Tectonic faulting's impact on vegetation and soil formation in the Mara River Basin, East Africa

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2 Setting of the Mara River Basin

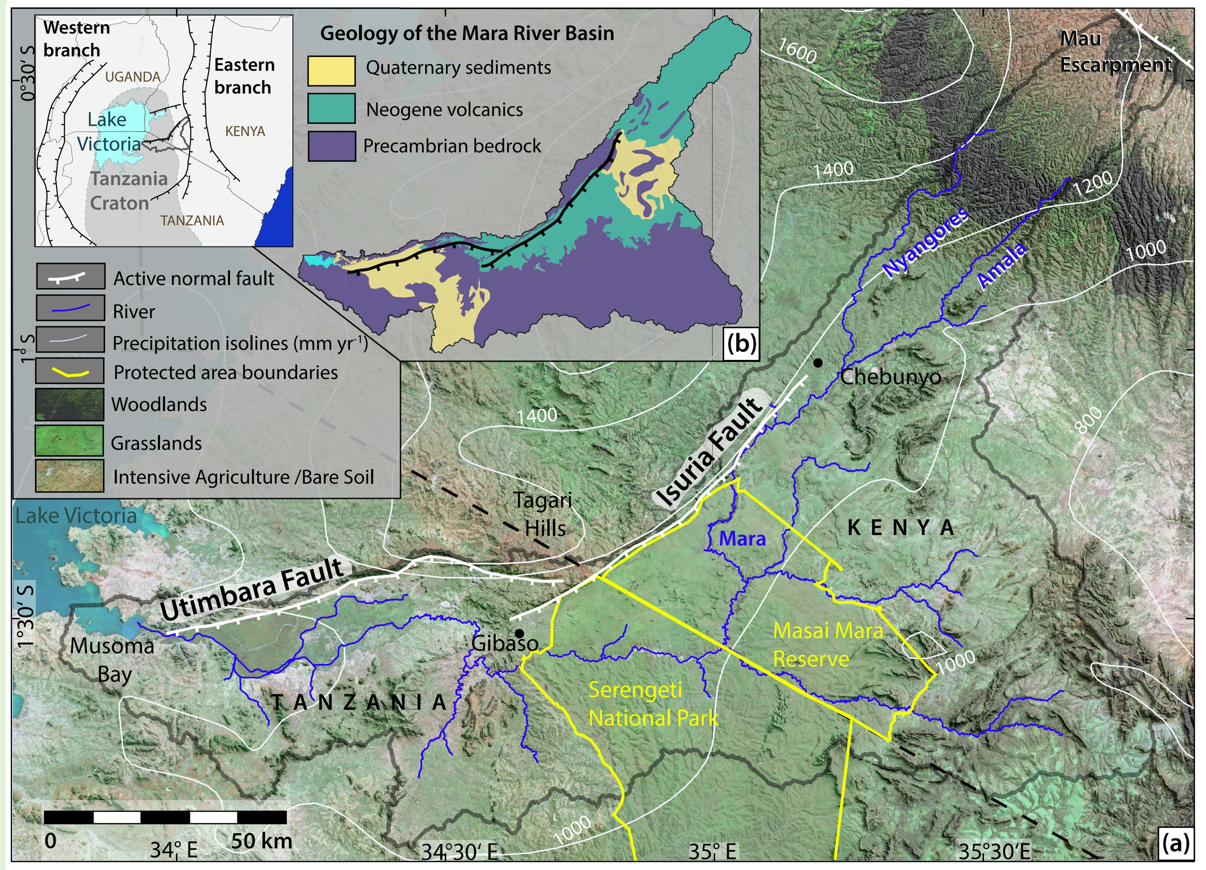

Figure 3 (a) Mara River Basin overview with vegetation derived from Sentinel-2 multispectral imagery [2] and precipitation isolines derived from WorldClim version 2.1 [3] (b) Simplified geological map [4]

The study area is located between the eastern and western branches of the **East African Rift System.**

- rich **biodiversity** (Serengeti ecosystem)
- previously unrecognised **active normal faulting** (Utimbara and Isuria faults)

The Mara River basin represents a key region to study the connection **between active tectonics, geology and ecosystem processes.**

3 Is the Isuria-Utimbara fault system active?

Numerous neotectonic features are signs for a **recent surface rupturing activity of the fault system.**

→ **characteristic morphology** for active normal faulting (uplifted plateau on the footwall separated by a steep escarpment from a wide plain on the downthrown hanging wall)

Long term fault displacement rates (**0.1 mm y⁻¹**) are bracketed by Pliocene (3 Ma) lavas [4] that are vertically displaced along the fault system by 390 (±10) m.

