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Landslide and Flooding Hazard Mapping in the Drainage Basin of Lake Kivu, Western Rift of East Africa Using GIS Tools

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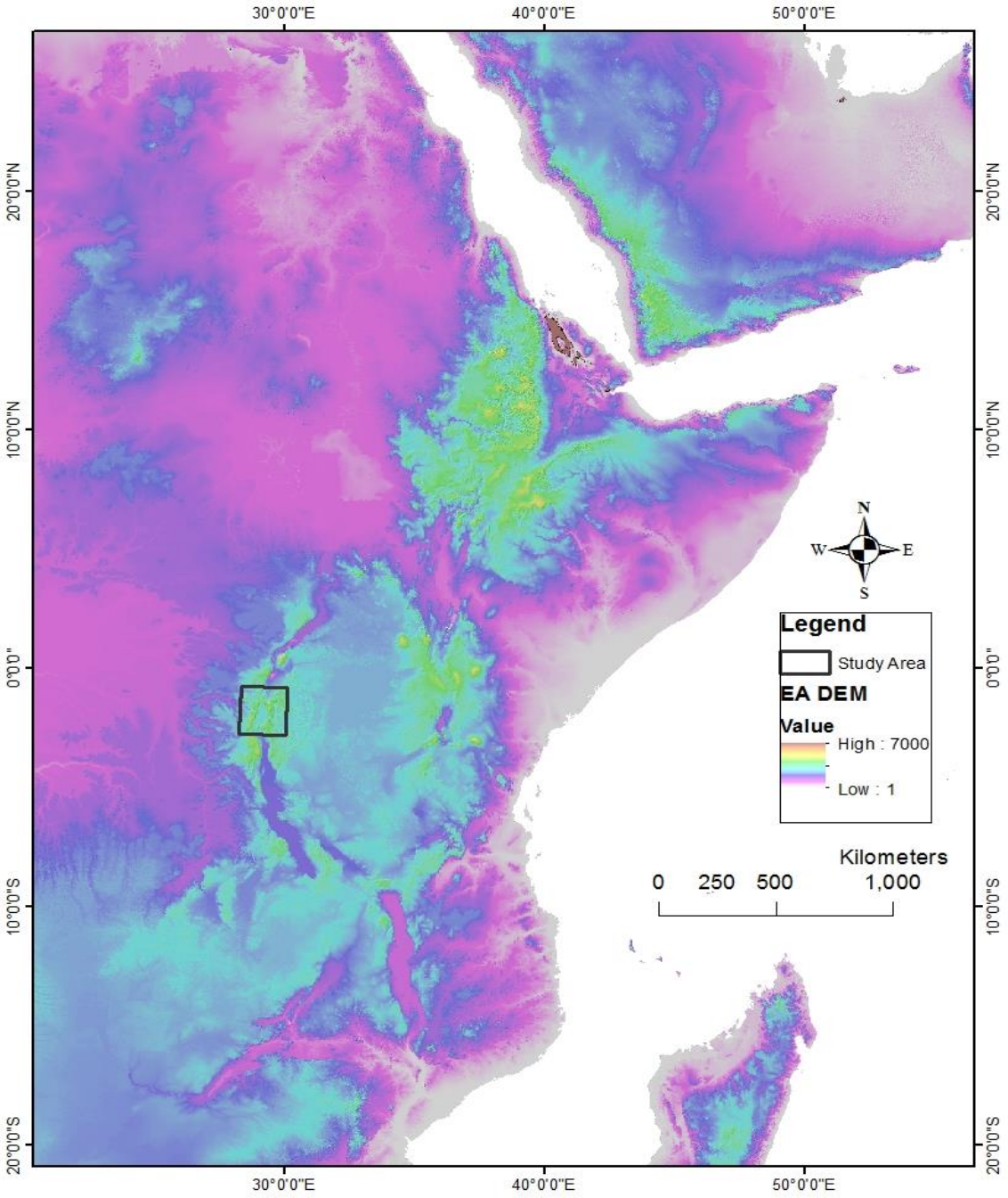
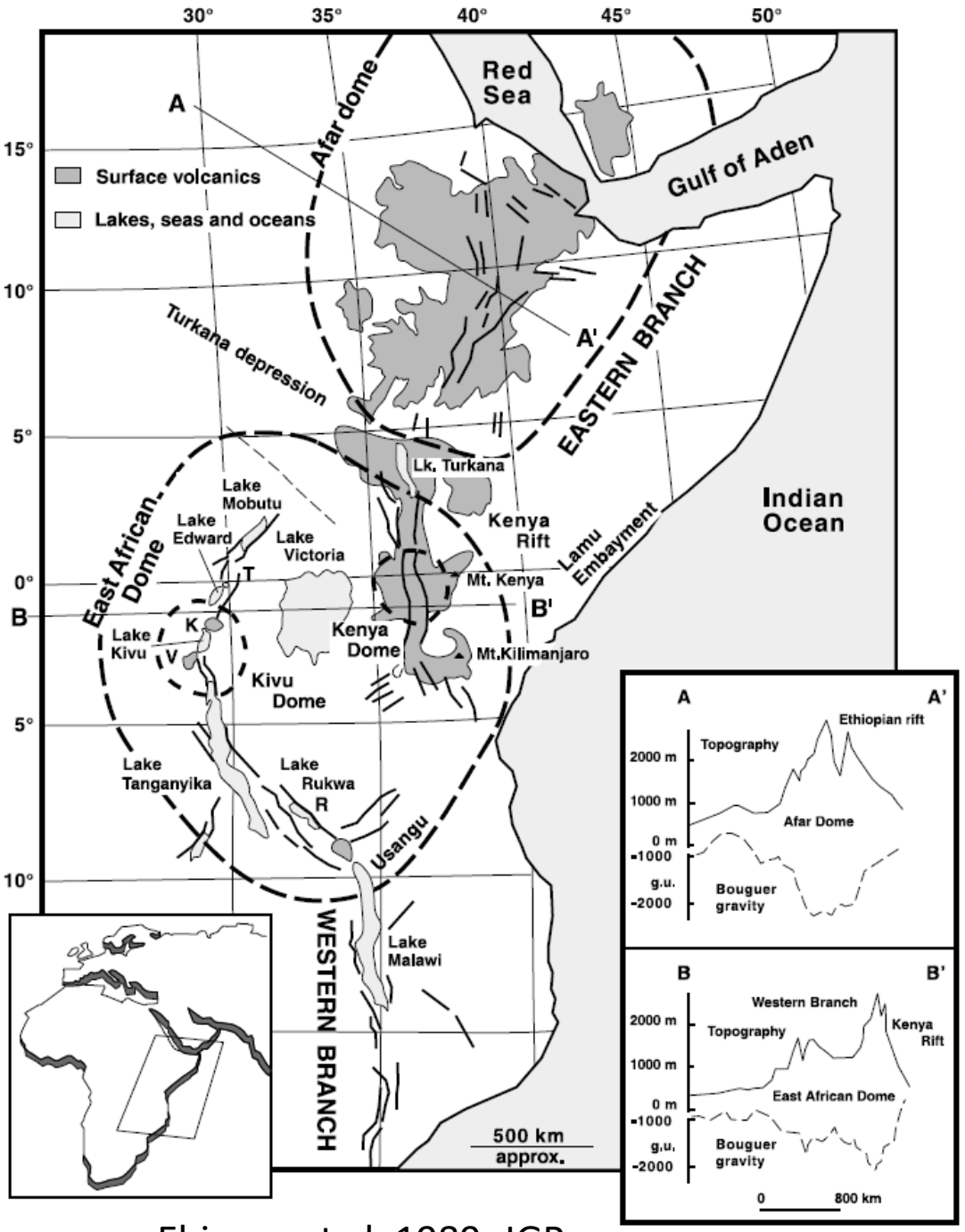
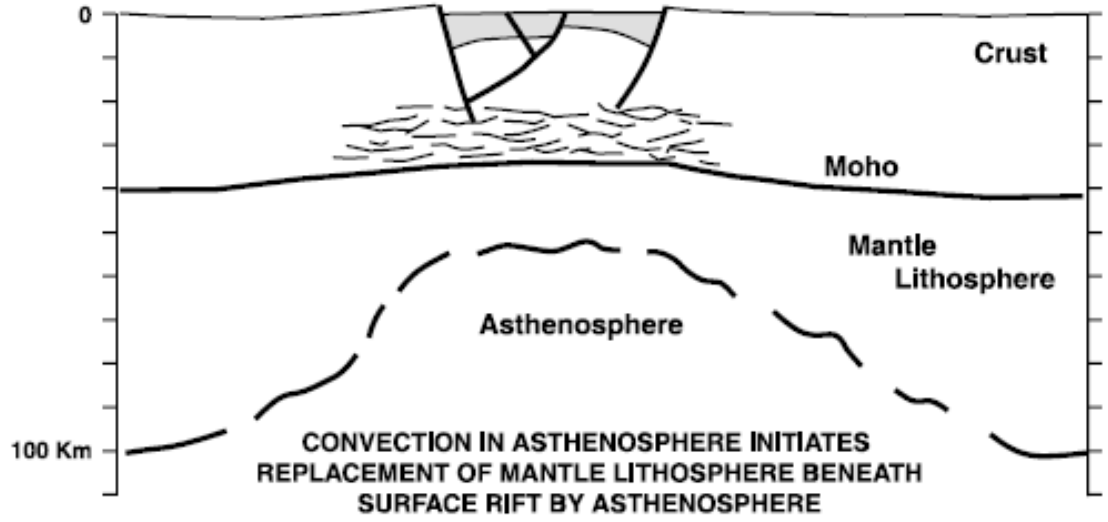
Regional and Local Setting

