AUTHORS' RESPONSE TO REFEREE No. 2 (E. Poyiadji)

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. The methodology is complicated, as this has been aforementioned, and too many assumptions have been made. For instance, (1) climate change has not been taken into account, a factor that is of the most important for the manifestation of landslides.

Indeed, the effect of climate change has not been specifically taken into account in our study. We are aware that climate change increases the susceptibility of surface soil to instability due to agricultural areas being abandoned, forest fires and an increase in heavy precipitation. However, it is difficult to quantify its impact in a deterministic study and to thereby discard its effect. We believe it is acceptable to assume that climate change does not appreciably affect the susceptibility values obtained in this study, as indicated in the paper's text (see line 105). Nevertheless, its effects on other data sets used in the paper are implicitly included and reflected in the trend curves obtained.

Even so, in order to not overlook the significant role played by climate change in hillside instability, the following paragraph has been included in the paper:

"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 landslide (Gallina et al., 2016)"

It is also a pity that there are so few studies on landslides in our country that look in detail at the effects of climate change, as pointed out by Gariano and Guzzetti (2016, cited in the paper): "Spain do not consider landslides in their climate change adaptation strategies, or in related preparatory and accompanying reports".

2. Although the authors understand that the exposure is different for the various types of landslides it is not clear if they have the data (does the inventory gives details on landslide types) and what type did they finally chose (debris flows?) and why?

Unfortunately, the inventory used is not very precise and only differentiates rockfall from other kinds of landslide. This data source comes from a study carried out by the Valencia Regional Government (COPUT), in which we did not take part. In our zone, landslides are generally rotational or translational, in addition to rockfalls. Debris flows are not very common and are not specifically differentiated in the aforementioned inventory. That is why this study mainly concentrates on landslides without considering rockfalls or debris flow.

3. Moreover, the authors believe that following the proposed methodology would be able to determine what causes the incidence of landslide risk (geomorphology, chance, land management, etc.), and would finally be able to suggest control tools for the public bodies tasked with monitoring such matters. In my opinion the methodology described has many unclear points and many gaps.

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 $m^2/k\,m^2$ of UAD), the total Risk Ratio RRt (€/1000 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 €/km2), 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 (*), Tárbena
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.

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:

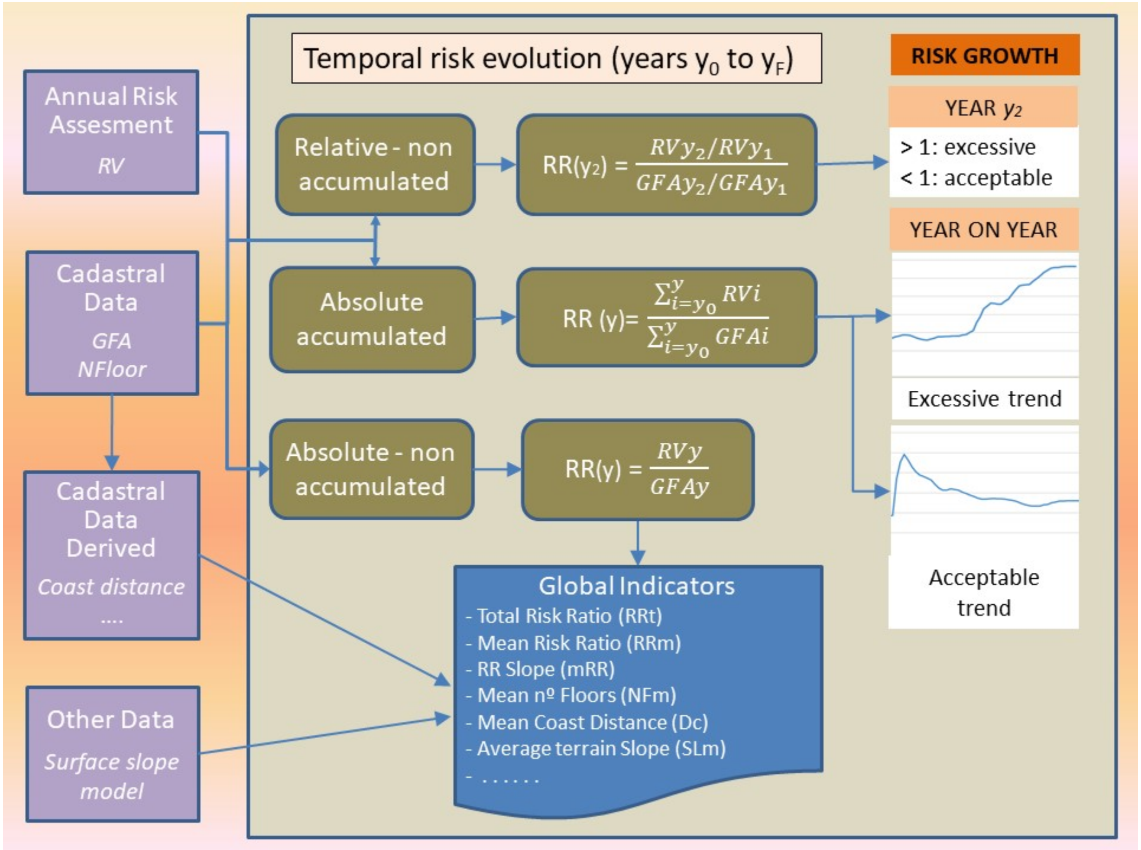
$$\mathrm{RR}(y_2,y_1) = \frac{\frac{\mathrm{RV}(y_2)}{\mathrm{RV}(y_1)}}{\frac{\mathrm{GFA}(y_2)}{\mathrm{GFA}(y_1)}} = \frac{\mathrm{rRV}}{\mathrm{rGFA}} \quad (6)$$

