

## **AUTHORS' RESPONSE TO REFEREE No. 1 (Paola Salvati)**

The authors are deeply appreciative of the referee's instructive comments, which have led to our making all the suggested corrections and have greatly helped us to improve the presentation and content of this paper.

Our responses to individual "comments to the author" are given below. Text in green is updated from the original paper's text.

### **1. My individual scientific questions concerns: How do you model the landslide susceptibility?**

Landslide susceptibility has been drawn up in keeping with the article mentioned in the text published in *Landslide* (Cantarino et al, 2019). In order to clarify this point, the following paragraph has been added to our article:

"Its characteristics are: pixels of 25 x 25 m as the unit of surface area and the spatial-multicriteria method (SCME) to weight the factors for obtaining the susceptibility values. The three significant factors used were: slope gradient, lithology and land cover."

### **2. Can you give more details and stress the possible limitations or uncertainties, if they exist, that can affect the results?**

The main limitation to this study stems from the use of a landslide inventory with few historical records according to the Spanish Geological Survey (BD-Moves) and a territorial analysis carried out in 1999 by the Valencia Regional Government. Both data sources, which are unrelated to this study, should be reviewed and extended by the corresponding official bodies. It is clear that an updated database would provide absolute values different from those obtained in this study. However, we believe that it would not substantially alter the conclusions reached, nor would it invalidate the usefulness of the index proposed in our study.

If necessary, this paragraph can be included in the text.

### **3. Do you consider the number completely representative of the landslide occurred in the 1,335 km<sup>2</sup> of the studied area?**

It is true that the eight landslides mentioned do not seem to be sufficient to represent such a large area. There have almost certainly been quite a lot more, but they have not been recorded in the inventory by the Spanish Geological Survey. Nevertheless, as mentioned in the previous section, an adjustment to the probability of occurrence in the levels of susceptibility used should not substantially change the trends in the curves obtained.

### **4. Do you account the landslide magnitude considering information on the landslide individual areas? it is not fully clear from the text.**

The landslide magnitude (LM) has actually been considered to be constant throughout the zone under study due to the difficulty in calculating it without the necessary field data. This study has followed the criterion of Silva & Pereira (2014) indicated in this paragraph and extracted from their paper: "Taking into account the previous example and the fact that shallow slide characteristics in the study area do not vary too much in terms of affected area, depth of the slip surface, velocity, volume and typical damage, we

assumed a single fixed value for LM. Therefore, the LM was assumed to be 0.6 on a heuristic scale ranging from 0 to 1”.

Hence, in our article the following sentence has been modified:

“Therefore, the LM was assumed to be 0.6 for the area of study on a heuristic scale ranging from 0 to 1 (Silva and Pereira, 2014) (see Table 5)”.

**5. Is this type of landslide of possible occurrence in the study area? Or do you apply the indicators to other type of landslide? In this case you should explain the reason that support your choice.**

Indeed, the paper cites some authors who have worked with debris flows. However, our zone under study is not especially affected by this type of landslide. The most common hillside instabilities are rockfalls and rotational and translational landslides. This study has only taken into account landslides in keeping with the information available in the inventories according to the Spanish Geological Survey (BD-Moves) and the Valencia Regional Government.

**6. The cluster analysis section, that in my opinion is relevant for the aim of the paper, should be improved as it is weakly explained and the results poorly described and discussed.**

A great effort has been made to improve and clarify this section, as suggested by the reviewer. Table 7 has been reorganised and improved, and a new Table 8 has been drawn up. Both are given below. Finally, the updated text in the article concerning cluster analysis is as follows:

“Various attempts were made to find the optimum cluster number, finally choosing a solution with the greatest number of clusters in order to isolate singularities, with 14 in total. The results (centroids) are shown in Table 7, where the 14 clusters have been organised into four classes A, B, C and D (from smallest to biggest in magnitude) according to the values of the three variables chosen for the analysis. These variables are: the rate of built-up area SpGFA (in  $\text{m}^2/\text{k m}^2$  of UAD), the total Risk Ratio RRt ( $\text{€}/1000 \text{ m}^2$  GFA) and the final section of slope of the straight trend line mRR Hi (degrees).