- East African topography dominated by rift relief.
- Presence of orogenic belts, and archaean/proterozoic cratons.
- Lake Kivu, bordering D.R. Congo and Rwanda.
- Deep Rift lake (max. 485 m).
- One of Africa's Great Lakes.
- Central part of the Western branch of the East African Rift System.
- Rwanda and Eastern D.R.C underlain by the Karagwe-Ankole and Kibara belts and rifting apart via Lake Kivu.
- Surface area of Lake Kivu = 2,728 km^2.
- Below 50-80 m of depth, 300 km^3 of CO_2 and 60 km^3 of CH_4 are dissolved. No seasonal mixing (Schmid et al., 2005, G^3).





Ebinger et al. 1989, JGR



Morley, 1994, Tectonophysics

- Kivu lithology dominated by metasedimentary rocks and volcanics.
- Drainage basin characteristics controlled primarily by tectonics (faulting and uplift) for rift lakes.
- Reversal of drainage often observed, as a result of shoulder uplift.
- Uplift comes with risks of landslide, and other mass flows.
- With climate fluctuations in tropical setting, flooding is another hazard.

Questions

- What is the drainage pattern in the watershed of Lake Kivu? How does topography influence it?
- How is landslide and associated flooding potentiality distributed across the drainage basin?

Data and Methods

- 1 arc second DEM tiles of the area – courtesy USGS 2018.
- GIS analysis in ArcGIS 10.6 (ArcMap):

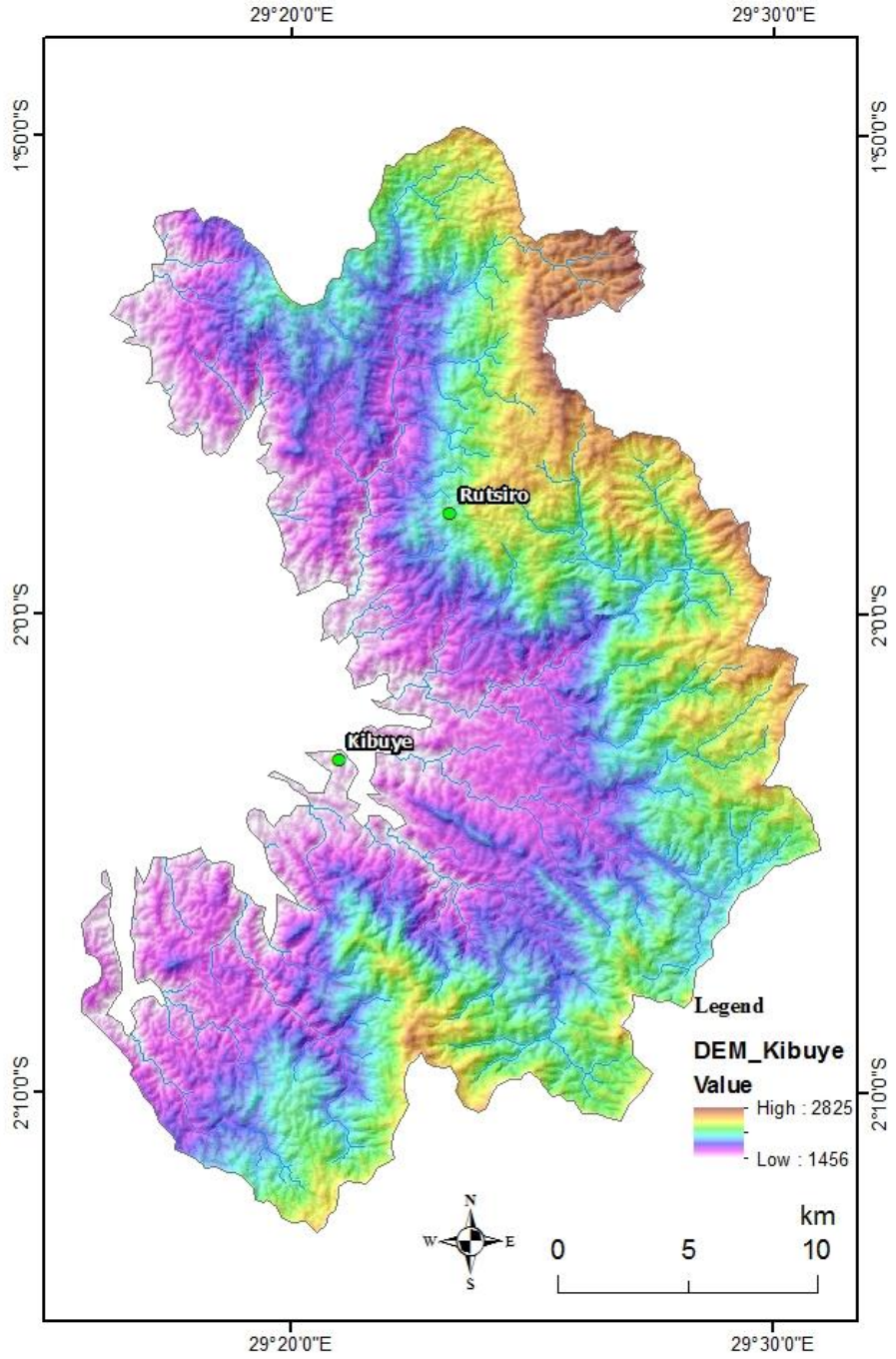
✓ 1. Mapping out the drainage divide.