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).

$$RR\ (y) = \frac{RVacc}{GFAacc} = \frac{\sum_{i=y_0}^{y} RVi}{\sum_{i=y_0}^{y} GFAi} \qquad (7)$$

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.”



4. Finally, I would suggest a major revision of the paper. It is a text not easy to follow, there are many up and downs (see comments on pdf) and points that must be clarified.

Following the reviewer’s advice, sections 2 and 3.3 have been completely restructured.

5. Also some of the references are not listed at the end of the document.

The mistakes in the bibliographical citations have been corrected.

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

Line 52. Missing reference Di Martire 2012

This reference has been included.

Line 105: Too many assumptions

This paragraph's text has been changed in order to explain the reasons for not specifically including the effects of climate change in this study. The modified text is:

"The second data set must arise from the geolocalised map of risk distribution. Normally, this is based on a landslide susceptibility map (LSM) that has been deemed stable during the period analysed. Indeed, the risk map is calculated based on the temporal nature of construction and must be approximately in sync with this process. Moreover, the occurrence of a landslide is generally linked to trigger mechanisms that respond to events subject to a specific return period. The probability calculation also uses feedback from the appearance of these events, whose frequency is being modified as a result of climate change. However, according to Gariano & Guzzetti (2016), the effects of climate change on the type, extent, magnitude and direction of the changes in the slopes' stability conditions, and on the location, abundance and frequency of the landslides, are not completely clear. In the end, climate change is not going to be taken into account specifically in this work."

Line 134:

This sentence has been changed for the following one:

"The essential purpose of this work is to define a reliable, simple method that will enable the risk's dynamics to be described."

Line 137: "Th e", errata

Corrected

Line 156: too much up and downs trying to look for the right equation

True. As indicated above, the text has been reorganised in sections 2 and 3.3 to smooth out these "ups and downs".

Line 244: Total risk value?? Due to landslides or any other geohazard .Please clarify

This sentence has been changed for the following text:

"The work by Cantarino et al. (2014) emphasises that Alicante was the province most affected by landslide risk value on residential buildings in the Valencia Community Region (Spain)".

Line 256: Needs to be modified. Unclear sentence: "Its mountainous terrain means the coastal strip is not exempt from risk, a situation that is aggravated by its high value for tourism and residential occupation".

This sentence has been changed for the following text:

"Its extensive mountainous orography reaches the coastal strip itself, which is not free from risk. This situation is aggravated by being highly attractive for tourism and its residential occupation."

Line 260: Missing reference EFA, 2006:

EFA corrected for EEA

Line 272: Instituto Geológico y Minero de España: in English : Spanish Institute of Geology and Mining or Spanish Geological Survey

The text has been changed for: "Spanish Institute of Geology and Mining"

Line 298: "In this study, the aforementioned thresholds are used to evaluate the risk in different cadastral parcels at any moment, as well as to determine their evolution over time and finally to calculate the level of hazard".
Unclear paragraph. How susceptibility will lead to risk and then in hazard??

This paragraph has been changed for the following text:

"For this study, the spatial probability for each class has been determined by comparing these susceptible areas with the ones indicated in the inventory. This information, together with the temporal probability, has enabled the hazard and finally the risk to be calculated."

Line 333: They year of…, errata

Changed to *"The year of …."*

Line 498: "The possible explanation for this has been given above."
It is not an easy text. There are repeated up an downs

In keeping the reviewer's suggestion, the following text has replaced the previous one, removing the need to look for this explanation in a section already dealt with.

"The possible explanation could be that the plots at greatest risk of landslide begin to be used at a greater pace once the best plots have been occupied following a period of intensive building activity. In other words, it is possible that when suitable plots become scarce, the next buildings are constructed in a worse location and thus a greater risk is taken on."