Each of these classes is defined as the result of a new grouping into four clusters for each variable. Table 7 also includes two indicators that provide information relevant to the established clusters. Those two indicators are the mean slope (SLm in degrees) and the specific risk rate (SpRV in  $\text{€}/\text{km}^2$ ), previously defined in Table 2. Table 8 explains each cluster’s most relevant characteristics and the municipalities within each of them. The evaluation of the risk building management (reviewable / improvable / suitable) is indicated only for the final curve section according to the mRR Hi value; if the trend is different for the first section, then the name of the municipality is marked at the end with an asterisk (\*).”

**Table 7. Cluster centroids and their levels organised from A (max) to D (min)**

Cluster centroids								Other indicators (mean)	
Cluster number	SpGFA x1000	Level 1	RRt	Level 2	mRR Hi	Level 3	Cluster CODE	SLm	SpRV x1000
1	170.7	A	86	C	38	B	ACB	11.3	14.62
2	152.3	A	80	C	-58	D	ACD	13.8	12.15
3	69.5	B	500	B	86	A	BBA	14.5	34.34
4	62.7	B	146	C	53	B	BCB	10.7	9.17
5	75.1	B	52	C	-18	C	BCC	10.8	3.74
6	50.2	B	0	D	1	C	BDC	6.1	0.01
7	18.6	C	154	C	71	A	CCA	14.3	2.81
8	20.4	C	98	C	-19	C	CCC	14.2	1.96
9	0.9	D	679	A	82	A	DAA	22.1	0.94
10	3.6	D	296	B	77	A	DBA	19.6	0.93
11	4.4	D	88	C	54	B	DCB	18.8	0.41
12	1.6	D	821	A	-72	D	DAD	23.2	1.36
13	2.5	D	324	B	-66	D	DBD	22.3	0.79
14	4.5	D	105	C	-39	C	DCC	16.7	0.52

**Table 8. List of clusters with their characteristics and assigned municipalities grouped by construction intensity ratio (SpGFA) from high to low.**

Cluster CODE	Noteworthy Characteristics	Risk building management	Municipalities
ACB	High Spec. Risk	Improvable	Benidorm (*)
ACD	High Spec. Risk	Suitable	Calpe (*)
BBA	High RR. VHigh growth trend and Spec. Risk	Reviewable	Altea, Benitachell
BCB	High Spec. Risk	Improvable	Teulada
BCC		Suitable	Alfaz, Xabia (*), La Nucía (*), Denia (*), Villajoyosa
BDC	VLow RR. Coast plain area	Suitable	Ondara, Vergel
CCA	VHigh growth trend	Improvable	Callosa, Polop, Pedreguer, Pego, Sanet y Negrals
CCC		Suitable	Beniarbeig, Benidoleig (*), Benissa (*), Finestrat (*), Gata de Gorgos (*), Orba (*), Rafol d'Almunia
DAA	VHigh RR and growth trend. Inland hilly area	Improvable	Confrides
DBA	High RR & VHigh growth trend. Inland hilly area	Improvable	Alcalalí, Benifato, Benigembla, Benimantell, Lliber, Orxeta, Relleu (*), Xaló
DCB	Inland hilly area	Improvable	Bolulla, Castell de Castells, Vall d'Ebo, Murla, Senija, Tormos, Vall de Laguart, Xaló
DAD	VHigh RR. Inland hilly area	Suitable	Castell de Guadalest, Sella (*)
DBD	High RR. Inland hilly area	Suitable	Adsubia, Beniardá (*), Tárben
DCC	Inland hilly area	Suitable	Benimeli (*), Vall de Alcalá (*), Parcent (*), Sagra (*), Vall de Gallinera (*)

(\*) Municipalities with a change in trend from the first part of a series to the second.

