Reviewer #2's Comments

1. General comments

I have only partially revised the manuscript "GIS-models with fuzzy logic for Susceptibility Maps of debris flow using multiple types of parameters: A Case Study in Pinggu District of Beijing, China". The manuscript deals with the application of susceptibility analysis on debris flow and could be interesting for the journal. Unfortunately, the manuscript is not written in a good English and many statements and descriptions are very difficult to understand. I revised only up to line 203 (3.4.2 Data-driven method in susceptibility modelling). I recommend the authors to submit a revised version of the manuscript after the revision of an English-speaking person. Few comments are throughout the text.

Response: Thank you very much for your valuable and constructive comments on this manuscript. Your comments are very helpful for us to improve the manuscript. Thank you for your suggestions on the language. These suggestions were of great help and improved the quality of our manuscript. According to your suggestions, we will send our manuscript to professional language embellishment agency and foreign students who are English-speaking person. Hope the final revision can meet your requirements. In the following, we will reply to and explain the language comments one by one to clarify our intended meaning. Please see the specific responses below for more details.

2. Specific comments

***Comment 1*:** Line 54, the sentence “in the early days, the susceptibility assessment of debris flows was mainly qualitative research” is not completely true.

Response: Thank you for your professional comments. We apologize for the misunderstanding caused by our expression. We would like to say that before 1970, the limitations of remote sensing and computer technology caused more studies to be expressed without a very precise quantification. Based on your comments and a review of the relevant literature, we think it is more appropriate to remove this ambiguous expression.

***Comment 2*:** Line 62, the sentence “Surely, they are also wasteful and unnecessary” has English problem

Response: Thank you for your professional comments. We apologize for the misunderstanding caused by our expression. We have reread this paragraph and consider it redundant and ambiguous. The sentence should be deleted.

***Comment 3*:** Line 62, what is 3S?

Response: Thank you for your professional comments. 3S is mean 3S technology, which is Remote sensing, Geography information systems, Global positioning systems. We apologize for the use of abbreviations without explanation.

***Comment 4*:** Line 66, the sentence "While due to the nonlinearity of debris flow system and the openness and complexity of geological environment, we realize that it is chaotic, with many factors affecting the system." need to be revised.

Response: Thank you for your professional comments. We reorganized the intention and made it clearer. It is revised below. "As research progresses, debris flows are increasingly seen as an open system. There are many factors influencing the system and the combination of factors is non-linear and the interactions are chaotic."

***Comment 5*:** Line 73-76, the sentence "According to the summary above, the primary object of my present study is to explore a geographic information system (GIS)-based quantitative model based on expert experience and field investigation. And the model is consistent with the system characteristics of debris flow gully and can also indicate the characteristics of disaster chain and that the geomorphic evolution of basin rather than simple data fitting(Porwal et al. 2006)." has English problem, it is not clear and correct.

Response: Thank you for your professional comments. We apologize for any confusion caused by the lack of English expression skills. We have rewritten the sentence below. "The main objective of this paper is to propose a quantitative geographic information system (GIS)-based model. The results of expert experience scoring and site surveys are used as guidance and reference in the modelling process. We have tried to apply methods that can indicate the non-linearity of the debris flow system. Finally, the modelling process should respect the laws of geomorphological evolution and the geological basis. Otherwise, the result will tend to be simply data fitting (Porwal et al. 2006)."

***Comment 6*:** Line 79, terrain should be replaced by elevation

Response: Thank you for your professional comments. We have replaced the word.

***Comment 7*:** Line 84, the sentence "political factors must be taken into account" is not clear

Response: Thank you for your professional comments. Different administrative regions often have

different financial incomes. The situation will lead to different standards and economic investments in the prevention and treatment of geological hazards. Therefore, different decisions will be made for hazards of the same level. This is what we mean by "political factors".

***Comment 8*:** Line 87, explain the meaning of the sentence “precision of the base map and the size of the study area”.

