Potential effect of agricultural terracces on landslide occurrence: the tropical mountains of Rwanda

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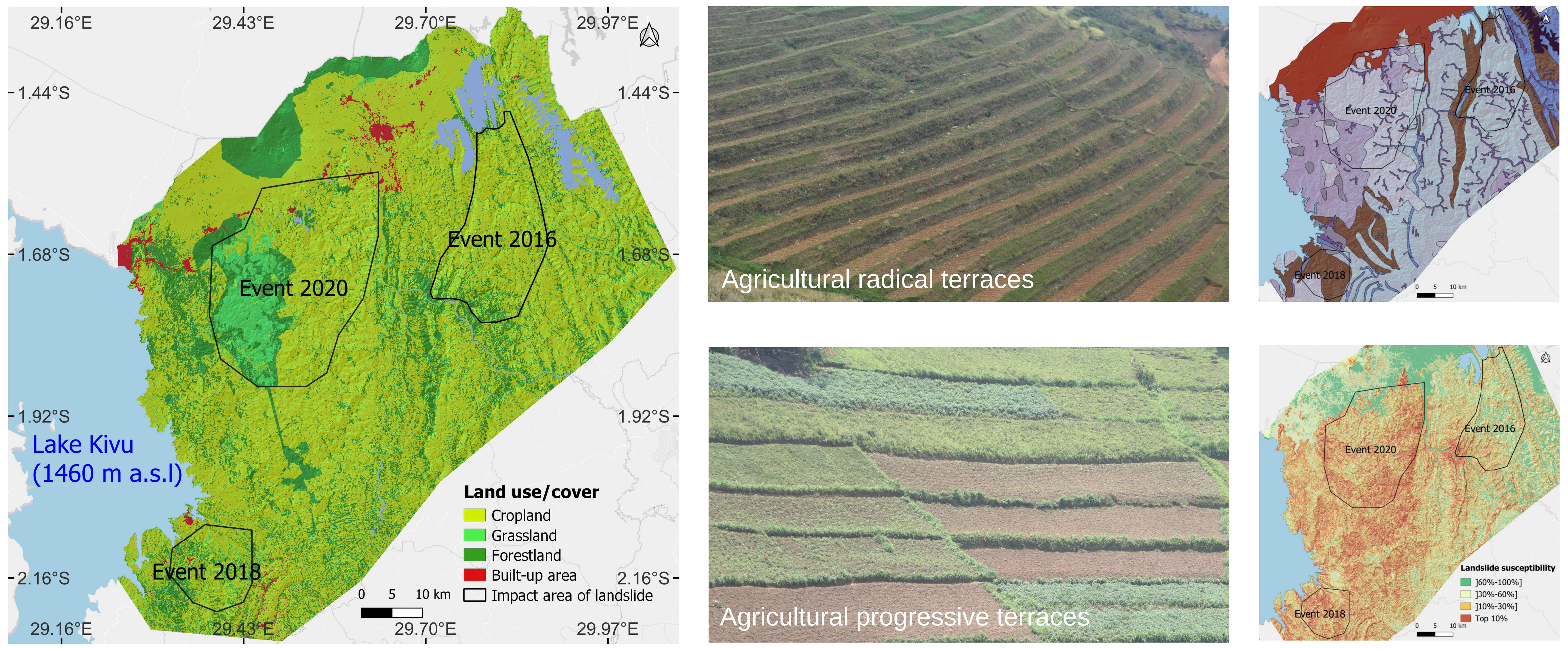
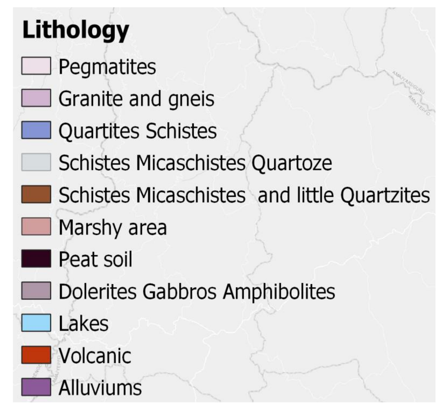
Context

- The tropical mountains of northern-western Rwanda are densely populated and the breadbasket of the country.
- This leads to intensive land use/management practices. Especially terraces are implemented at a large scale.
- However, the region is also landslide prone. The terrace systems on numerous hillslopes might have an impact on this.
- Nonetheless, the potential effect of terraces on landslides (LS) remains poorly understood.
- By documenting and analyzing three landslide events, we investigate:
  1) whether more landslides occur in terraces?
  2) whether landslides in terraces are larger or smaller?
  3) whether terraces lead to the same type of landslides?
  4) which factors potentially control the effect of terraces on landslides?