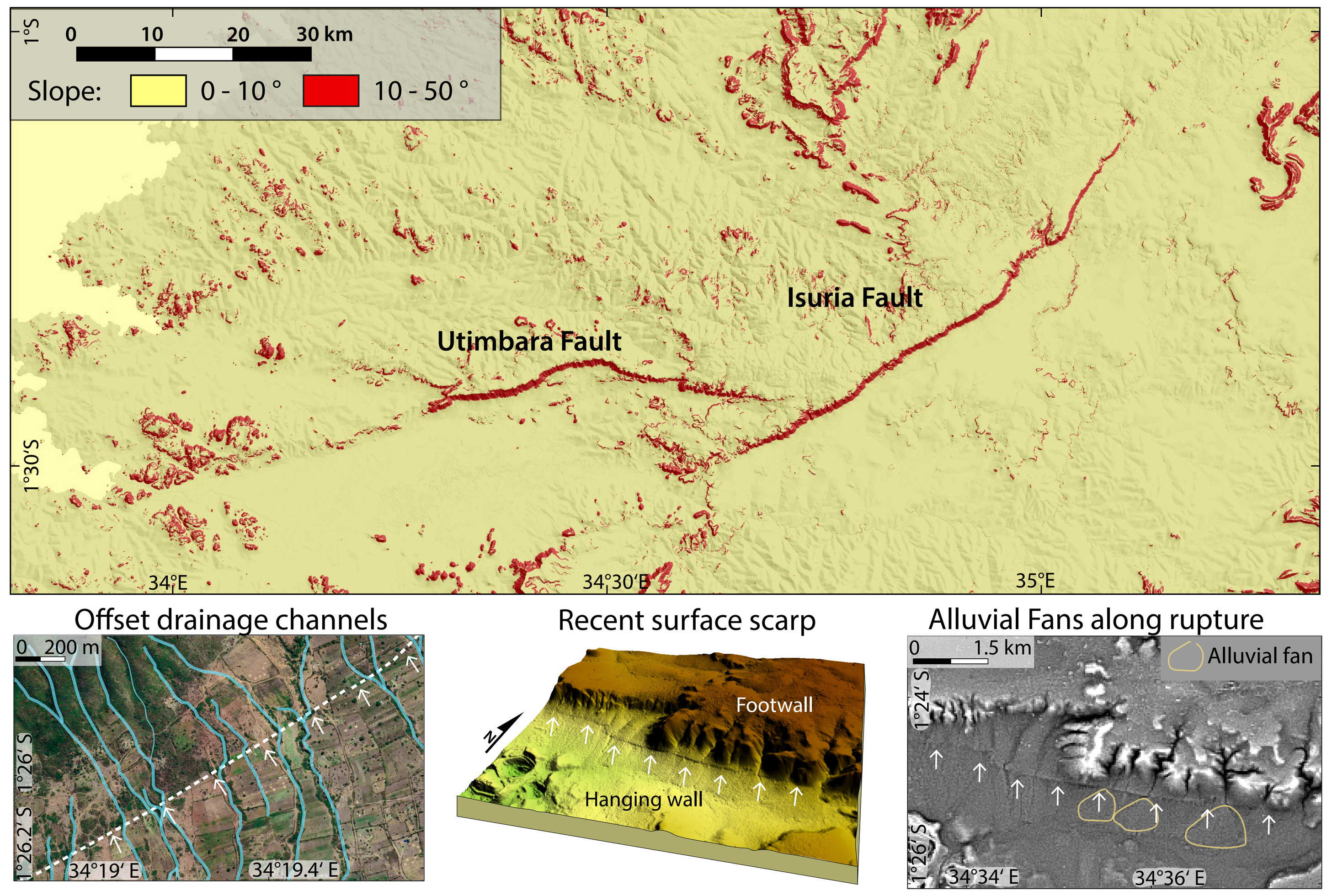

Figure 4 Evidence for fault activity along the Isuria Utimbara Fault Zone from TanDEM-X [5] and Google Earth imagery.

