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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Learning in an Interactive Simulation Tool against Landslide Risks: The Role of Amount and Availability of Experiential Feedback" *by* Pratik Chaturvedi et al.

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General Comments:

The study described in the paper addresses an important and very relevant issue in natural disaster risk management – to explore potential ways to improve risk awareness and knowledge. The authors reported how they used feedback in an Interactive Landslide Simulator to influence people's risk reduction investment behavior. The manuscript was written generally in good English that can be relatively easily understood, but the ILS model still needs to be better elaborated and explained. While the study represent a good initiative, it also suffers from a number of design problems.

Authors: Thank you for summarizing our contribution and providing encouragement to our work. We have now made several improvements to the manuscript based upon review comments from you and other reviewers. In agreement with different reviewers, we have now also extended this paper in both the design choices as well as system constraints. Now the elaboration of the ILS model has been improved and we have also explained the experiment design in detail. In the revised manuscript, we have also addressed several design problems related to participant demographics and details concerning assumptions in the ILS tool.

Specific issues:

The ILS model and simulator structure Significant information about the ILS model was from the authors' published conference paper in 2016. The authors need clearly state this. Much of the information needs not to be repeated. Even so, the current description of the model is still not clear enough. More details are needed to help understand how the rather sophisticated landslide probability calculation relates to damage estimation. For example, the total P is an additive results of the two constituting components, P(I) and P(E), however P(E) is the multiplicative results of its two constituting components. The authors did not give full information to justify this choice. The authors mentioned "study area" only in 2.1.1, while very limited information was provided. The authors also did not give any explanation on how W is determined.

Authors: Thank you for your kind comments.

In the revised manuscript, we have now given proper citation to our 2016 conference paper at different places in the manuscript (actually the year of publication of this conference paper is 2017 and not 2016 and the year has been corrected in the manuscript). Furthermore, we have now clarified the contribution in the manuscript and how this work builds upon prior work (pg. 3). In addition, we have now extended the paper to include a better description of relevant theory (pg. 2-3) and a better description of the probability calculation for P(S), P(R), and P(E) (pg. 5-7). As part of our revision, we have also suggested the rationale for different design and system choices made. In the revised version, we have explained study area by giving more details about its geographic location, climate, and demographic profile (pg. 3, 12-14).

The W is a free parameter. We have fixed the W parameter in this experiment such that human action play a significant role in the reduction of landslide risk (pg. 13). However, as a part of our future research work with ILS tool, we will also vary the M and W parameters to see the effect of this variation on participants' investment decisions against landslides (pg. 20-22).

The assumptions of the ILS model: The ILS was designed with the assumption that people susceptible to landslide hazard aims to maximize their total wealth and the authors started that "a high probability of landslide damages will make people suffer monetary losses and people would tend to minimize these losses by increasing their mitigation actions". This assumption neglects much of the social science research on people's risk perception, attitude and behavior, that people do not behave as an economic rationale individual in the face of extreme events.

Authors: Thank you for providing valuable comments that helped to further improve our research.

First, we have now revised our expectations to be over time (pg. 3). Second, at a first glance, the expectations may seem to assume people to be economically rationale individuals while facing landslide disasters (Bossaerts and Murawski, 2015; Neumann and Morgenstern, 1947), where one disregards people's bounded rationality, risk perceptions, attitudes, and behaviours (De Martino, Kumaran, Seymour, and Dolan; 2005; Gigerenzer and Selten, 2002; Kahneman and Tversky, 1979; Simon, 1959; Slovic, Peters, Finucane, and MacGregor, 2005; Thaler and Sunstein, 2008; Tversky and Kahneman, 1992). However, in this paper, we consider people to be bounded rational agents (Gigerenzer and Selten, 2002; Simon, 1959), who tend to minimize their losses against landslides slowly over time via a trial-and-error learning process driven by per-

sonal experience in an uncertain environment (Dutt and Gonzalez, 2010; Slovic et al., 2005). We have now added these explanations on pg. 3 of the manuscript.

Furthermore, we now also discuss how the repeated experiential feedback likely enables learning by repeated trial-and-error procedures, where bounded-rational individuals (Simon, 1959) try different investment values in ILS and observe their effects on occurrence of landslides and their associated consequences. Also, we now mention that according to Slovic et al. (2005), loss-averse individuals tend to increase their contribution against a risk over time. In our case, similar to Slovic et al. (2005), participants started contributing slowly against landslides and, with the experience of landslide losses over time, they started contributing larger amounts to reduce landslide risks. These explanations have been discussed on pg. 20 of the manuscript.

The authors assumed that "damages concerning injury and fatality affect one's income levels". This is rather naïve. While reduced income level is going to be a consequence, but it would be much less a concern for most people than the injury and fatality itself. In reality people can also choose to migrate when mitigation cost is too high and adaptation becomes impossible. The nature of landslide hazard, including its notorious fame of being extremely hard, if not impossible, to predict, makes it quite different from other hazards such as flood and drought, and general climate risk.

