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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 paper deals with a very relevant topic, the involvement of stakeholders in landslide risk management and the adoption of "gamification" type approaches to promote it. The ILS software results a promising tool for capturing the interest of attendees and it could be applied with reduced effort to other test cases. The sections 3 and 4 show in effective ways procedures and results.

Authors: Thank you for appreciating our research. We agree with you that the ILS tool

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is a promising tool for capturing the decisions of participants against landslide risks and it could be applied with reduced effort to other natural disasters involving human decisions.

We have now added these suggestions as part of our discussion section in the manuscript (pg. 20-22).

However, several elements would require further examination. First, the test case is not adequately introduced: geology, past and recent events, rainfall patterns recognized as main triggers. In this regard, also in ILS, dynamics inducing the events (physical or anthropic) are not adequately taken into account. For example, it is not clear how the spatial distribution of landslide events is accounted for in ILS or if the information about occurrence probability are used in simulation.

Authors: Thank you for your kind comments.

We have now extended our methodological exposition by showing how spatial probabilities (susceptibility of an area to landslides) along with environmental probabilities (triggers due to rainfall patterns) influence the total landslide risk excluding the human factor (pgs. 5-7). Specifically, we have now shown how we used the spatial area and the total estimated hazard (THED) scale of study area in ILS to compute the spatial probability distribution (P(S); pg. 7). In addition, we have now explained how a value of spatial probability was sampled from the P(S) distribution for each participant in ILS (pg. 10). Next, we have also shown how the environmental probability distribution was calculated in ILS from the seasonal rainfall in the area (pg. 5-6). Finally, we have now also shown how the human decisions cause a change in the anthropic probability of landslides and how the anthropic probability interacts with the spatial and environmental probabilities (pg. 5-6).

The role of “anthropic activities” on slopes could often be detrimental and the reduction in earnings due to reducing these one for preserving stability should be taken into account. Moreover, the main stakeholders for ILS are probably not citizens but policy makers and administrators and then financial management (daily income) should be revised accordingly.

Authors: Thank you for your kind comments.

In agreement with you, we have now explained how the anthropic activities may be detrimental to landslide risks (footnote 1 on pg. 4). Also, we have discussed both these ideas as part of our manuscript's discussion section. Specifically, we now discuss both the positive and negative (detrimental) effects of human actions in influencing the anthropic probability of landslides (e.g., afforestation may not help deep-seated landslides). Also, we have now discussed that the use of the ILS tool goes beyond school education and it applies to administrative and policy research as well (pg. 20-22). Here, we have mentioned that for pursuing this research in future, the financial components would have to be revised in ILS to include the population at the risk (rather than a single individual's savings) (pg. 20-22).

The timescales also for simulations does not appear adequate. Several decisions and protection measures need substantial longer times. Timing for measure implementation could be crucial for deciding the more effective strategies.

Authors: Thank you for your comment. 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 in the real-world, the experiment used the daily setting in the ILS tool. By using the daily setting, we were also able to use the logistic-regression equation to derive the daily probability of landslides due to rainfall (pg. 7). However, as part of our future research, we plan to extend this daily assumption by considering people to make decisions on longer time-scales ranging from months to years. We have added this discussion on pgs. 20-22.

Finally, the references in first part should be extended and updated. Under such constraints, a substantial revision (major revision) of the text should be performed in order to address the issues arisen above (and below) on specific items; on the other side, the text could be rearranged only to promote the general approach and followed procedures and main results stressing the role that it could cover for landslide risk management after proper characterizations of areas of interest.

Authors: Thank you for your comment.

We have now cited latest research concerning landslide risk in the paper, including more research about Early Warning Systems (EWSs) for landslide risk reduction (pg. 1-3). In addition, we have now broadened the discussion section of the paper by including the points suggested by you and other referees (pg. 20-22). Furthermore, we have now also clarified the exposition of different probabilities concerning the anthropic, spatial, and environmental factors in influencing landslide susceptibility in the manuscript (pg. 5-7). In agreement with your kind suggestion, this exposition allowed us to promote the general capabilities of the ILS tool and the procedures we followed for generating outcomes and probabilities.

Specific issues:

Abstract:

rephrase the first sentence; the verb appears missing

Authors: Thank you for the comment.

We have now improved the first sentence of the abstract (Pg. 1).

Introduction

L25-27: please give further details; in my view, “Knowledge about causes-and consequences of landslides and awareness about landslide disaster mitigation” act in different ways; the first one supporting structural protection measurements could reduce the occurrence/magnitude of landslides. The other one tends reducing people and assets vulnerability not varying the physical processes inducing them.

