

Reply for review comments
Reviewer 1 (Professor Roy C. Sidle)

We sincerely thank you for the efforts you have made to improve our submission to *Natural Hazards and Earth System Sciences*. We have responded to all review comments and have made appropriate modifications to our manuscript related to these comments as detailed in the following paragraphs. The blue-highlighted sentences are the review comments; sentences in black represent our responses to these review comments.

1) L54 ‘...ratio to outside of the valley.’

We have removed “the” (L.58).

2) L77-79 This sentence needs to be improved.

We have revised as the following sentence (L.92-94).

“Furthermore, considering the morphological conditions of the drainage basin forming debris flow fans as the conditions generating debris flows, the risk of debris flow occurrence can be evaluated even in basins where debris flow fans are disappeared owing to the effects of erosion by mainstream rivers and artificial land formation.”

3) L.117 & 119 (and other places) use the term ‘rock’ in these cases, not rocks.

We have replaced “rocks” to “rock”.

4) L124 between the two sites

We have added the “between” after “different” (L.143).

5) Paragraph beginning on L145 state when the field surveys were conducted

We have rewritten the sentence (L.309-310). Additionally, “Paleogene accretionary prism” was replaced to “Paleogene accretionary complex”, which express the geology in study site more accurately. Strictly speaking, this Paleogene accretionary complex is the trench-fill turbidites. Therefore, we explained it in the parentheses (L.96-97).

6) L212 (and other places) it seems like here, and maybe in some other places, you are confusing alluvial fans with debris fans. Many people do this, but it is my sense that fan formation dominated by debris flows should be called debris fans (or debris flow fans) and those dominated by water flooding should be called alluvial fans. I know these terminologies have been extensively discussed and debated by geomorphologists and I do not wish to add to that debate which has largely been confusing, but it

seems to me that when alluvial processes (floods) dominate fan development the fan should logically be called an alluvial fan and when debris flow processes dominate the fan should be called a debris fan. Of course, there is some continuum between these two dominating processes, but I think fans can be characterized by some of the defining characteristics – e.g., for debris fans, steep gradients, poorly sorted materials and for alluvial fans, gentler gradients and more well-sorted materials in the fan. I don't think the authors need to go into any detailed explanation of this, but they just need to use consistent and appropriate terminology.

In this study, we have focused on fans formed by debris flows.

Therefore, we decided not to use the term alluvial fan.

We have replaced “Alluvial fan” to “Fan”.

7) L221-223 Can you provide any insights into why these fans were wrongly identified?

These fans were wrongly identified because fluvial processes partially eroded the debris flow fans.

We have revised as the following sentence (L. 394-395).

“Field surveys in these four basins revealed that fluvial processes from the main river partially eroded the debris flow fans.”

8) L251 You say ‘only a few gravels’, this would better read “only a little gravel”; but did you not find coarser materials (e.g., boulders) on the surface?

We have replaced “only a few gravels” to “only a little gravel” (L.423).

We confirmed that there were cobble gravels on the surface of debris flow fans.

9) L258 gravel instead of granules?

We have replaced “granules” to “gravels” (L.432).

10) L323 You could also cite some of Lee Benda's early research here.

We have added the Benda and Cundy (1990) in the sentence (L.509).

Additionally, we also added it in the list of reference.

11) L359 again, maybe you mean ‘debris fans’?

Saito (1998) was defined it as fans.

We have revised as the following sentence (L.548-549).

“Saito (1998) also pointed out that the relief ratio is the most important morphological factor affecting the presence or absence of fans.”

12) L370 Here and in at least one other place, try to avoid using one-sentence paragraphs.

We have revised it.

13) **Conclusions:** It might be worth mentioning in which cases it would be most desirable to conduct some field checking of debris fan conditions.

We have inserted the following sentence after “sites” (L.627).

“Debris flow fans and the boundaries of drainage basins at the study sites were extracted using topographic maps and DEMs. Field surveys were conducted to validate the extraction of debris flow fans from topographic maps and to check current activity of the debris flow in selected basins. After calculating the morphological parameters in each basin, a decision tree analysis was performed using the presence or absence of debris flow fans as the objective variable and the morphological variables of the drainage basin as the explanatory variables.”