**7. In addition to the comments in the pdf file attached, I add some suggestions to the paper structure:**

**7.1. Section 2, “General Methodology” needs a graphical schema to illustrate the different theoretical issues.**

Given that the section “Temporal Evolution of Risk” is one of the most relevant ones in the paper, new paragraphs have been added to the article following the reviewer’s suggestion. Furthermore, a new diagram has been added (Temporal risk flow chart, Fig. 2) showing the method explained in the section. The updated text is given below, as well as the new figure.

“The adimensional (relative) Risk Ratio (RR) between years  $y_1$  and  $y_2$  is defined in the following equation:

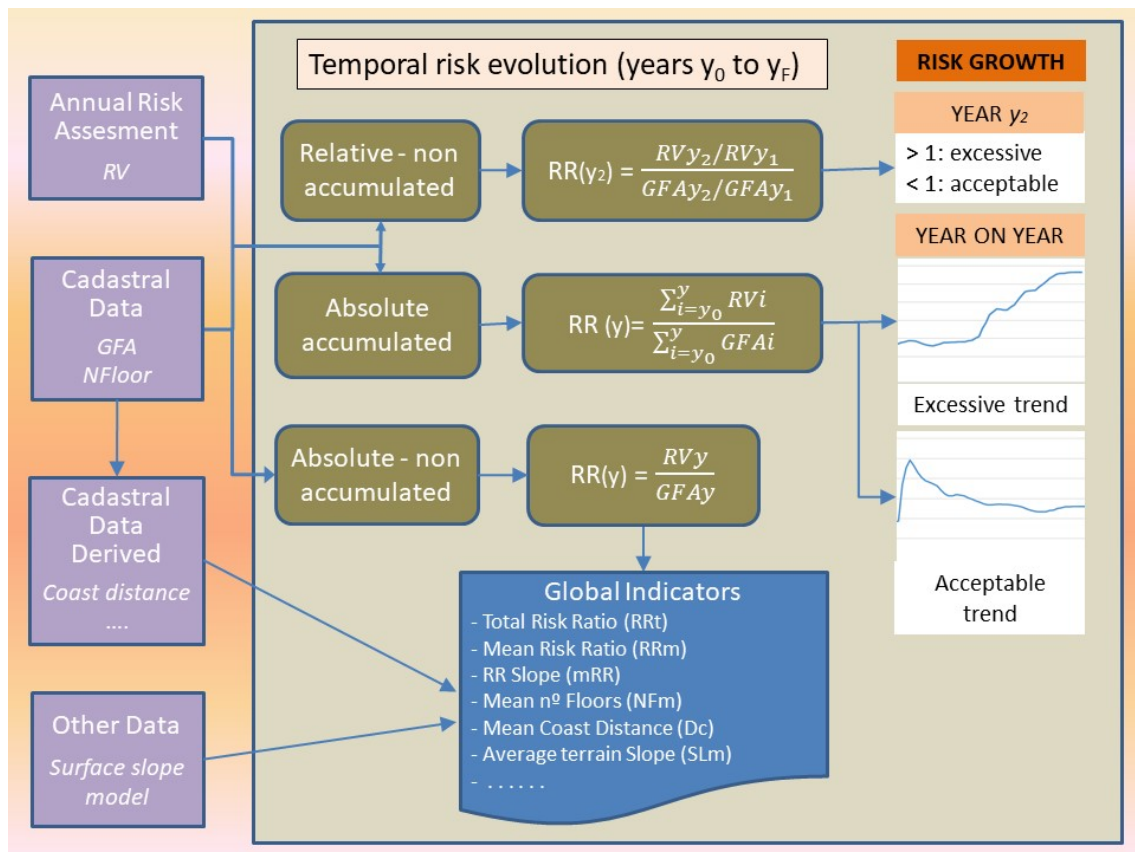
$$RR(y_2, y_1) = \frac{\frac{RV(y_2)}{RV(y_1)}}{\frac{GFA(y_2)}{GFA(y_1)}} = \frac{rRV}{rGFA} \quad (6)$$

To sum up, it is concluded that  $f(y)/g(y)$  is a function whose growth slope is defined by the growth of the Risk Ratio value (RR) for the chosen interval  $[y_1, y_2]$ . The different options are summed up in Table 1.