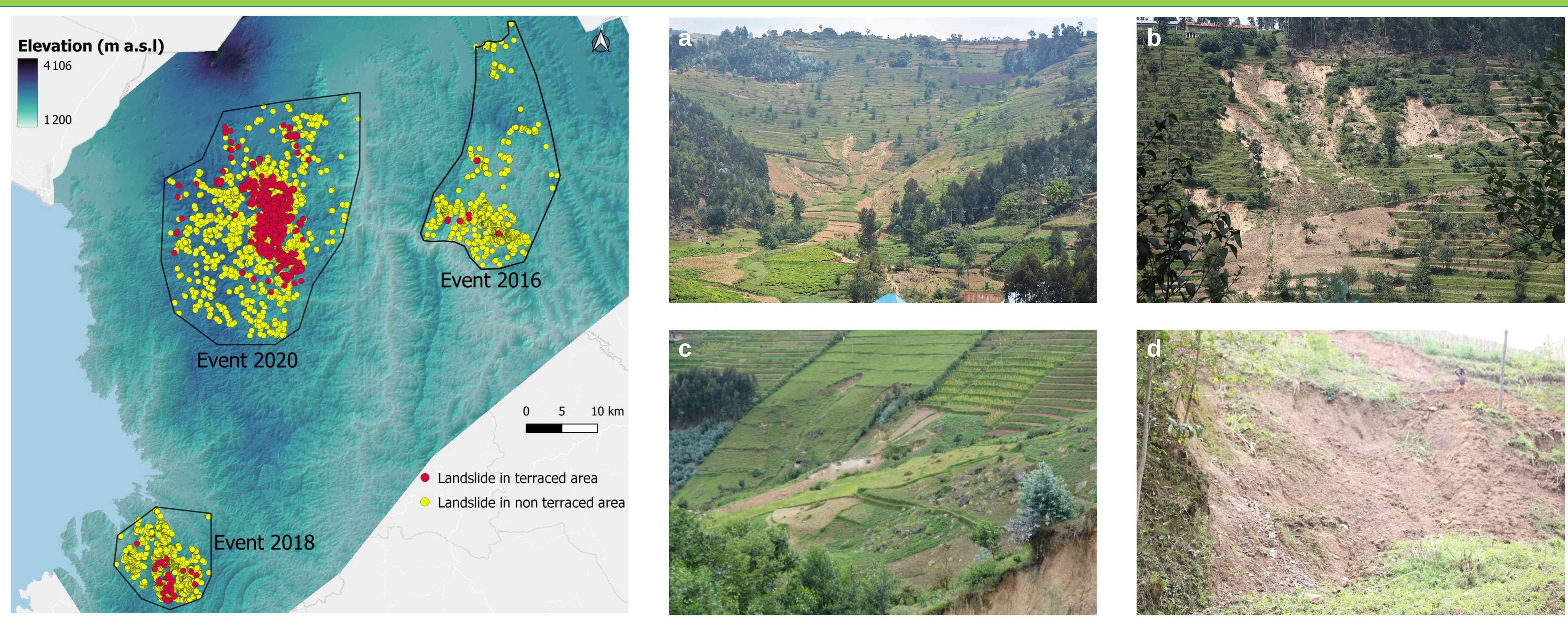




The population density in the study area (western and northern provinces) is around 700 inhabitants per km2.Around 80% of the population practices agricultural activities.

Fig. 1 Location of the three landslide events and environmental context.

Landslide inventories



- A total of **4687** mapped landslides of mostly of the avalanche and slide types.
- Event 2016:1039 LS
- Event 2018:1427 LS
- Event 2020: 2222 LS
- A total of 773 landslides occurred on terraced hillslopes that represent 8% of the total study area.

Fig. 2 Landslide spatial distribution and field examples of instability processes in (a,b) radical terraces, (c) progressive terraces, and (d) on a cultivated hillslope.

Role of terraces on landslide occurrence

Overall, landslide frequency is higher in terraces than in the non terraces (Fig. 3.a, b). Landslide frequency increases with slope and susceptibility.

The cumulative landslide areas are higher in terraces than in non-terraced hillslopes (e.g, for a slope angle of 25° - 30°, the odds ratio shows that landslide cumulative area is five times higher in terraces).