Interested in more evidence for active faulting along the Isuria-Utimbara fault system?

Attend the talk by Beth Kahle (session TS3.4 from 11:10 to 11:20 in room D1):
Fragmentation of the Victoria microplate: geomorphological evidence for active faulting along the Isuria-Utimbara fault system, Kenya-Tanzania transboundary region

References

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[2] Drusch, M., Del Bello, U., Carlier, S., Colin, O., Fernandez, V., Gascon, F., Hoersch, B., Isola, C., Laberinti, P., Martimort, P., Meygret, A., Spoto, F., Sy, O., Marchese, F., and Bargellini, P.: Sentinel-2: ESA's Optical High-Resolution Mission for GMES Operational Services, Remote Sensing of Environment, 120, 25-36, https://doi.org/10.1016/j.rse.2011.11.026, 2012.
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[4] Shackleton, R. M.: Geology of the Migori Gold Belt and Adjoining Areas. Report No. 10, Colony and protectorate of Kenya - Mining and geological department Nairobi, 1946.
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[6] Pettorelli, N., Vik, J. O., Mysterud, A., Gaillard, J.-M., Tucker, C. J., and Stenseth, N. C.: Using the satellite-derived NDVI to assess ecological responses to environmental change, Trends in Ecology & Evolution, 20, 503-510, https://doi.org/10.1016/j.tree.2005.05.011, 2005.
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[8] Hunt, E. j. and Rock, B.: Detection of changes in leaf water content using Near- and Middle-Infrared reflectances, Remote Sensing of Environment, 30, 43-54, https://doi.org/10.1016/0034-4257(89)90046-1, 1989.

