp faces; orange and yellow, slide deposits. Closer inspection shows hummocky topography and distinct lobes suggesting repeat events. Satellite image from Google Earth.

Observations

- Model results show high LSI values in areas with observed failures (left, right, top-right). Loess, granite, and schist/gneiss are the most susceptible lithologies with greatest risks in regions of high seismicity and faulting.
- Results appear to show slide deposits as lower susceptibility, and source slopes as higher, which may be used to assess reactivation potential.
- Such techniques can be widely applied. However, the uniqueness associated with assignment of relative weights to contributing factors makes models for any given location unique and inapplicable to other areas without alteration.

Conclusion

Although advances in methodology and data quality would allow for improvements in landslide susceptibility analyses, comparisons in this study show that reasonable approximations can still be made with relatively coarse data sets.

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