It is preferable to use the absolute values from the relationship between RV and GFA in order to be able to compare their magnitudes between the different municipalities. In addition, working with the functions of the accumulated values RVacc and GFAacc, it is ensured that the two base curves are monotonically increasing for the entire period under study. It is easily demonstrated that the quotient function of the accumulated series RVacc/GFAacc also meets the characteristics determined for the RR value in Table 1. These annual values can be transferred to a graph showing the resulting curve in order to analyse its ascending or descending trend (see Fig. 2).

$$RR(y) = \frac{RV_{acc}}{GFA_{acc}} = \frac{\sum_{i=y_0}^y RV_i}{\sum_{i=y_0}^y GFA_i} \quad (7)$$

Equation 7 shows the calculation of the accumulated RR values for each year. It is applied for the entire time series available, always starting from an original year  $y_0$ . In these quotient functions, a simple deterministic trend is going to be assumed.”



**7.2. In some cases you refer to results or questions discussed later in the text making difficult the comprehension to the reader.**

To solve this problem, section 2 (with a new sub-section 2.2, “Risk evaluation”) and section 3 have been reorganised.

**7.3. The section has too many sub-chapters and titles interrupting the reading.**

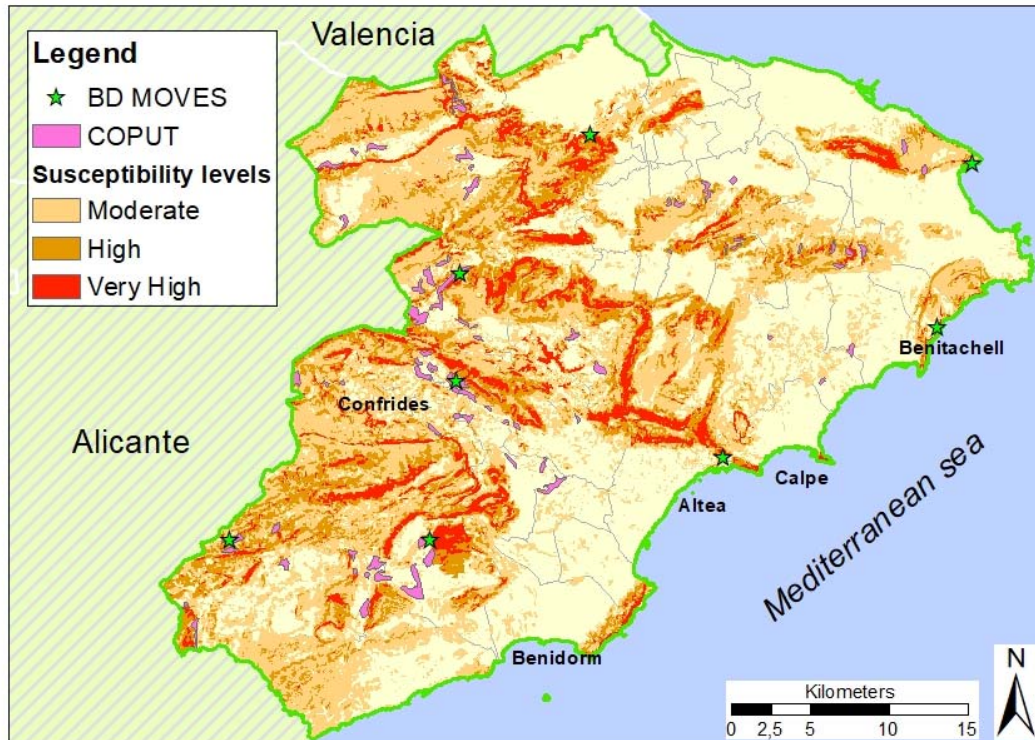
An effort has been made to reduce such interruptions in the new text.