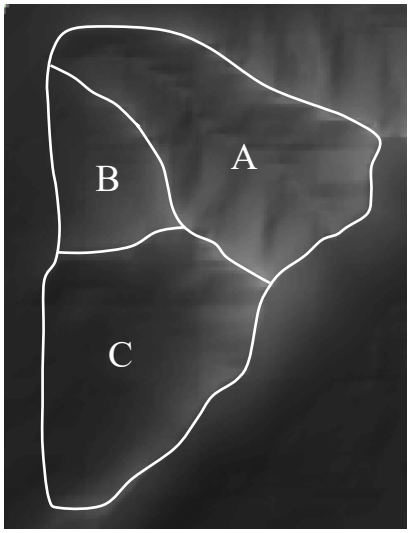
Response: Thank you for your professional comments. Base map mainly refers to geological map and digital elevation map (DEM) in this paper. The geological map is 1: 50 000 and the accuracy of dem is 30 m. We think the above precision is suitable for the study area. In other words, it is not appropriate to use the above-mentioned precision map to study global scales.

***Comment 9*:** Line 91, the sentence “drainage basins unit”, explain what they area

Response: Thank you for your professional comments. The“drainage basins unit” are showed in Fig.4 line 128.

***Comment 10*:** Line 95, explain the sentence “obvious watershed characteristics”

Response: Thank you for your professional comments. In our research, typical valley debris flows are the major research object. Therefore, as shown in the figure below, A has typical watershed characteristics, but B and C do not. There is another advantage of determining the length of the main ditch in the watershed parameter characteristics. For watersheds without obvious watershed characteristics, it is difficult to determine their length from the picture. Similarly, the calculation of drainage density is very difficult.



***Comment 11*:** Line 98-99, the sentence "it is scientific to make full use of qualitative understanding to determine the weight of the parameters of watershed characteristics factors" is not clear.

Response: Thank you for your professional comments. We have reorganized our language: field inspection is generally required in geological hazard surveys. If the data from the field inspection is applied to the model, it can help the model building and reduce the time for model training. The weights derived from the grey relational analysis method used in the following section (in section 3.4.1) are based on the data from the field inspection.

***Comment 12*:** Line 102, explain better the workflow

Response: Thank you for your professional comments. First, a DEM map of the Pinggu area was downloaded. Then, the basin units are then generated from the DEM map using the ArcHydro tool. The derived results were analyzed and units that did not fit the characteristics of the watershed were removed. During the analysis, the field survey data and Google images were referenced. After that, the controlling and triggering factors for the remaining 135 catchments were counted. For the fuzzy memberships, watershed characteristic parameters were determined by grey correlation and the geological and geomorphological factors were determined by the frequency ratio (FR) method and the cosine amplitude method. Finally, the individual layers were overlayed by fuzzy logic operations to obtain the final assessment map. As there were different combinations of factors, 17 results were derived. In order to compare advantages and disadvantages of these results, three indexes, AUC, AR and RR, were used to evaluate the models.

***Comment 13*:** Line 104-105, this is also a local property

Response: Thank you for your professional comments. This statement was made to emphasize the importance of micro-landscapes in the evaluation, which is why we included the parameter roughness in the model.

***Comment 14*:** Line 107-109, the sentence "Finally, the model should also need to integrate the system characteristics of debris flow disaster, the future development trend of climate change, and the social demand under the theoretical background of the new era to carry out reasonable modeling" has English problem

Response: Thank you for your professional comments. The sentence has been revised. "Finally, the model is expected to reflect the system characteristics, the trend of climate change, and the social demand."

***Comment 15*:** Line 111, The workflow should be explained.

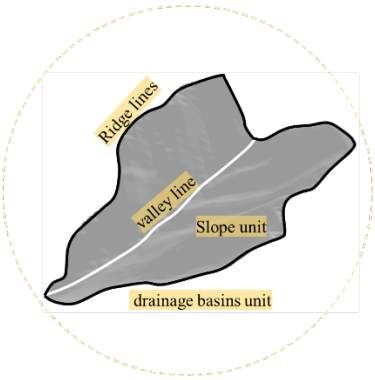
Response: Thank you for your professional comments. I have replied to this comment. Please refer to ***Comment 13*** above for details.

***Comment 16*:** Line 112, explain better how did you completed the debris flows inventory

Response: Thank you for your professional comments. All the cataloguing process is carried out on the ArcGIS software. The specific process is divided into the following steps: (1) Filling the initial digital elevation model to eliminate the common errors caused by the resolution and rounding of the data. (2) Encoding the outflow direction of each pixel in the grid based on an 8-direction algorithm. (3) Calculating accumulated flow as the accumulated weight of all cells flowing into each downslope cell in the output raster. (4) Applying a threshold to the results obtained by the flow accumulation tool based on a condition function and describing the drainage network of the study area. (5) Extracting the basic drainage basins unit of the study area, that is, the basic unit for susceptibility assessment. The fourth of five steps, threshold determination is a factor of subjective human choice, and my current research involves how to choose this parameter objectively.