✓ 2. Generating the stream network digitally.

✓ 3. Computing a slope map.

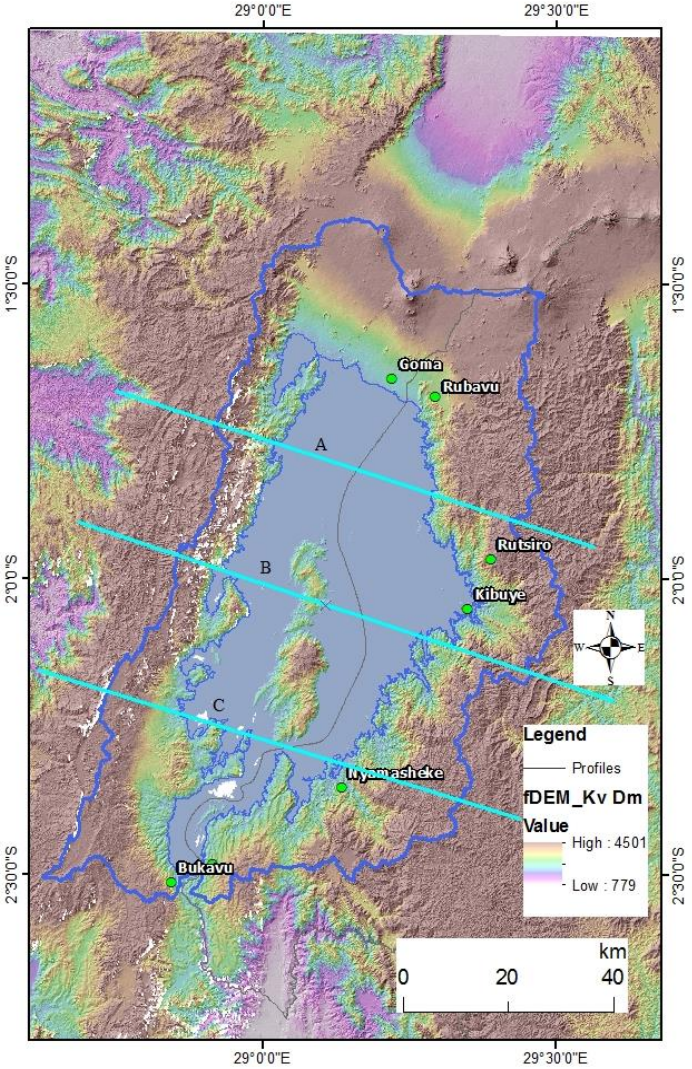
✓ 4. Computing landslide potentiality based on slope and elevation alone (other factors influencing the actual potentiality distribution).