**7.4. Section 3, “Case study”. It should be better to highlight that you are assessing the specific risk. You are assessing the risk in terms of expected economic loss due to landslide damage to residential building and not the total risk. In my opinion there are some basic data that you missed.**

Good point. Now the text indicates that the type of risk analysed is “economic loss due to landslide damage to residential buildings”. Furthermore, an effort has been made to include all of the data necessary to reproduce the calculation made in the paper, although it is possible that some minor data has not been included. However, this should not be relevant enough to alter the results obtained.

Following the reviewer’s advice, a new map has been created in Figure 5 attached, indicating the three highest levels of susceptibility, together with the location of landslides according to the Spanish Geological Survey (BD-MOVES) and the areas with instabilities according to the Valencia Regional Government (COPUT).





### 7.5. I would suggest a full revision of the English language

The entire text has been translated by a professional of recognised prestige with a great deal of experience in translating technical, scientific and academic texts. All of the text has been revised again completely and thoroughly. We are willing to improve the text of any paragraph you may indicate in order to achieve the desired quality in writing it. Attached is the certificate of English proof-reading provided by the professional service.

As for the supplementary notes indicated in the article's text, the following modifications have been made:

**Line 20: Please write clearly the first paragraph, give more references and avoid opinions**

That first paragraph has been modified, introducing two new references:

“Landslide risk evaluation, management and mitigation are aspects that have been dealt with profusely in recent decades in the literature specialising in such matters. Specially by the knowledge that a proactive approach to risk management is required to significantly reduce loss of lives and material damage associated with natural hazards (Kalsnes, 2016). There are a multitude of studies on these matters, notably the summary put forward by Dai et al. (2002) with a critical review of landslide research and the strategies for reducing damages and losses, as well as the relevant publications by Lee and Jones (2004) and Glade et al. (2006) with a multidisciplinary perspective on landslide risk management. The recent review of quantitative methods for analysing landslide risk by Corominas et al. (2014) also gives recommendations to improve these procedures.

It is important to consider that the risk associated with landslides is changing as a consequence of environmental change and social developments. Climate change, the increased susceptibility of surface soil to instability, anthropogenic activities, growing (and uncontrolled) urban development and changes in land use with increased vulnerability for the population and infrastructure as a result, all contribute to the change—and in most cases the increase—in the risk of landslides (Gallina et al., 2016)”

**Line 140: Please better emphasize that this is a theoretical example.**

The text has been changed, placing special emphasis on the fact it is referring to a theoretical example, as indicated by the reviewer. The final text is now as follows:

“In the early years of this example situation pattern, [...] This theoretical behaviour is shown...”

The title to Figure 1 has also been changed, thus:

“Theoretical evolution of the risk accumulated over time for a one-year series pattern”

**Line 333: Please, change "they" with "the”**

The errata has been corrected.

**Line 338. Please, give reference**

The following quote and text have been included in the article:

“These two types of probability—temporal and spatial—are in keeping with equation...”

**Line 343. the information on landslide magnitude??**

The evaluation of the landslide magnitude (LM) has been dealt with in the section on vulnerability.

**Otherwise if the temporal recurrence probability is affected by error, the whole analysis could be affected”**

There is indeed some error in the risk calculation due to uncertainty in calculating the temporal probability. The landslide probability will be based on the historical frequency of recorded landslides, but within reason and making use of this available data, knowledge and experience, too. This leads to a range of estimates, even when using exactly the same basic information. As a result, it was decided not to complicate the calculation method with confidence intervals so as to obtain results that can be interpreted more easily.

**Line 417 “Are debris flows mapped in your study area?”**

No; the only hillside movements mapped in the zone are rotational and translational landslides, as well as rockfalls. This section has been corrected in order to avoid confusion.