Reply for review comments
Reviewer 2 (Assistant Professor Takashi Kimura)

We sincerely thank you for the efforts you have made to improve our submission to *Natural Hazards and Earth System Sciences*. We have responded to all review comments and have made appropriate modifications to our manuscript related to these comments as detailed in the following paragraphs. The blue-highlighted sentences are the review comments; sentences in black represent our responses to these review comments.

1) The title refers to rock strength, yet the authors did not directly measure the strength of the base rocks at their study sites; they provided only supporting evidence of difference in rock strength. I recommend modifying the title to reflect geological differences rather than rock strength differences. After submitting this paper, we measured the rock strength in the research areas using a Schmidt rock hammer. We have added the rock strength results of the research areas in the study site chapter (L.121-122). Additionally, we also organized it in table 1. Therefore, we have kept the title as it is.

2) 1. 60-61 “distinguishing between debris flows and debris floods” might be more precisely described as “distinguishing between debris flow deposits and debris flood deposits.”

We have replaced “distinguishing between debris flows and debris floods” to “distinguishing between debris flow deposits and debris flood deposits” (L.64-65).

3) 1.63 “discriminant function” might be more accurately described as “discriminant analysis,” since discriminant function is used in discriminant analysis.

We have replaced “discriminant function” to “discriminant analysis” (L.67).

4) 1. 82-83 “geological sedimentary processes” might be more accurately described as “(rock) formation processes.”

We have replaced “geological sedimentary processes” to “rock formation processes” (L.97-98).

5) “many debris flow fans have been formed” might be better stated as “many debris flow fans remain.”

We have replaced “many debris flow fans have been formed” to “many debris flow fans remain” (L.100).

6) The authors used “ha” here but “m²” elsewhere. Consistency in units for the same quantity is recommended.

We have used m² consistently.

We have replaced “ha” to “m²” (L.129, L.131).

7) l. 125-126 The authors did not describe the geological and geomorphological features related to landform development during the Quaternary period except for uplift rates. However, understanding the Quaternary landform development of the valley-fill plains, where debris fan distribution was investigated, is crucial. Are the valley-fill plains in this study composed of Holocene strata? Are there any (old) debris fans formed on Pleistocene terraces away from the present riverbeds? Introducing the Quaternary geology and geomorphology characteristics of your study sites is important for understanding the relationship between current sediment productivity and debris fan development, and consequently, the sediment transport process within the basin and the debris-flow hazard risk at the basin outlet.

We have inserted the following sentence in Line 145.

“Most of the debris flow fans have been formed on valley plains or Holocene terraces in the studied area. In other words, the target debris flow fans have been constructed during the Holocene with warm and wet climates similar to the current conditions.”

8) l. 139 “extracted” could be replaced with “delineated.”

We have replaced “extracted” to “delineated” (L.303).

9) l. 139 “using topographic maps and DEMs” might be more specific as “using published topographic maps and digital elevation models (DEMs).”

We have replaced “using topographic maps and DEMs” to “using published topographic maps and digital elevation models (DEMs)” (L.303-304).

10) l. 147 “such as grain size, timing of debris flows, and morphology of debris flow fans” might be more accurately described as “such as grain size distribution, debris flow history, and morphology of fan deposits.”

We have replaced “such as grain size, timing of debris flows, and morphology of debris flow fans” to “such as grain size distribution, debris flow history, and morphology of fan deposits” (L.311-312).

11) l. 216-217 This part is unclear. Pebble represents the 4-64 mm class, but a grain size of 24 cm falls into the Cobble class.

This is a mistake in the Cobble class. We have revised it to the Cobble class (L.386).

Furthermore, Line 431 was also classified as a pebble even though its particle size was 14 cm. We have also revised it to the Cobble class.

12) I. 218 “which continue to be a source of sediment” might be better as “which continue to produce (or generate) sediments.”

We have replaced “which continue to be a source of sediment” to “which continue to produce sediments” (L.387).

13) I. 223 Specify “fluvial processes” as either those of the main river or those of the tributaries.

Part of the debris flow fans had disappeared due to erosion from the main river.

We have rewritten as following sentence (L. 394-395).

“Field surveys in these four basins revealed that fluvial processes from the main river partially eroded the debris flow fans.”

14) I. 260 “topographic map analysis” could be more accurately described as “topographic map interpretation.”

We have replaced “topographic map analysis” to “topographic map interpretation” (L.434).