Authors: Thank you for sharing this thought provoking comment. In agreement with you, we have now stated as part of our discussion section that currently, in the ILS model, we have assumed that damages from fatality and injury influence participants' daily-income levels. The reduced income levels do create adverse consequences, but one could also argue that they would be much less of a concern for most people compared to the injury and fatality itself. Furthermore, people could also choose to migrate from an area when the landslide mitigation cost is too high and adaptation becomes impossible, especially due to the differences between the landslide hazard and other hazards such as flood, drought, and general climate risks. As part of our future research, we plan to investigate the influence of feedback that causes only injuries or fatalities compared to feedback that causes economic losses due to injuries and fatalities. Also, as part of our future research in the ILS tool, we plan to investigate people's migration decisions when the landslide mitigation costs are too high and adaptation to landslides is not possible.

These explanations have been provided as part of the discussion section in the manuscript (see pg. 21).

The authors' choice of P(I) formula from Hasson et al. 2010 does not seem to be appropriate. It may seem to be obviously useful by applying specific parameters from the Mandi area in India as the participants seem to be mostly from the area (the authors did not clearly elaborate this), however, since the algorithms was not disclosed to the participants and a random number generator was used in producing damages, using the seemingly sophisticated algorithms is in fact not much related to the authors' main objective, instead, a more generic algorithm would serve the same purpose and potential be more useful for testing with participants from other areas.

Authors: Thank you for your kind comments. In agreement with your suggestions, we have now stated as part of our discussion section that in the ILS model, we used a linear model to compute the probability of landslides due to human factors (i.e., Hasson et al. 2010's model). Also, the probabilistic equations governing the physical factors in the ILS model were not disclosed to participants, who seemed to possess high education levels. One could argue that there are several other linear and non-linear models that could help compute the probability of landslides due to human factors. Some of these models could not only influence the probability of landslides, but also the severity of consequences (damages) caused by landslides. Also, other generic models could account for the physical factors in the ILS tool. We plan to try these possibilities as part of our future work in the ILS tool. Specifically, we plan to assume different models of investments in the ILS tool and we plan to test them against participants with different education levels.

These explanations have been added to the discussion section (pg. 21).

Also, we have now clearly elaborated in the revised manuscript that the sample used in the experiment was representative of the study area's population because the literacy rate in the town and surrounding areas is quite high (81.5%) (Pg. 15).

Day was used as the time unit for simulation and people make daily choice in landslide mitigation investment. This is not relevant for real world situation either.

Authors: Thank you for your observation.

We have now stated as part of our methods section that the ILS tool can run for different time periods, which could be from days to months to years. This feature can be customized in the ILS tool (pg. 8). However, to showcase the potential of using ILS, the experiment used the daily setting in the ILS tool. As part of our future research, we plan to extend this limitation by considering people to make decisions on a longer time scale ranging from months to years. Please see this discussion in the discussion section of the manuscript (pg. 20-22).

In most cases, especially in developing countries, households and communities themselves almost never have resources substantial enough to mitigate landslide risk, which is often financed by government and/or international donors. The huge disparity between the average asset (calculated as per capital GDP) and the salary (with the former being 2000 times of a person's annual income) also supported my above statement.

Authors: Thank you for your kind comments. In agreement with you, we have now added to our discussion section that we assumed a large disparity between a participant's property wealth and her daily income. In addition, as part of the ILS model, we did not consider any support from government or international agencies against damages from landslides. As suggested by you, in certain cases, especially in developing countries, mitigation of landslide risks may be often financed by government or international agencies. As part of our future work, we plan to extend the ILS model to include assumptions of contributions from government or international agencies. Such assumptions will help us determine the willingness of common people to contribute against landslide disasters, which is important as the developing world becomes developed over time.

These comments have been reported on pg. 22.

The authors chose a value of 0.8 for W, indicating that the landslide risk can largely be mitigated by human. This is in general not the case, especially for the type of mitigation measures mentioned by the authors – tree plantation. There has been studies showing that afforestation does not help with landslides in similar areas to Mandi in the Sivalik Hills.

Authors: Thank you.

Now, as part of our discussion section (see pg. 22), we have mentioned that these W and M values indicated that landslide risks could largely be mitigated by human actions. However, in agreement with your suggestions, this assumption may not be the case always, especially for mitigation measures like tree plantations. For example, afforestation alone may not help in reducing deep-seated landslides in hilly areas (Forbes, 2011). Thus, it would be worthwhile investigating as part of future research on how people's decision-making evolves in conditions where investments likely influence the landslide probability (higher values of W and M parameters) compared to conditions where investments unlikely influence the landslide probability (lower values of W and M parameters).

3. The study design

The high damage scenario is simply not realistic at all. With such a high risk of mortality and 90% change of injury, no one would still choose to stay in the landslide area, even in least developed countries. The low damage scenario would already be a very high risk area in reality, in any countries.