1 How do geological processes influence tectonically active ecosystems?

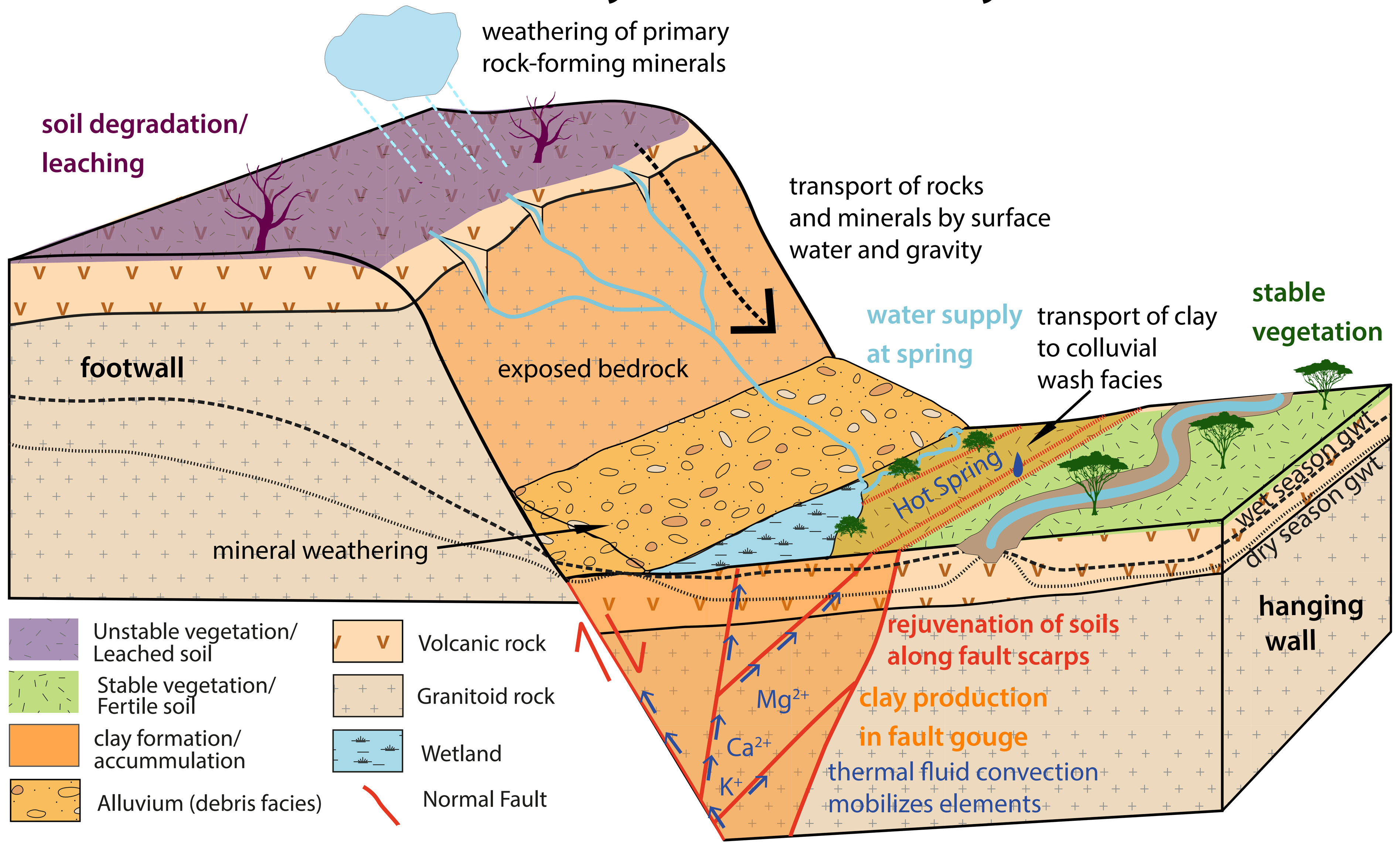

Figure 1 Conceptual model of tectonic activity influencing hydrological and clay forming and/or accumulating processes in a normal fault zone and schematic distribution of different rock types in the study area.

This study shows for the first time that **tectonic processes stabilise vegetation growth** by creating favourable hydrological and pedological conditions along the escarpments of active faults.