15) I. 318-400 Consider discussing why certain morphological features did not contribute to the formation of debris fans in your study sites, despite their importance in previous studies. Adding discussion about features not selected as significant determinants in the decision tree analysis would be beneficial (though not a requirement for acceptance).

We have rewritten the following sentence in place of sentence in line 566.

“Basin area and basin relief, which characterize the entire basin, were not selected as factors determining the decision tree in both of geologic units. These morphological variables are affected by areas that does not directly contribute occurrences of debris flows. Consequently, regardless of the geology, the morphological factors that control sediment supply activities and the ratio of sediments reaching the valley mouth as debris flow are more important for the formation of debris flow fans than morphological features of the entire basin.”

16) I. 326 “still exists” might be better as “still remains.”

We have replaced “still exists” to “still remains” (L.512).

17) I. 331-332 “Jakob (2021) defined such basin as watershed supply-limited basins.” Is the term “watershed” necessary here?

We have removed “watershed” (L.518).

18) I. 332-333 “once a debris flow occurs because of a landslide” could be replaced with “once a landslide-initiated debris flow occurs.”

We have replaced “once a debris flow occurs because of a landslide” to “once a landslide-initiated debris flow occurs” (L.519).

19) l. 333 “are formed” could be “were formed” or simply “exist.”

We have replaced “are formed” to “exist” (L.519).

20) l. 335 “missing” might be better as “absence of.”

We have replaced “missing” to “absence of” (L.525).

21) l. 347 “the knick line” should be replaced with “the convex slope break.”

We have replaced “the knick line” to “the convex slope break” (L.537, L453).

22) l. 375 Specify “valley side” as “valley side slopes.”

We have replaced “valley side” to “valley side slopes” (L.574).

23) l. 376 “bed sediments” might be more accurate as “bed materials.”

We have replaced “bed sediments” to “bed materials” (L.575).

24) l. 379 “classified” might be better as “determine.”

We have replaced “classified” to “determine” (L.578).

25) l. 386-393 It’s unclear why the cited previous studies support the authors’ hypothesis. If the authors aim to argue this point, they need to explain which type of rock in which regions has lower strength and produces finer-grained sediments in the referenced studies, and vice versa.

We have inserted the following sentence after line 583 (Sed Group 4). In addition, we have measured the joint spacing of the outcrop in each area. We have added the value of joint spacing in results chapter as follows (L.387, L.432).

“In our field observations, the sediments (gravelly clasts) on the debris flow fan exhibited a maximum particle size of 14 cm at the Neogene sedimentary rock site. These clasts were sourced from weathered soft rocks with dense fractures spaced at intervals of 1-15 cm. In contrast, at the Paleogene accretionary complex site, which consisted of relatively hard rocks with sparsely developed joints spaced at 5-25 cm, the maximum particle size of the debris flow fan was 24 cm. This suggests that sediments from the Neogene region can be easily transported downstream even with low relief ratios. Previous studies reported that lower limits of relief ratio for forming debris flow fans varies depending on geology (Wilford et al., 2004; De Scally et al., 2010; Ilinca, 2021) “

Additionally, we have replaced the sentence “These results...” on line 589 with the following sentence.

“Our study implies that the difference in the threshold of relief ratio reflects the variations in rock strength and the resultant dominant gravel size among the studied sites.”

Wildford et al., 2004 was a mistake in Wilford et al., 2004. We have revised the relevant parts.

Finally, we have added a table that summarizing the results for each region.

26) 1. 391-393 Is the grain size at the former site (the Paleogene accretionary prism site) coarser than at the latter site (the Neogene sedimentary rock site)?

The grain size derived from the Paleogene accretionary prism is coarser than that from the Neogene sedimentary rocks. However, this sentence has been removed due to the revision mentioned above.

27) 1. 396 The authors use expressions like “terrains (basins) that have not experienced significant dissection” in several places. A more concise term like “poorly-dissected basins” could be used. Conversely, “well-dissected basins” can describe the opposite.

We have replaced “terrains (basins) that have not experienced significant dissection” to “poorly-dissected basins” (L.594).

28) 1. 412 “no formation” might be clearer as “absence.”

We have replaced “no formation” to “absence” (L.639).

29) 1. 417 “classified” might be better as “determine.”

We have replaced “classified” to “determine” (L.644).