***Comment 17*:** Line 119, what is difference with the slope unit.

Response: Thank you for your professional comments. In general, the main difference is the way in which they are defined. A slope unit is a basic closed unit enclosed by a ridge and valley line. Basin units, on the other hand, often consist of at least two slope units. This is shown in the figure below.



***Comment 18*:** Line 120, the phrase “irregular areas”. What do you mean? It is not clear why you have selected only 135 basins.

Response: Thank you for your professional comments. irregular areas refers to areas which are not basin units automatically generated by using ArcHydro tool, such as slope unit in ***Comment 18.*** We admit that there is a certain subjective component (extent depending on the accuracy of the DEM), but it is proven to be an attempt to improve the accuracy of the model. When deleted and

merged, there are 135 basins left.

***Comment 19*:** Line 133, facros should be replaced by factors.

Response: Thank you for your professional comments. We have replaced the wrong word.

***Comment 20*:** Line 135, the phrase "in this paper" should be deleted.

Response: Thank you for your professional comments. It has been deleted.

***Comment 21*:** Line 138, the sentence "is bounded by the watershed". What do you mean?

Response: Thank you for your professional comments. The statistics for these factors are based on the watershed as a basic unit and the parameters change as the delineated watershed changes. Geological factors, however, are not bound by geological boundary lines. For example, the same stratigraphic lithology can span several watersheds.

***Comment 22*:** Line 143-144, we indirectly consider the influence of natural loose material source by evaluating geological conditions, but cannot consider the impact of human activities. It is not clear what is the relationship between the two factors

Response: Thank you for your professional comments. The sources of debris flow in the study area include both naturally occurring and anthropogenic sources (road construction, mining). Natural sources can be evaluated indirectly by relevant factors (geological and geomorphological conditions), but the intensity of anthropogenic sources cannot be predicted. Moreover, the thickness cannot be clearly counted on remote sensing images. Therefore, the evaluation factor can indirectly consider the influence of natural loose material source, but not human-generated loose source (slag, gravel soil, etc.)

***Comment 23*:** Line 149 in Table 1, the phrase "derived from DEM". Automatically?

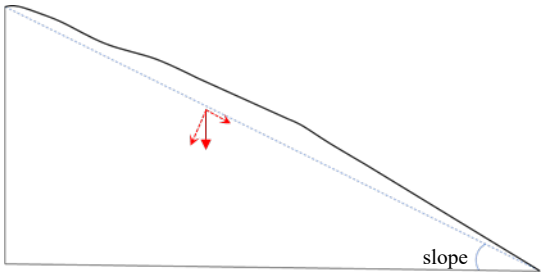
Response: Thank you for your professional comments. It is not derived automatically. Firstly, we first determine the scope of the basin according to DEM. When the scope is determined, it can be directly in ArcGIS 10 2 calculate and count the projected area value of each watershed. The rest of the factors are the same steps

***Comment 24*:** Line 149 in Table 1, the word "numerical" should be deleted.

Response: Thank you for your professional comments. It has been deleted.

***Comment 25*:** Line 149 in Table 1, the sentence "higher frequency of slope failures" is not always true.

Response: Thank you for your professional comments. We understand what you arguement, that this is not a linear increase. what we are describing is that all other conditions are constant and only this one variable is present. In terms of mechanics , the greater the slope, the greater the downward component of gravity, and the more likely it is to slide. We will try other expressions to prevent this ambiguity.



***Comment 26*:** Line 156, "curve length" is not clear. Why curve?

Response: Thank you for your professional comments. This is a mathematical concept. As shown in Fig. 5, relative to the linear connection between two points (A_7), the connection line is called curve line in this paper. And its length is called curve length.

***Comment 27*:** Line 159-161, the sentence "Fuzzy set theory proposed by Zadeh (1965) is a effective method to express the concept of partial set membership degree. This concept is different from the classical binary (two-valued) logic by using fuzzy descriptions such as low, moderate, high, steep, favourable and close to (Kritikos and Davies 2015)." Should be rephrased.