Authors: Thank you.

In agreement with your suggestions, we have now mentioned as part of our discussion section (see pg. 22) that to test our hypotheses, we presented participants with a high damage scenario and a low damage scenario, where the probability of property damage, injury, and fatality were high and low, respectively. However, such scenarios may not be realistic, where people may want migrate from both low and damage areas in even the least developed countries. In future research with ILS, we plan to calibrate the probability of damages, injury, and fatality to realistic values and test the effectiveness of ILS in improving the participants' investment decision making.

In Fig. 3b, the authors give a smiling face followed by "Landslide did not Occur". This gives a false feeling that the fact that landslide did not occur because of mitigation investment, while in reality much of it should be due to stochastic in the nature of landslide.

Authors: Thank you for your kind comments. In our experiment, when landslide did not occur and experiential feedback was present, people were presented with a smiling face followed by a message. The message and emoticon were provided to connect the cause-and-effect relationships for participants in the ILS tool. However, it could also be that the landslide did not occur on a certain trial due to the stochasticity in the simulation rather than participants' investment actions. Although such situations are possible over shorter time-periods, however, over longer time-periods increased investments from people will only reduce the probability of landslides.

In agreement with your comments, we have now added these explanations as part of the discussion section (pg. 22).

4. The results

First, part of the results were already included in the 2016 paper (apparently including 43 of the 83 participants reported in this study) and this should be fully disclosed.

Authors: Thank you.

In the revised manuscript, we have now given proper citation to our 2016 conference paper (actually 2017 conference paper, where the year has been corrected). We have now clarified the contribution in the manuscript and how this work builds upon the prior 2017 work (pg. 3, 12).

Also, via a footnote on pg. 12, we have mentioned that data reported in Chaturvedi et al. (2017) has been included in this paper with two more conditions, the high-damage feedback-absent (N = 20) and the low-damage feedback-absent (N = 20). Data in all four conditions was collected simultaneously.

Second, the part of the results on people's increasing investment in mitigation seems to be largely an artifact of the choice of M being 0.8. It'd be more interesting to study, with a much larger sample, how how changing M will affect people's behavior, given that the authors choose more realistic scenarios.

Authors: Thank you for your kind comment, which helped us get new ideas for our research. In agreement with you, we have now mentioned that in the experiment, we assumed a value of 0.8 for the return to mitigation (M) parameter. This M value indicated that landslide risks could largely be mitigated by human actions. However, this assumption may not be the case always, especially for mitigation measures like tree plantations. For example, afforestation alone may not help in reducing deep-seated landslides in hilly areas (Forbes, 2011). Thus, it would be worthwhile investigating as part of future research on how people's decision-making evolves in conditions where investments likely influence the landslide probability (higher values of M parameter) compared to conditions where investments unlikely influence the landslide probability (lower values of M parameter).

This discussion appears on pg. 22 of the manuscript.

Some detailed comments on texts:

1. In Abstract, the first sentence is incomplete. ' Authors: Thank you.

In the revised manuscript, we have now improved the first line of abstract. All other formatting errors and references are corrected in the revised version. Now, the manuscript has also been proofed.

2."Different amount of feedback" was used, but in fact the difference between the two different levels of feedback may better be described as "intensity" of "strength" of feedback.

Authors: Thank you.

In agreement with your kind suggestion, we have now changed the "amount of feedback" in the paper everywhere to the "strength of feedback."

3. Fig. 2 is similar to the Fig 2 in the authors' 2016 conference paper and needs to be disclosed.

Authors: Thank you.

In the revised manuscript, we have now given proper citation to our 2017 conference paper as part of this figure.

4. Fig. 5b, it should be high/low damage instead of more/less damage.

Authors: Thank you.

In the revised manuscript, we have now rectified this error.

5. Reference – Mathew et al. was published in 2014 and should be rearranged in alphabetic order.

Authors: Thank you.

In the revised manuscript, all the formatting errors and references are corrected.

While the study represents an interesting attempt, it suffers from seriously false model assumptions and weakness in study design in relation to reality. I personally even think that the simulator may falsely influence participants in terms of how they should make decisions in the face of landslide risk. But I strongly recommend the authors to continue developing the simulator with stronger social science understanding and better design.

Authors: We are thankful for your kind comments as they helped us provide an improved exposition of our methods and results. These comments have also given a lot of new ideas which we will use in our future experimentation with ILS tool. We, hereby want to clarify that current experimental study with ILS was a preliminary but important work to test the effectiveness of simulation models on people's understanding of landslide risks. But, in future we will use several of the manipulations in the model parameters and probabilities to make the simulation exercise more realistic.

In agreement with you, we have now added several ideas suggested by you as part of our discussion section in the manuscript (pg. 20-22). The revised draft with the changes made is enclosed as a supplement.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-297/nhess-2017-297-AC3-supplement.pdf

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