✓ 5. Integration.

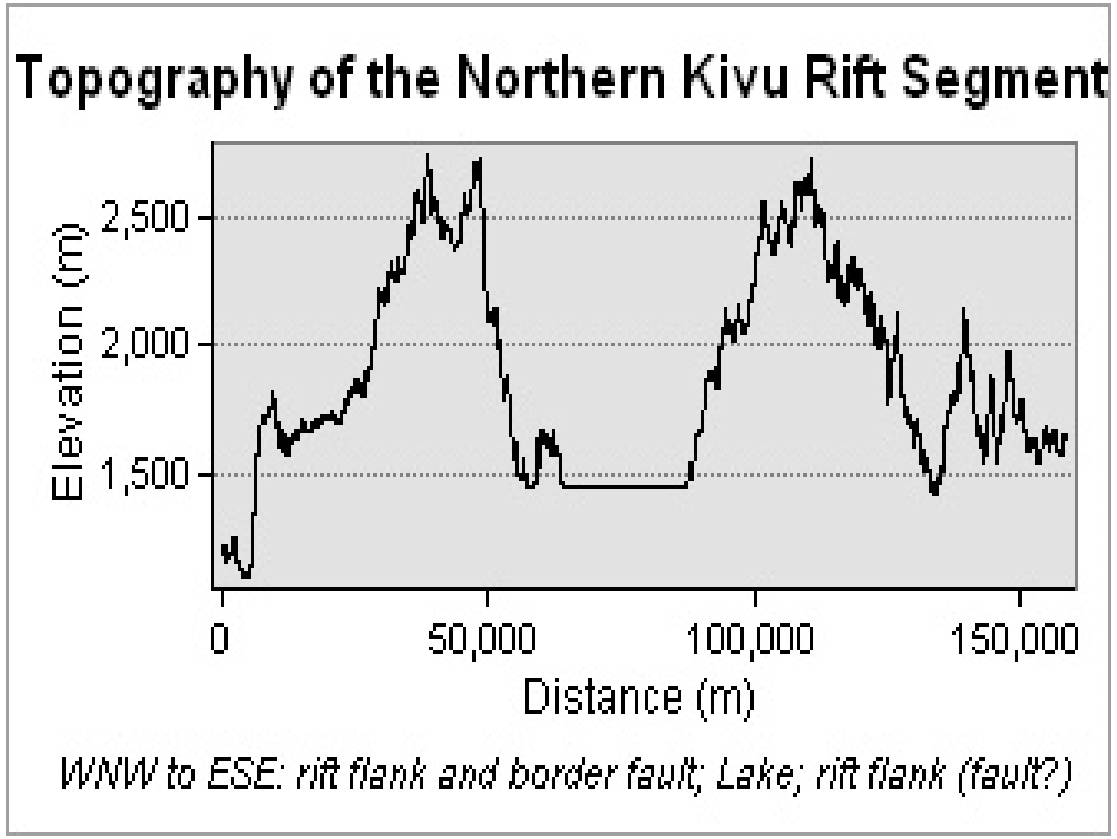


Results

Narrow drainage basin suggesting border fault and local hanging wall flexure control.