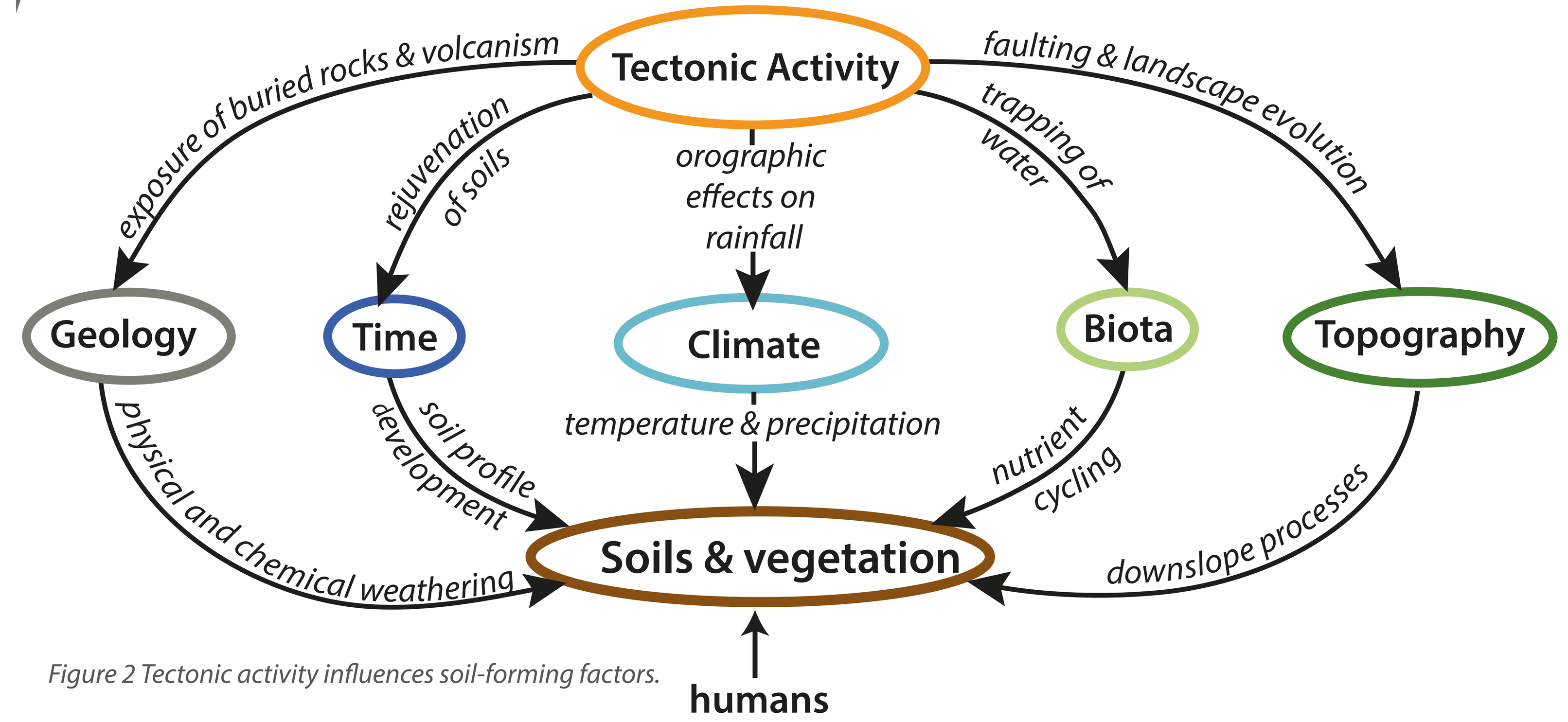

Figure 2 Tectonic activity influences soil-forming factors.

6 Conclusions

Active faulting stabilises vegetation growth patterns in the Mara River Basin by trapping water, rejuvenating soils, promoting clay mineral formation, and enhancing weathering and downslope processes. Lithology has only minor control on vegetation growth. Incorporating geological factors into interdisciplinary ecosystem studies improves the understanding of tectonically active landscapes and aids in interpreting natural processes.

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Scan!

In our satellite-based analysis we illustrate the impact of geological processes on the stability of the Mara River Basin ecosystem with regard to the newly detected tectonic activity of the Isuria Utimbara fault system as well as lithological variability. Results reveal that active faulting seasonally stabilises vegetation growth patterns, whereas lithology only exerts minor control on vegetation growth in this climatically sensitive region.

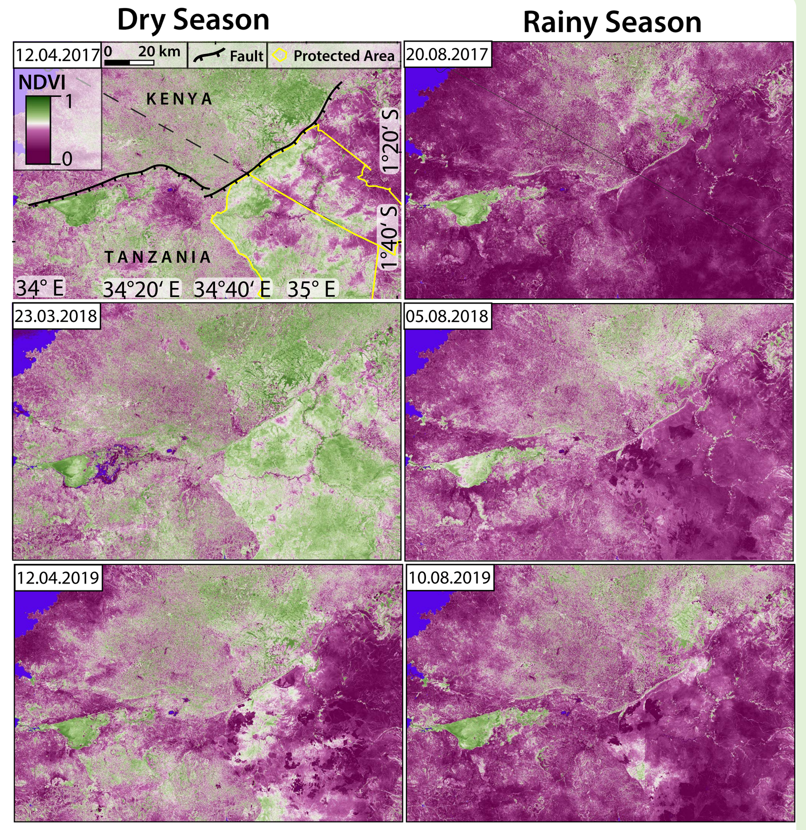
4 Multispectral Analysis

Sentinel-2 multispectral imagery was used to extract vegetation information by using spectral indices:

- **Normalized Difference Vegetation Index (NDVI)** indicates health of the vegetation [6]
- **Clay Mineral Ratio (CMR)** identifies deposits containing clay and alunite [7]
- **Moisture Stress Index (MSI)** indicates plant available water [8]

The band ratios serve as proxies to **characterise vegetation stability and soil quality.**

→ All indices highlight several locations with **permanent values favourable for season-independent plant growth** along the escarpments.



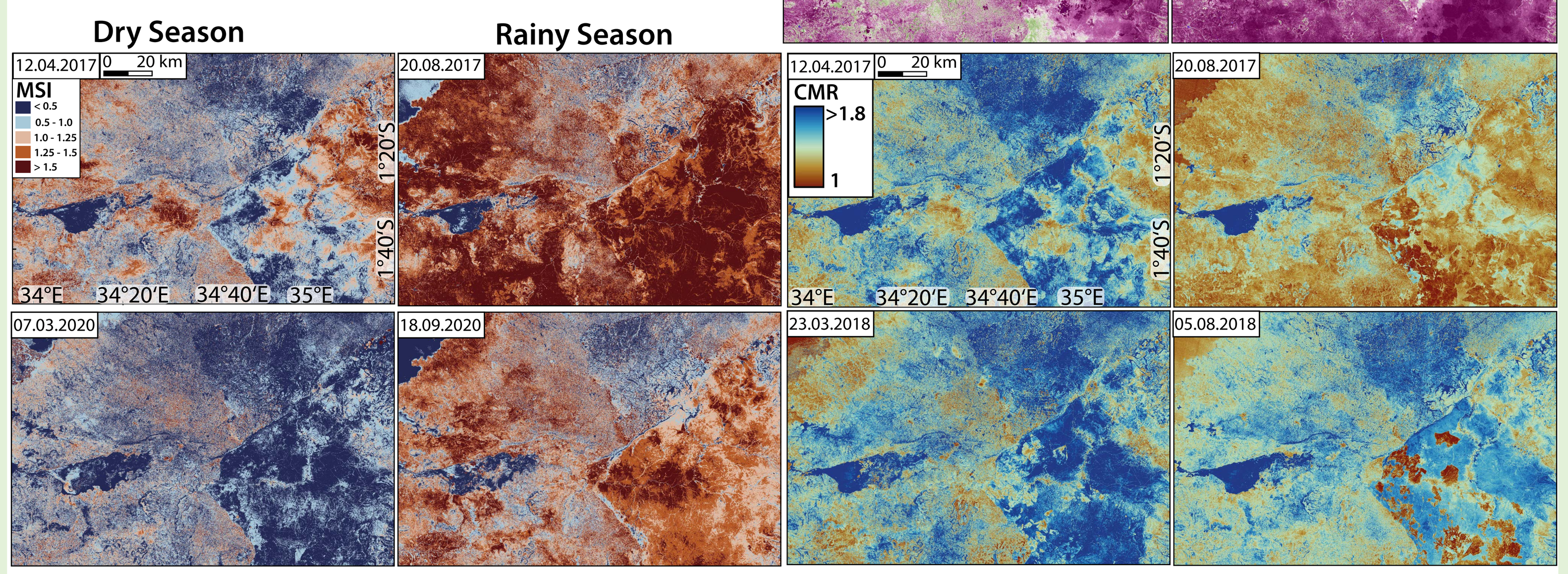


Figure 5 Spatio-temporal distribution of NDVI, MSI and CMR in the Mara River Basin represented by Sentinel-2 multispectral images

5 Discussion

Several locations with consistently high values indicate that healthy vegetation is probably connected to tectonic processes (e.g. Mara wetland, Mara hot spring).