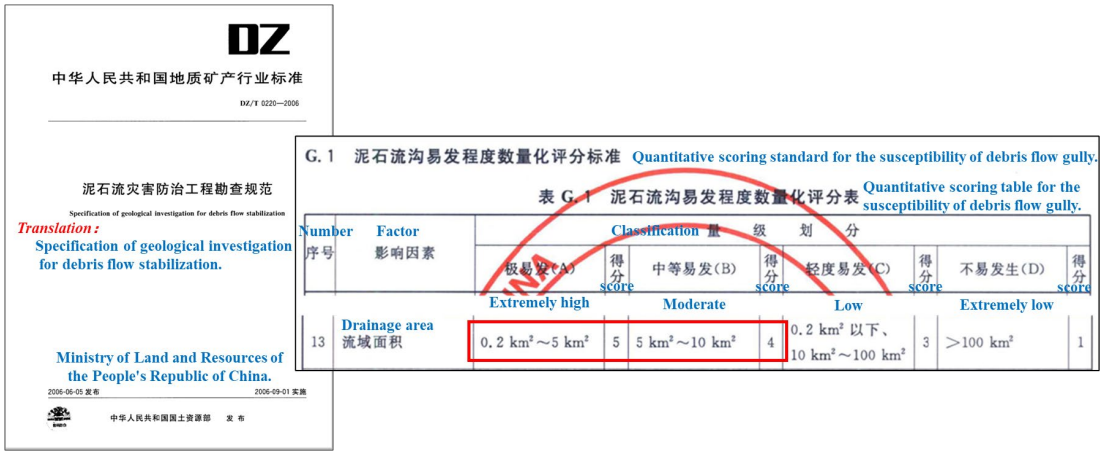
Response: Thank you for your professional comments. The sentence has been rephased. "Fuzzy set theory is proposed by Zadeh (1965). It is an efficient way of expressing the concept of partial set membership degree. This concept differs from classical binary(0-1 value) logic. More words with a transitional fuzzy descriptions (such as low, medium, and high) are used (Kritikos and Davies 2015). This fuzzy expression is particularly applicable to geological hazard classification."

***Comment 28*:** Line 191 in table 2, why only same basins are shown in the table.

Response: Thank you for your professional comments. "gully" represents "the name of the gully", "score" represents "the score of the gully". We have modified the format to remove the ambiguity.

***Comment 29*:** Line 191 in table 2, where this score comes from?

Response: Thank you for your professional comments. According to the "Specifications for Geological Investigation of Debris Flows Stabilization (DZ/T0220-2006) (2006)" published by the China Ministry of Lands and Resources. It is an industry standard that we need to follow for field surveys. Likewise, if in another country, people could use their local standards. This is also the flexibility of the model


DZ

中华人民共和国地质矿产行业标准

DZ/T 0220—2006

泥石流灾害防治工程勘查规范

Specification of geological investigation for debris flow stabilization

Translation:

Specification of geological investigation for debris flow stabilization.

Ministry of Land and Resources of the People's Republic of China.

2006-06-05 发布 2006-09-01 实施

中华人民共和国国土资源部 发布

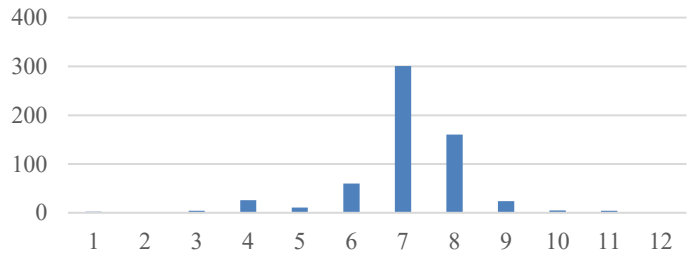
G. 1 泥石流沟易发程度数量化评分标准 Quantitative scoring standard for the susceptibility of debris flow gully.

表 G. 1 泥石流沟易发程度数量化评分表 Quantitative scoring table for the susceptibility of debris flow gully.

Number 序号	Factor 影响因素	Classification 量级划分							
		极易发(A) Extremely high	得分 score	中等易发(B) Moderate	得分 score	轻度易发(C) Low	得分 score	不易发生(D) Extremely low	得分 score
13	Drainage area 流域面积	0.2 km²～5 km²	5	5 km²～10 km²	4	0.2 km² 以下、10 km²～100 km²	3	>100 km²	1

***Comment 30*:** Line 196-197, the sentence "it can be seen from the results that the occurrence of debris flow is highly correlated with basin volume, basin area and main gully bending coefficient with fuzzy membership above 0.7 in Beijing area." How do you explain this behaviour.