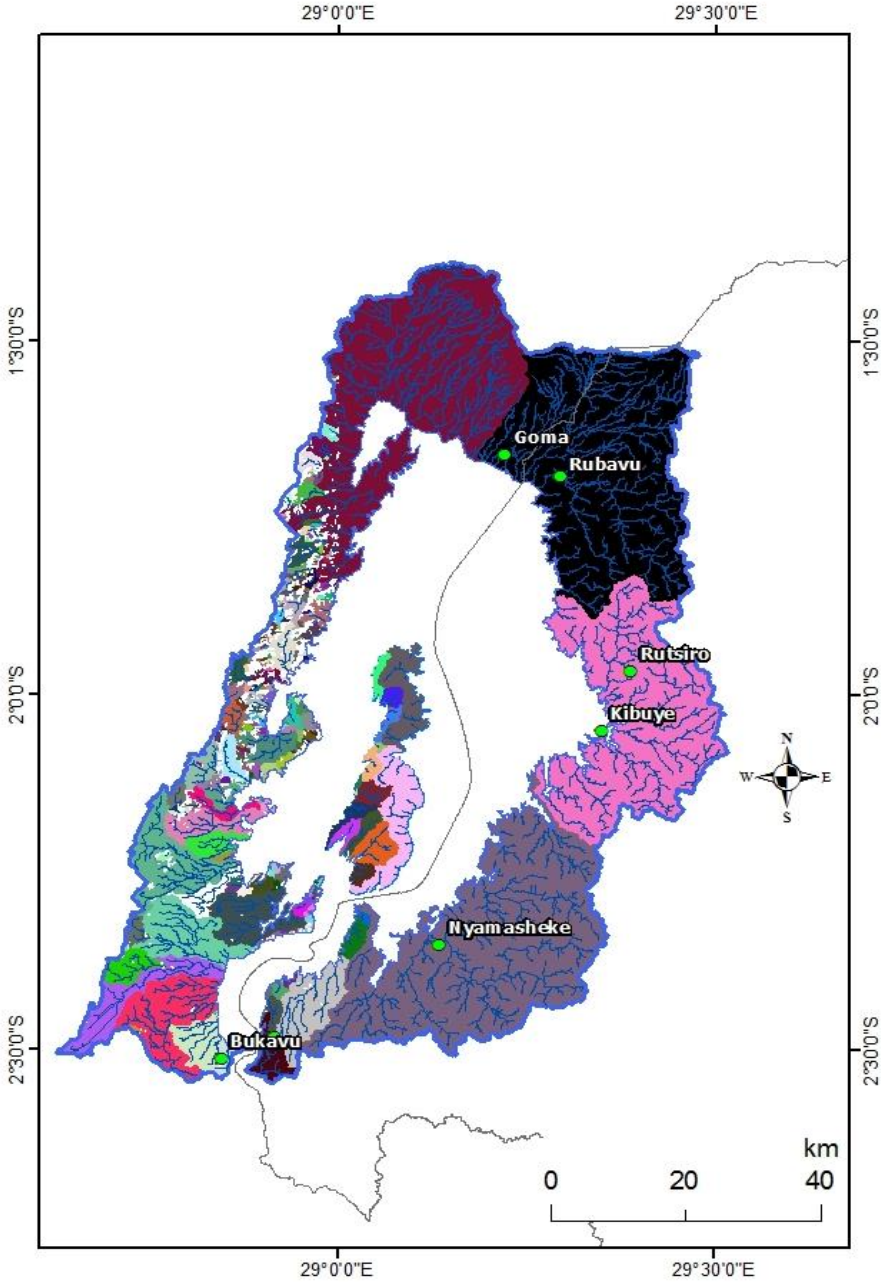


Steep rift flanks. Western shoulder steeper, with less slope retreat. Erosion stronger on eastern margin.