- strong correlation between temporally **stable NDVI/CMR values and steep topography:** tectonically active regions produce larger stable vegetation zones than inactive regions
- faults lead to a high water retentivity: stable hydrological conditions (**low MSI values**)

→ creation of climatically insensitive environment and possible drought refuges for the Serengeti migrants

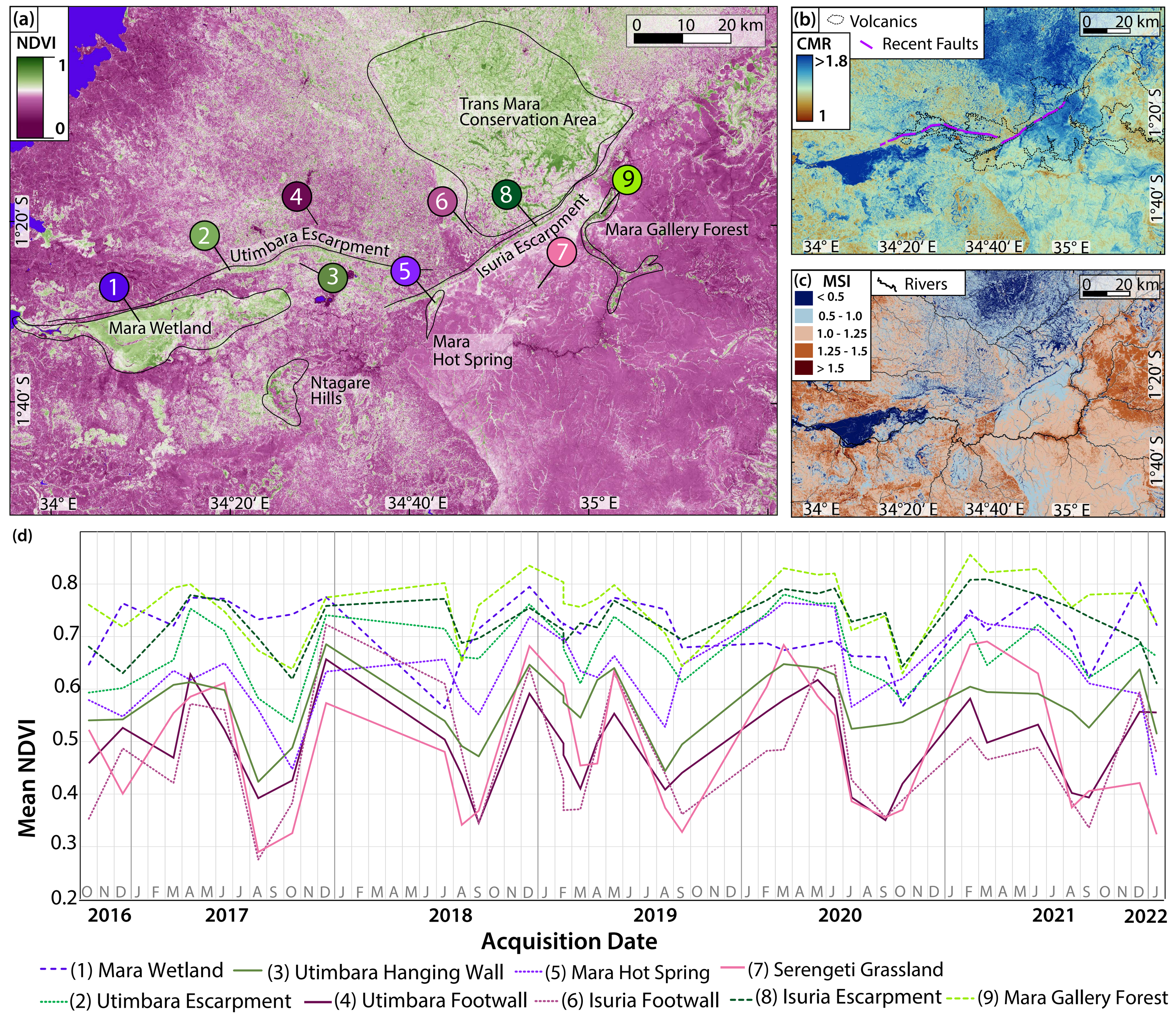


Figure 6 (a) Mean NDVI (b) Mean CMR (c) Mean MSI (d) Temporal distribution of NDVI along the fault zone using a 5-year time series.