**Line 422: please, better explain how you evaluated the BR percentage**

Silva and Pereira (2014) explain the way of calculating the “building resistance” (BR), using a total of five “building features”. Recent buildings have very similar construction characteristics (brick walls joined by reinforced concrete) with very little variation in the scope of this study. The only “building feature” with some variation and about which we have data via the cadastre is the number of storeys. Their weighting appears in Table 1 of the aforementioned article by Silva and Pereira. The resistance value has been reduced as much as possible according to this characteristic in order to allow for a greater range of variation in the results for risk calculated.

**Line 433 “It should be remarked as a final reflection on the risk calculation methods, that it does not seem to be essential here to carry out a very comprehensive, exhaustive application”.**

**This sentence has no sense. it could be better if you state that it is a simplified method to assess the risk value and find references concerning the application of other simplified methods.**

Our observation refers to the fact the data used is not of such quality as one might wish since there is no official data or specific studies within the scope of this study. Data sources have been used that are not complete or fully up-to-date, which means a lower accuracy on using them in this study. In other words, a complete method has been applied but with a little uncertainty as regards its results, though this does not invalidate the objective or the usefulness of the index proposed in our research. We propose changing the sentence for the following:

“As a final reflection on the application of this or any other method for calculating risk, it should be noted that there is some difficulty in obtaining precise results due to the lack of official data and specific, up-to-date studies in the sphere being studied. Some of these procedures are based on data that is not very exact, and even on subjective evaluations, which means some error must be assumed in the results obtained, though this does not invalidate the objectives or the validity of the index originally proposed in our study.”

**Line 460. Please, better explain table 6 in the text**

The following text has been introduced in order to improve the explanation of Table 6:

“The values of these indicators calculated for the 50 municipalities that make up La Marina are shown in Table 6, accompanied by their interval of variation.

A series of annual values were calculated for the 50 municipalities of La Marina area as a whole. The total values for the built-up area (GFA) and risk (RV) are shown in Table 6. The mean values are listed in the same table, as well as their interval of variation of the global indicators in the previous Table 2.”

**Line 480. did you first cite and discuss fig.4??**

It is true that Figure 4 is mentioned before naming it. The mention has been deleted since it is not necessary to analyse it in this paragraph.



**Line 524. Why did you not normalized it?**

In the software used to carry out the cluster analysis (Statagraphics), a prior standardisation was carried out on all of the variables used, though it is true that this was not mentioned in the text. It is now mentioned.

**Line 535. Can you show a table with the obtained values?**

As indicated above, the modified Table 7 has now been included as well as a new Table 8 with the results from the cluster analysis (centroids of variables).

**Line 542. Can you please explain what are you referring with segments?**

The term “segment” is perhaps not suitable for a curve; perhaps “curve section” is preferable. The text has thus been changed.

**Line 585. The first three paragraphs 585-600 could be deleted or reduced**

The first three paragraphs of the Conclusions section have been simplified as follows:

“In this vein, it would seem reasonable to think that studies on the mechanics and distribution of landslides, the growth in information about behaviour of the ground, the restrictions imposed on residential expansion etc. should progressively improve the effectiveness in tackling the risks. However, it has been shown that not all municipalities are capable of reducing the incidence of these risks over time and that, according to Fig. 5, this incidence is still generally high. So why is this happening?”

**Certificate of translation of the paper “Landslide risk management analysis on expansive residential areas. Case study of La Marina (Alicante, Spain)” (ES>EN)**

Translator: Gary Smith

Tax ID: (ES) X1600081V (Professional activity group 774 of the Spanish Tax Agency)

I, Gary Smith, independent translator with tax no. (ES) X1600081V, voting board member of the International Association of Professional Translators and Interpreters (IAPTI) and member of ASETRAD, the Mediterranean Editors and Translators Association (MET) and La Xarxa (XarxaTIV, former president) certify that I have translated and revised the text “Landslide risk management analysis on expansive residential areas. Case study of La Marina (Alicante, Spain)” from Iberian Spanish into British English and I testify to the standard of English used therein.

Gary Smith

3 February 2021

**GLOKALIZE**  
traducciones . translations . traduccions

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