Authors: Thank you for your kind comments.

In agreement with you, we have now clarified on lines 25-27 that imparting knowledge about causes-and-consequences as well as spreading awareness about landslide disaster mitigation are two different ways of managing landslide risks. The former supports structural protection measures that reduce the probability of landslides. In contrast, the latter likely reduces people's and assets' perceived vulnerability and it does not influence the physical processes. We believe that the ILS tool engages people in both ways (pg. 1).

L31-33: please add further details about Early Warning System tools; e.g. you could refer to reviews available in literature.

Authors: Thank you for your kind suggestions. We have now cited more research about Risk Communication Systems.

Specifically, we have now added on pg. 2 of the revised manuscript that Several satellite-based and sensor-based landslide monitoring systems are being used in landslide RCSs (Hong et al., 2006; Quanshah et al., 2010; Rogers et al., 2011). To be effective, however, landslide RCSs need not only be based upon sound scientific models, but, they also need to consider human factors, i.e., the knowledge and understanding of people residing in landslide-prone areas (Meissen and Voisard, 2008).

L71: "Chaturvedi et al. (2016)" reference is missing in the list

Authors: The reference's year should have been 2017 and not 2016. We have fixed this typo everywhere in the revised manuscript.

We have also rectified the referencing problems in the reference section in the revised manuscript (Pg. 24-26).

L82-83: please consider, I'm not sure that "increasing the amount of damage feedback" and "increasing the probabilities of landslide damages" could be assumed equivalent

Authors: Thank you for the comment. In agreement with you, we have now revised the wording as the following:

"...increasing the strength of damage feedback by increasing the probabilities of landslide damages in simulation tools." (pg. 3).

2 Computational model of landslide risk

L106-108 (Figure 1): for landslides, the issue could be quite more challenging; indeed, you should consider "human interventions" detrimental for slope stability. For example, land use/cover changes (e.g. deforestation, conversion to agricultural practices). In this regard, rainfall required to induce the phenomena (e.g. duration, intensity) could be affected by "human interventions". Furthermore, researchers monitor data for landslide occurrence but not determine them as for "user" with investments. Finally, both influence not only the hazard ("total probability of landslide") but the risk.

Authors: Thank you for your kind comments. We agree with your observations.

Now, as part of our revised manuscript, we have mentioned that although our model assumes human mitigation actions in the ILS tool, there may also be other model assumptions possible where certain human detrimental actions (footnote 1 on pg. 4). For example, deforestation may increase the probability of landslides or the risk (probability * consequence) of landslides. We plan to consider these model assumptions as improvements to our model as part of our future research (pg. 20-22).

Furthermore, in this manuscript, we restricted our analyses to only people's investments influencing landslides. However, we agree with you that there may be contributions made by the national, regional, and local governments for providing protection measures against landslides in addition to the investments made by people residing in the area We plan to consider the role of governments as part of our future research (pg. 4). We have also discussed these issues in the discussion section of our revised manuscript and we will take them up as a part of the future work to make the ILS model more realistic (pg. 20-22).

L109: please specify if you consider weather(rainfall)-induced landslides

Authors: Thank you. In the current work, we are only dealing with weather (rainfall)-induced landslides.

We have now mentioned this point as footnote 2 on pg. 4.

L128: the main part of investments for protection measurements as structural (e.g. drainages, retention walls) as soft (e.g. EWS) are funded by Administrations (National, Regional and Local); in which ways it is accounted for?

Authors: Thank you. The theme of our research in the manuscript was focused upon common people's contribution for mitigating landslide risks and the effectiveness of the ILS tool in improving people's understanding about landslide processes.

We agree with your comments and as part of our revision we have now added this point on page 4 as a foot note as well as in the discussion section (pg. 20-22).

Section 2.1.2:

further clarifications are needed. Firstly, brief information about the landslides in the area of interest are required; indeed, the relevance of antecedent precipitations is strictly linked to several geomorphological factors (e.g. soil depth, bottom boundary conditions, hydraulic and mechanical properties); without them, it is not possible to evaluate if considered durations (1d, 3d, 30d) are proper. Moreover, it is not clear the role of "Landslide Susceptibility Zonation"; indeed, "susceptibility" does not provide details about frequency of phenomena but attempts defining the area more "vulnerable" to the events while in this case it is intended providing also Hazard. Moreover, please add details about the rating (0-11). Finally, all the slopes in the area are recognized to be affected by the same rainfall patterns (similar properties, similar soil depths and so on)?

Authors: Thank you for your kind comments.