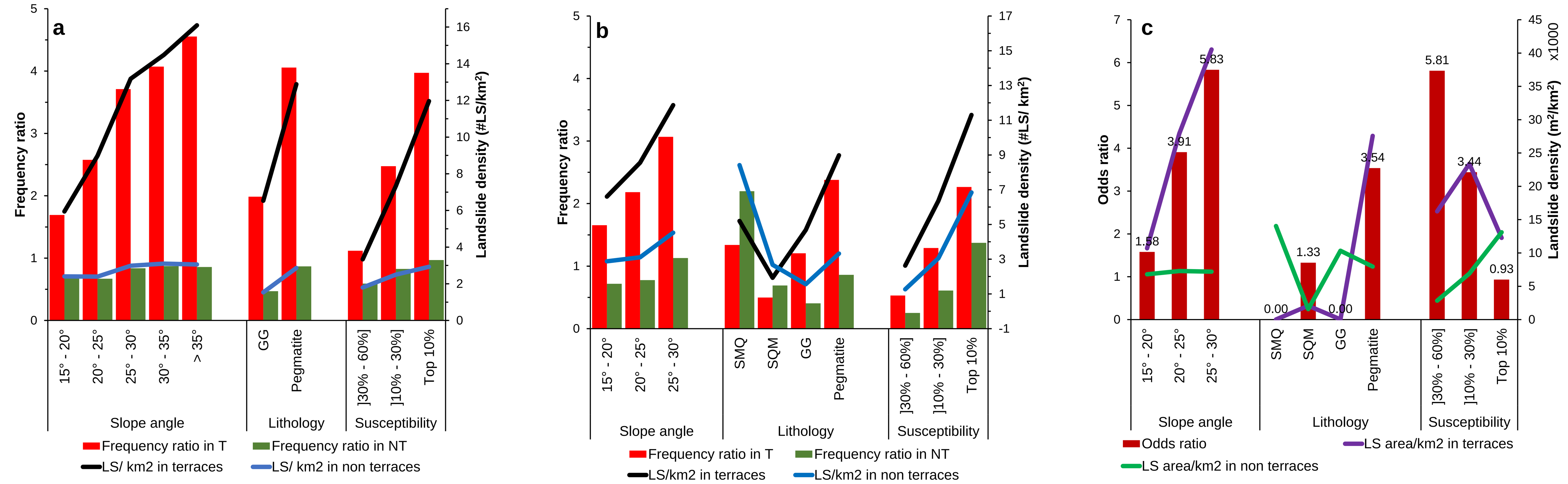
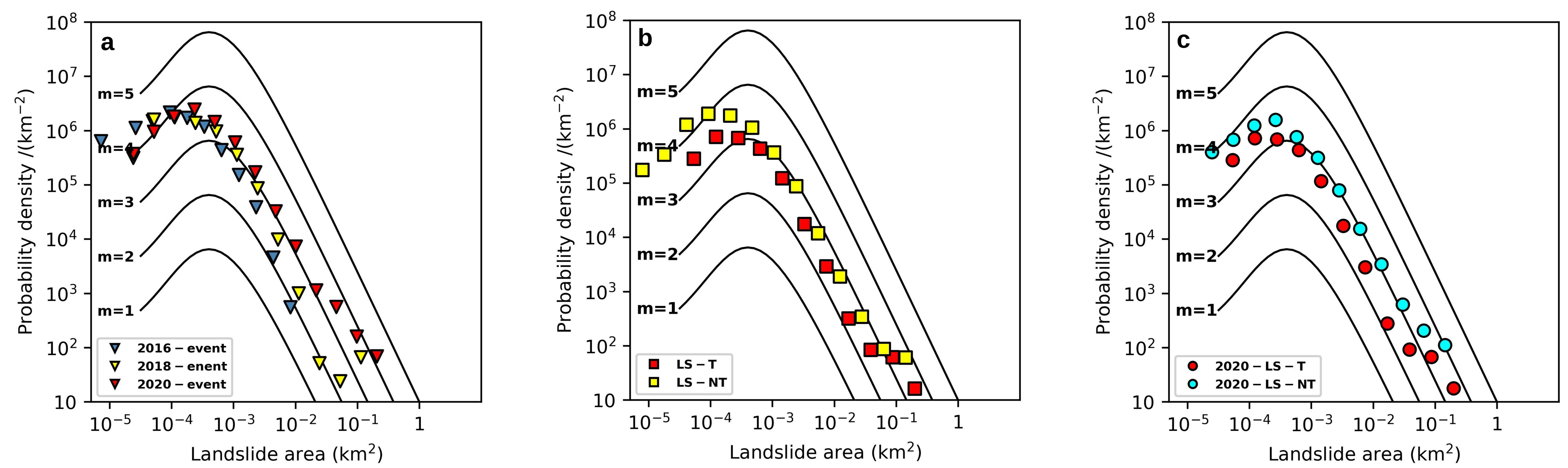


Fig. 3. Frequency ratio of landslide frequency for the 2020 event alone (a) and the three events together (b), respectively. Odds ratio between the cumulative areas of landslides that occurred in terraced hillslopes and in non terraced hillslopes (c).

SMQ: Schistes, Micaschiste, and Quartzites, SQM: Schistes, Quartz, and Micaschistes, GG: Granite and Gneiss

The probability area distribution shows that overall landslides in terraced hillslopes are smaller.



LS-T: landslide occurred in terraced hillslope

LS-NT: landslide occurred in non-terraced hillslope

Fig. 4: Probability area distribution a) for the set of three landslide events; b) landslides occurred in terraces and non-terraces for the set of three landslide events; c) the 2020 landslide event subdivided into terraced and non-terraced areas.

Conclusion

Overall, terraces increase the frequency of smaller landslides whose total impact in terms of cumulative areas is larger than the landslides in non terraces. Differences between landslide processes (slide, avalanche) as well as differences between terrace types could not be found. Therefore, more research is needed to analyze the mechanism leading to the higher landslide frequency on terraced hillslopes.

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