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How is Climate Change Affecting Landslide Susceptibility in California?

Shabnam J. Semnani, Ph.D.
Department of Structural Engineering, University of California, San Diego

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Issue

Environmental shifts resulting from climate change have led to increased risk of natural hazards such as drought, wildfires, floods, and landslides, which all represent major threats to the state's infrastructure. One risk that is posed by greater rainfall in hilly areas that have experienced wildfires is the increased likelihood of landslides.

There is little research available for predicting future landslide susceptibility. To address this gap, our research team developed a landslide susceptibility assessment framework which reflects changing climate conditions under different levels of projected greenhouse gas emissions and applied it to assess the vulnerability of California's transportation infrastructure.

Key Research Findings

Landslide susceptibility depends on projected rainfall. Our study examined landslide susceptibility of roadway segments under two different climate models, namely, CNRM-CM5 (cool/wet) and HadGEM2-ES (warm/dry) under moderate emissions (RCP 4.5) and high emissions (RCP 8.5)[1]. The cool/wet model generally predicts higher precipitation compared to the warm/dry model. The climate models and emission scenarios considered in our study indicated increases in landslide susceptibility occurring through 2010-2040 in regions with moderate to very high historical susceptibility. The cool/wet climate model showed a continuing increase in susceptibility through 2070 (Figure 1), while the warm/dry climate model showed decreasing susceptibility throughout 2040-2070 (Figure 2).

Over time more roadway segments will face very high landslide vulnerability. Our study indicated that by 2070 approximately 8% more of the state's roadways will be highly susceptible to landslides under the cool/wet climate scenario with projected moderate emissions (CNRM-CM5 RCP 4.5), however, this change is projected to occur by 2040 with higher emissions (CNRM-CM5 RCP 8.5). Should this occur, a total of around 25% of California's roadway segments would have very high vulnerability to landslides. Under the warm/dry climate scenarios with either moderate or high emissions assumptions (HadGEM2-ES RCP 4.5 and RCP 8.5), no increase in the total percentage of areas and roadways with very high susceptibility is expected. However, various individual locations would experience changes of about ±15% in susceptibility under these scenarios. This highlights the importance of considering geographical variations in landslide susceptibility in addition to the total changes in the state.

There are wide geographical variations in landslide susceptibility throughout the state. Our results indicated that Caltrans districts 1, 2, 3, 4, and 10 can expect the largest increase in vulnerability. For the wetter scenario with high emissions (Figure 1), this increase continues through 2040-2070 for districts 2, 3 and 10. Under the drier scenario with high emissions (Figure 2) landslide susceptibility decreases in all districts throughout 2040-2070.

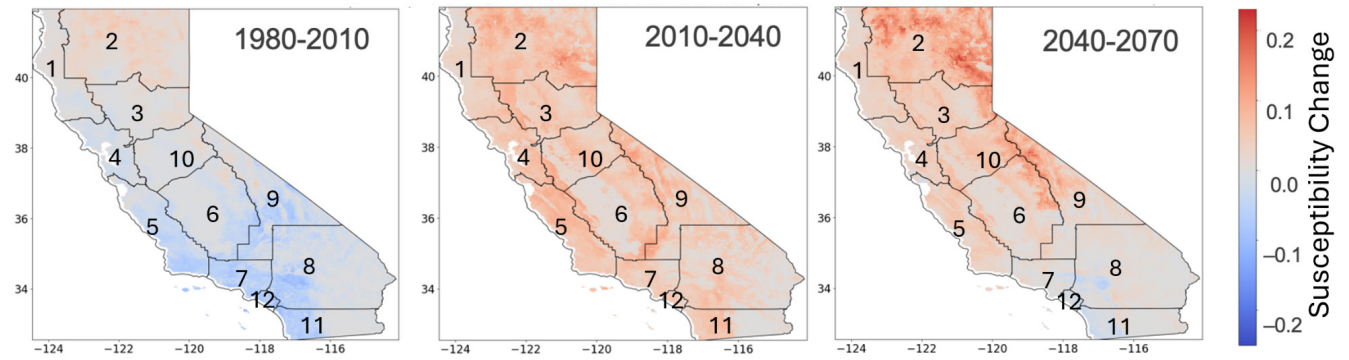

Figure 1. Changes in landslide susceptibility (susceptibility ranges from 0 to 1) compared to 1950-1980 for cool/wet climate model with high emissions. District numbers are shown for each Caltrans district.

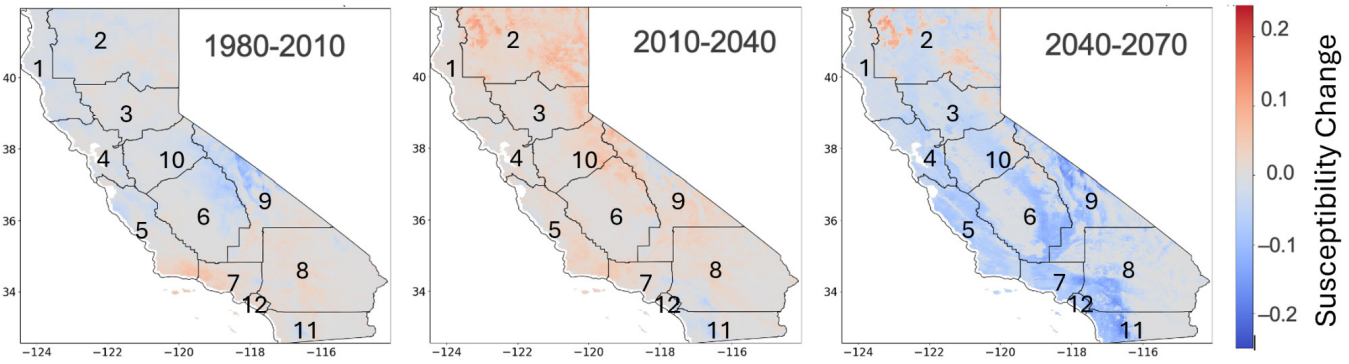

Figure 2. Changes in landslide susceptibility (susceptibility range is from 0 to 1) compared to 1950-1980 for warm/dry climate model with high emissions. District numbers are shown for each Caltrans district.

More detailed landslide susceptibility studies are needed. Our large-scale preliminary study could serve as a guideline to identify regions and roadways of high or increased susceptibility for more detailed investigation. For example, more refined landslide susceptibility maps can be derived by incorporating higher pixel resolution (less than 1km) over smaller areas to better identify vulnerable transportation assets, and help inform transportation planning and climate change mitigation efforts.

Further Reading

For more information about findings presented in this brief, contact Shabnam Semnani at ssemnani@ucsd.edu.

[1]Under global climate scenario RCP 4.5, emissions peak around 2040 and subsequently decline, while under RCP 8.5 emissions continue to rise throughout the 21st century.

Han, Y., Semnani, S.J. Important considerations in machine learning-based landslide susceptibility assessment under future climate conditions. Acta Geotechnica, 20(1), 475-500 (2025). https://doi.org/10.1007/s11440-024-02363-3.

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