We have now extended our methodological exposition by showing how spatial probabilities (susceptibility of an area to landslides) along with environmental probabilities (triggers due to rainfall patterns) influence the total landslide risk (test case) excluding the human factor (pg. 5-7). Specifically, we have now shown how we used the spatial area and the total estimated hazard (THED) scale of the study area in ILS to compute the spatial probability (P(S)) distribution (pg. 7). In addition, we have explained how a value of spatial probability was sampled from the P(S) distribution for each participant.

Next, we have now also shown the environmental probability distribution and how it was calculated in ILS from the seasonal rainfall in the area (pg. 5-7). Finally, we have now shown how the human decisions causes a change in the anthropic probability of landslides and these decisions interact with the spatial and environmental probabilities (pg. 5-7).

L170: what do you intend for landslide “benign”? Authors: When the landslide is benign, then there is no injury, fatality, or damage to property.

We have now added this definition to the manuscript (pg. 8, 10).

Section 2.1.3:

please, what do you intend for “random numbers”? which ways are the three damage probabilities computed in?

Authors: Thank you for your kind comments. If a uniformly distributed random number in [0, 1] (U (0, 1)) is less than a probability value, then it simulates this probability value. For example, if U (0, 1) < 30

We have now included these details on pgs. 5-7 of the revised manuscript.

Section 2.2:

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why do you consider a daily time step? Several decisions and protection measures need substantial longer times. Timing for measure implementation could be crucial for deciding the more effective strategies.

Authors: Thank you for your kind comments.

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 (pg. 7). Furthermore, the length of the time-period in the ILS can also be customized (pg. 7). For this manuscript, we have used the daily setting in the ILS tool to showcase the potential of using this tool for improving understanding of landslide risks among people. As part of our future research, however, we plan to extend our findings by considering people to make decisions on a longer time scales ranging from months to years. Please see this discussion in the discussion section of the revised manuscript (pg. 20-22).

L205: who is the reference stakeholder of interest? Citizens, administrators, policy makers.

Authors: Thank you for your kind comment.

We have now clarified that “decision maker” refers to participants, i.e., common people residing in the study area (pg. 10).

L212-213: in ILS, how is it decided if, for a certain day, landslide could occur or not?

Authors: A landslide occurs on a certain day when an independent random number (U(0, 1)) become less than or equal to the corresponding net probability of occurrence of landslide, which is a weighted sum of landslide probability due to environment (spatial and triggering factors) and human factors.

We have now mentioned this point on line 145 (pg. 5).

3 Experiment

L289-295: I am not sure that the sample composition is consistent with those of communities living in the area affected by landslides as in terms of background as in terms of age. It could deeply affect the findings and the generalization of the results also taking into account the very interesting issues arisen in L44-47

Authors: Thank you for your kind comments. The sample was representative of the study area's population because, like in our sample, the literacy rate is quite high (81.5

We have now mentioned these points in the revised manuscript on pg. 15. Furthermore, we have also observed that the use of the optimal invest-all strategy was maximized when the experiential feedback was highly damaging in the ILS tool. One likely reason for this observation could be the high educational levels of participants residing in the study area, where the literacy rate was more than 80

L302: It is quite equal to what reported in L287; in my view, it could be removed

Authors: Thank you for your comment.

As per your kind suggestions, we have now removed this repeated line from the paper.

L313: please, provide further details about the symbols reported in brackets

Authors: We performed analysis of variance statistical tests for evaluating our expectations. The F-statistics is the ratio of between-group variance and the within-group variance. The numbers in brackets after the F-statistics are the degrees of freedom (K-1, N - K), where K are the total number of groups compared and N is the overall sample size. The p-value indicates the evidence in favour of the null-hypothesis when it is true. We reject the null-hypothesis when p-value is less than the alpha-level (0.05). The η2 is the proportion of variance associated with one or more main effects. It is a number between 0 and 1 and a value of 0.02, 0.13, and 0.26 measures a small, medium, or large correlation between the dependent and independent variables given a population size.

We have now mentioned these points as a footnote on pg. 15.

L374: what do you intend for “K-12”?

Authors: By K-12 we meant kindergarten to standard 12th.

We have now clarified this definition on pg. 20.

L457: Mathew et al. reference should be moved in proper alphabetical order

Authors: Thank you for the comment.

As per your kind suggestions, we have now moved the reference Mathew et al. to the proper place as per alphabetic order in the manuscript.

Appendix A

It reports information quite similar to those in Figure 4; for these reason, it could be removed

Authors: We agree with your kind assessment.

As per your kind suggestions, we are now removing Appendix A from the paper.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-297/nhess-2017-297-AC1-supplement.pdf

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