Response: Thank you for your professional comments. This is a regional attribute and regular characteristics of debris flow development in the study area. Debris flows occur mostly during the rainy season (June to August). Moreover, the study area is characterized by short duration heavy rainfall and the distribution of rainfall is not significantly different across the study area. The source of the loose material therefore becomes the dominant factor. And the three factors mentioned above are highly correlated with total physical sources. Both basin area and basin volume determine the upper limit of the maximum source, while the bending factor directly influences the replenishment of loose sources along the debris flow ditch.



Monthly rainfall in Pinggu district, Beijing, 2018

***Comment 31*:** Line 197-202, the English expressions "In the case of sufficient rainfall, the basin directly determines the total amount of catchment, and the bending coefficient reflects the replenishment of the source along the river. The basin volume is closely related to the number of supplementary sources. Therefore, it is necessary to do well in rainfall monitoring and early warning in large watersheds, check for loose matter accumulation in river basins before rainy season, and pay attention to slope protection of basin with large volume potential energy for the purpose of disaster prevention and reduction" should be revised.

Response: Thank you for your professional comments. The sentence has been revised. "Rainfall in the study area is abundant to induce the debris flow. Loose source and sinks the total volume of catchment become more important. The watershed area determines the total volume of catchment. For the same rainfall, generally, the larger the area, the larger the catchment is. The bending coefficient reflects the replenishment sources along the channel. The greater the coefficient, the slower the flow is. Then loose source along the channel has more time to replenish. Basin volume characterizes the maximum amount of loose material that can be supplied. These three features reflect the development characteristics of debris flow in the study area. It also provides ideas for disaster prevention and mitigation.

***Comment 32*:** Line 204, the expression "landslide is one of the main fixed sources of debris flow" is not clear.

Response: Thank you for your professional comments. Excluding human activities, such as mining, construction, etc., loose material produced by natural geological processes is the primary source of debris flow formation. Great debris flows may result from numerous, small slope failures that subsequently coalesce (Fairchild 1987; Roeloffs 1996), from flow enlargement due to incorporation of bed and bank debris (Bovis and Dagg 1992; Pierson et al. 1990), or from large, individual landslides that mobilize partially or almost totally (Iverson et al. 1997; Vallance and Scott 1997). Debris flows may also scour steep channels to bedrock and accelerate sediment delivery to downstream, lower-gradient channels. The spatial and temporal distribution of shallow landslides are important controls on landscape evolution and a major component of both natural and management-related disturbance regimes in mountain drainage basins (Benda 1987; Crozier et al. 1990; Dietrich et al. 1986; Tsukamoto et al. 1982).

Cited Reference:

Fairchild LH (1987) The importance of lahar initiation processes Reviews in Engineering Geology 7:51-62 doi:10.1130/REG7-p51

Roeloffs E (1996) Poroelastic techniques in the study of earthquake-related hydrologic phenomena 38:135-195 doi:10.1016/S0065-2687(08)60270-8

Bovis M, Dagg B (1992) Debris flow triggering by impulsive loading - mechanical modeling and case-studies Canadian Geotechnical Journal 29:345-352 doi:10.1139/t

Iverson RM (1997) The physics of debris flows Reviews of Geophysics 35:245-296. doi:10.1029/97RG00426

Vallance JW, Scott KM (1997) The Osceola mudflow from mount rainier: Sedimentology and hazard implications of a huge clay-rich debris flow Geological Society of America Bulletin 109:143-163 doi:10.1130/0016-7606(1997)109<0143:TOMFMR>2.3.CO;2

Pierson TC, Janda RJ, Thouret J-C, Borrero CA (1990) Perturbation and melting of snow and ice by the 13 November 1985 eruption of Nevado del Ruiz, Colombia, and consequent mobilization, flow and deposition of lahars Journal of Volcanology and Geothermal Research 41:17-66 doi:10.1016/0377-0273(90)90082-q

Thank you for your professional comments. We apologize for the bad reading experience caused by our poor English. We also hope that language issues will not become a barrier to scientific communication and that you will Reconsidering our research beyond the language issue. We will try our best to improve the manuscript and make changes in the manuscript. We appreciate for Editors/Reviewer's warm work earnestly, and hope that the revision will meet with approval. Once again, thank you very much for your comments and suggestions! Please feel free to contact me, if any further changes are required. We look forward to hearing from you.

Yours sincerely,

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