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Natural Hazards and Earth System Sciences
Discussions

# *Interactive comment on* "Landslide susceptibility near highways is increased by one order of magnitude in the Andes of southern Ecuador, Loja province" *by* A. Brenning et al.

**Anonymous Referee #1**

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This manuscript on landslide susceptibility uses advanced statistical methods to analyze the landslide hazard along roadways. GLM and GAM models are fitted to the data to detect the environmental and anthropogenic variables that are strongly associated with the landslide occurrences. The authors strongly emphasize the increased landslide hazard after road building. Although this result is not particularly surprising or novel, the robustness of the statistical methods is certainly exemplary in this work.

Before publication, I would suggest the authors to address the following issues:

(1) The landslide database is now compiled with data from field observations (from



2010, landslide close to the roads) and airphoto interpretation (2000, for landslides far from the roads?). As far as I can understand from the text, these two datasets are then merged into one dataset for statistical analyses. It is not entirely clear if the two landslide inventories derived with completely different techniques (and with different spatial resolution?) are entirely compatible, and I would like to see a discussion on this. Some questions: How do you correct for the fact that there were major road works in the area during this time period (2000-2010)? How do you map the spot of landslide initiation during fieldwork, given that most of the landslide affected areas are extremely steep and still unstable?

(2) The representation of the geological data in this analysis is rather weak, and should be improved to say something meaningful on geological hazards. First of all, lithological strength (internal cohesion, friction angle, etc.) affects slope stability and you would expect to see a reclassification of the raw geological data into 'lithological strength classes' or similar. Second, the authors have used old geological maps (1975) of the area to characterize the bedrock geology. The geology of Southern Ecuador has been revised by the British Geological Survey in the 2000s, with a completely revised classification. Why is the new geological data not used in this work? Can you rather give the name of the Formation and the Period (instead of numbers which are not very instructive)?

(3) The authors currently make abstraction of any potential impact of vegetation (land use, housing) on slope stability. It is well known that the land use pattern is strongly controlled by the road network, and that land use change can control landslide susceptibility. Areas close to the roads typically have agricultural fields, pastures, farmhouses, staples and irrigation canals; that can all enhance landslide susceptibility. So, it is not uncommon that part of the enhanced landslide susceptibility close to the road network is not directly caused by road construction but rather by land use change.

(4) There is some inconsistency in the number of landslide events that was used in the analyses. In the data section, the authors mention 2185 slides, while on p. 1953 they

mention 2106 mapped slides. Please clarify.

(5) The statistical models were evaluated based on the AUROC and ROC curves. It is not entirely clear why the authors opted to use all the LS points for the calibration of the empirical models, and not a subset of 40 to 60% of the data. The latter would make an external validation possible.

(6) At the end of section 4.2 (p. 1958, L. 3-19), the authors make some statements of the mechanical effects of road building on landslide susceptibility. A multitemporal analysis is needed to bring more insights. I would suggest to remove the two last paragraphs of this section, as they are not based on hard data nor statistical analyses.

Specific comments - P. 1946, L21: Rephrase 'technological denudation' - P. 1947, L. 29: Rephrase. What do you mean with 'empirical effect of highways' - P. 1948, L. 6: Delete 'two' before 'paved' - P. 1948, L. 14: Can you really speak of the western escarpment here? Is this part not just draining to the InterAndean Valley, and not corresponding to the Western Escarpment of the Andean chain? - P. 1948, L., 16: Rephrase. I would not consider 400mm of annual rainfall as something 'extremely dry' - P. 1948, L.20-24: A geological map is needed with clear delineations of lithological units. Also, I would suggest to add the names of the geological Formations to avoid confusion. - P. 1948, L. 24: Rephrase, as land use is always the result of human activity - P. 1948, L. 25: Rephrase: 'converted into pasture' - P. 1949, L. 1-3: The authors mention that the protected areas are not located in the study area. I can agree for the Podocarpus National Park, but what about the 'ECSF' (Estacion Cientifica de San Francisco')? This is indicated on Fig. 1, but there is no reference at all in the text. - P. 1949, L. 27-28: What do you mean here with 'catchment slope angle' and 'catchment area'? Is this the contributing area to a landslide initiation point? If so, clarify and rephrase. - P. 1950, L 1-5: The authors state that catchment area is a proxy for soil moisture and soil depth. I can see their point for soil moisture, but not really for soil depth. Can you clarify? - P. 1951, L 1-3: The authors mention that most of the area is not pristine land cover. I assume that land use conversion also has a major effect on landslide



susceptibility. Why is this not analysed? In how far, can you make abstraction of the presence of ECSF being a pristine or semi-natural protected area in the mid of the study area? - P. 1952, L. 20-23: Explain 'bivariate loess smoother' in one sentence. - P. 1953, L. 9-12: The cluster analyses on the point coordinates is not clear to me. What is the meaning of this? What do you finally get as clusters? - P. 1954, L. 10: Give some more details on the landslide magnitude-area distribution of the landslide inventory. The big landslides seem to be more than 100m long (so with initiation point outside 'high hazard zone'?) - P. 1954, l. 20 and following: Give the p-values and number of observations to see if these values are significant - P. 1955, L. 1-3: What is the physical meaning of having higher susceptibility for steeper catchments and higher elevations? - P. 1957, L 1-20: There exists more work on the effect of roads, paths and human infrastructure on landslide hazards and sediment mobilization rates. It would be good to see a broader discussion. - P. 1958, L. 24 and following: This section on the geological control of landslide susceptibility is not clear, and even a bit confusing. It would certainly help if the authors would rather use lithological strength and reclassify the geological maps. - P. 1960, L 1-5: It is suggested that the rainfall amount is not a good proxy for rainfall-triggered landslides, as rainfall intensities can be high in semi-arid climates. Some hard data are needed to back up these statements, with some reference data on rainfall intensities.

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