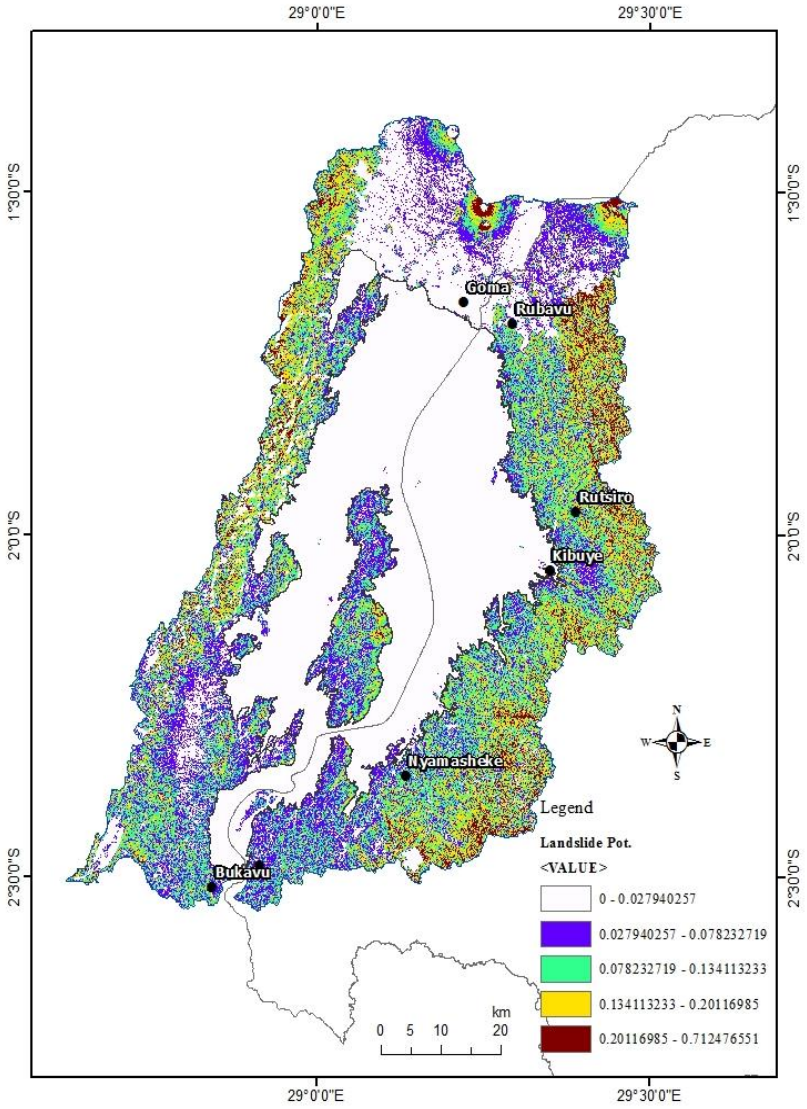


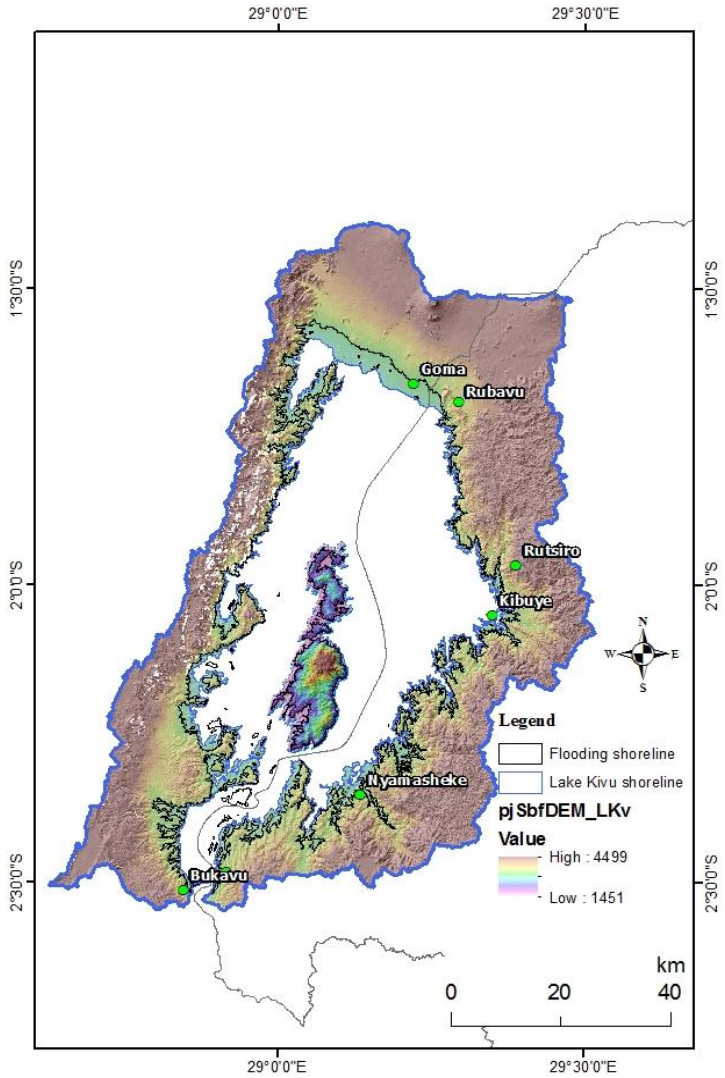
Results (more)

- Catchment area = 7,382 km^2.
- Dense drainage network.
- Broad eastern sub-watersheds; many, smaller western sub-watersheds. Erosion processes more effective on eastern margin? Difference in geology?
- It is known that most of SW covered by Cenozoic weathered basic lavas, whereas North covered by fresh volcanics; E made of Precambrian parametamorphic rocks.



Results (more): Lake level rise(?) and Landslides

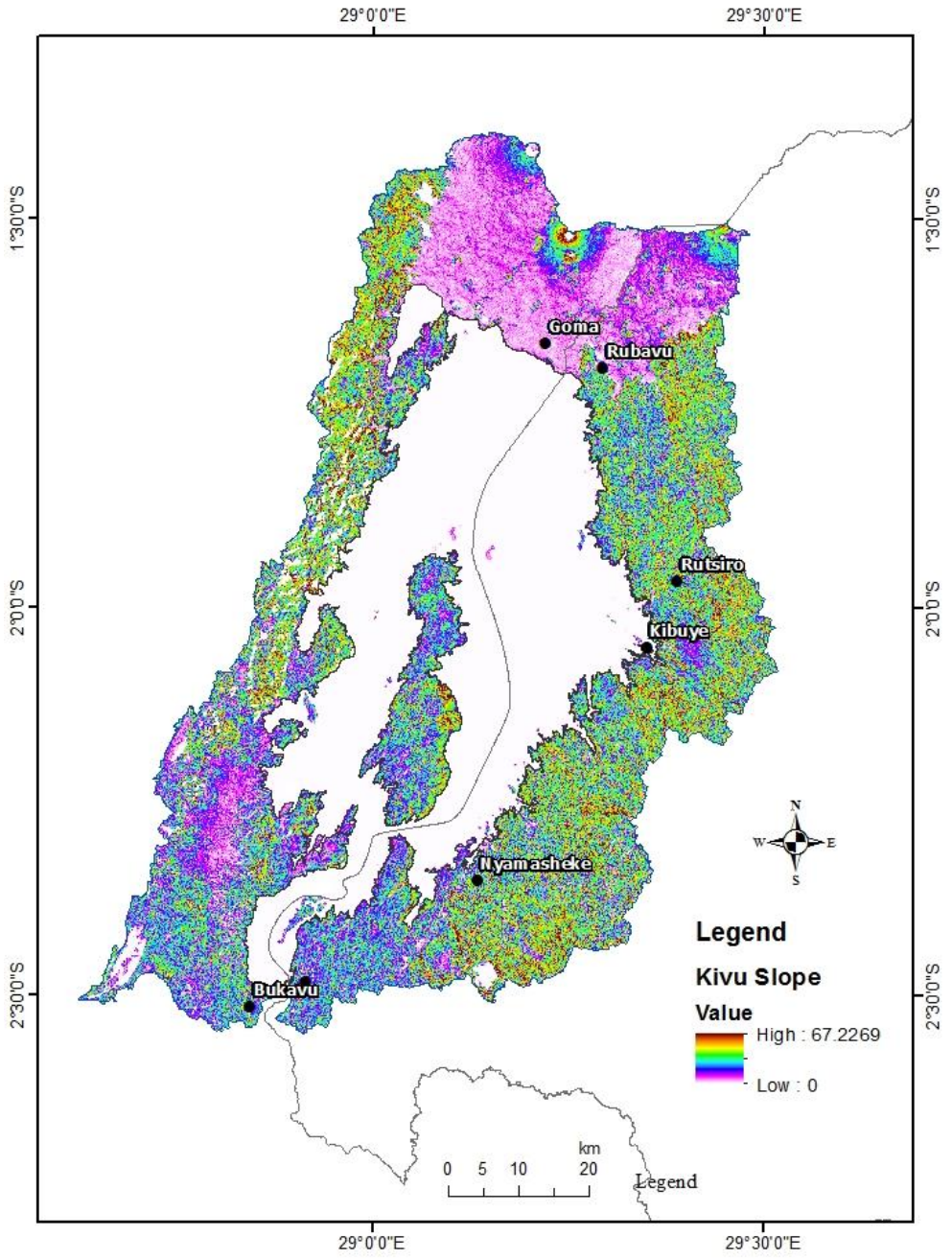




- Floods (mud flows, debris flows) dynamically linked with landslides in humid climate and high slopes.
- Hypothetic 100-m lake level rise would flood 590 km^2 .
- High landslide potentiality across most of the drainage basin, based on slope and elevation alone.
- South and North having least landslide potentiality. Why?

Conclusions

- South and N**o**rth having gentle slopes causing them to have least landslide potentialities.
- Pattern of slope distribution very similar to that of landslide potentiality implying strong influence of slope on landslide occurrence across the Kivu drainage basin compared to elevation.
- Lake draining smaller area along the western margin, suggesting eastern margin potentially supplying more sediment + water to the lake.
- Drainage reversal noted on rift shoulders, but none observed along axis as suggested by Beadle (1981) Longman. Implies Lake Kivu probably did not flow to Lake Edward as previously anticipated.
- North and South of the lake, and close to its shore are the areas of least landslide potentiality. Landslides coupled with flows in rainy seasons. Areas close to the shore, most exposed to lake flooding.



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