Automatic Detection and Quantification of Erosional Badland Levelling in Central India Using LandTrendr with PlanetScope Imagery in Google Earth Engine

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I) Introduction

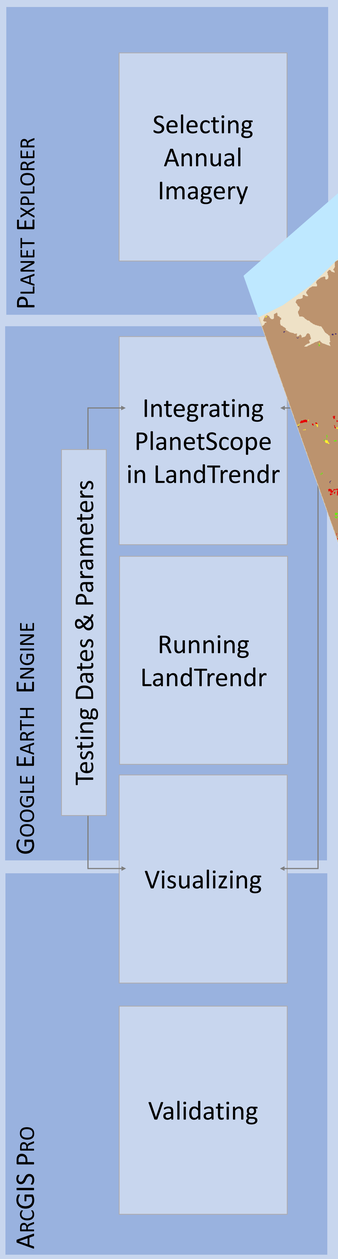
With their highly dissected morphology, the Chambal badlands in the Lower Chambal Valley in Madhya Pradesh, Central India, range among the largest badland zones in the world. The badland erosion leads to a loss of land and decline in agricultural productivity, and thereby threatens the livelihood of the local population. Land levelling by local farmers and through government programs has therefore become a widespread practice.

To investigate this anthropogenic interference, the study aims to automatically detect and quantify newly levelled land in the Lower Chambal Valley. For this purpose, it pioneers in integrating high-resolution PlanetScope imagery (3 m, available since 2016) in the Google Earth Engine implementation of the time series analysis algorithm LandTrendr (LT-GEE).

II) Research Question

Is the LT-GEE implementation using PlanetScope imagery suitable to automatically detect and quantify newly levelled land in the Chambal badlands?

III) Methodology



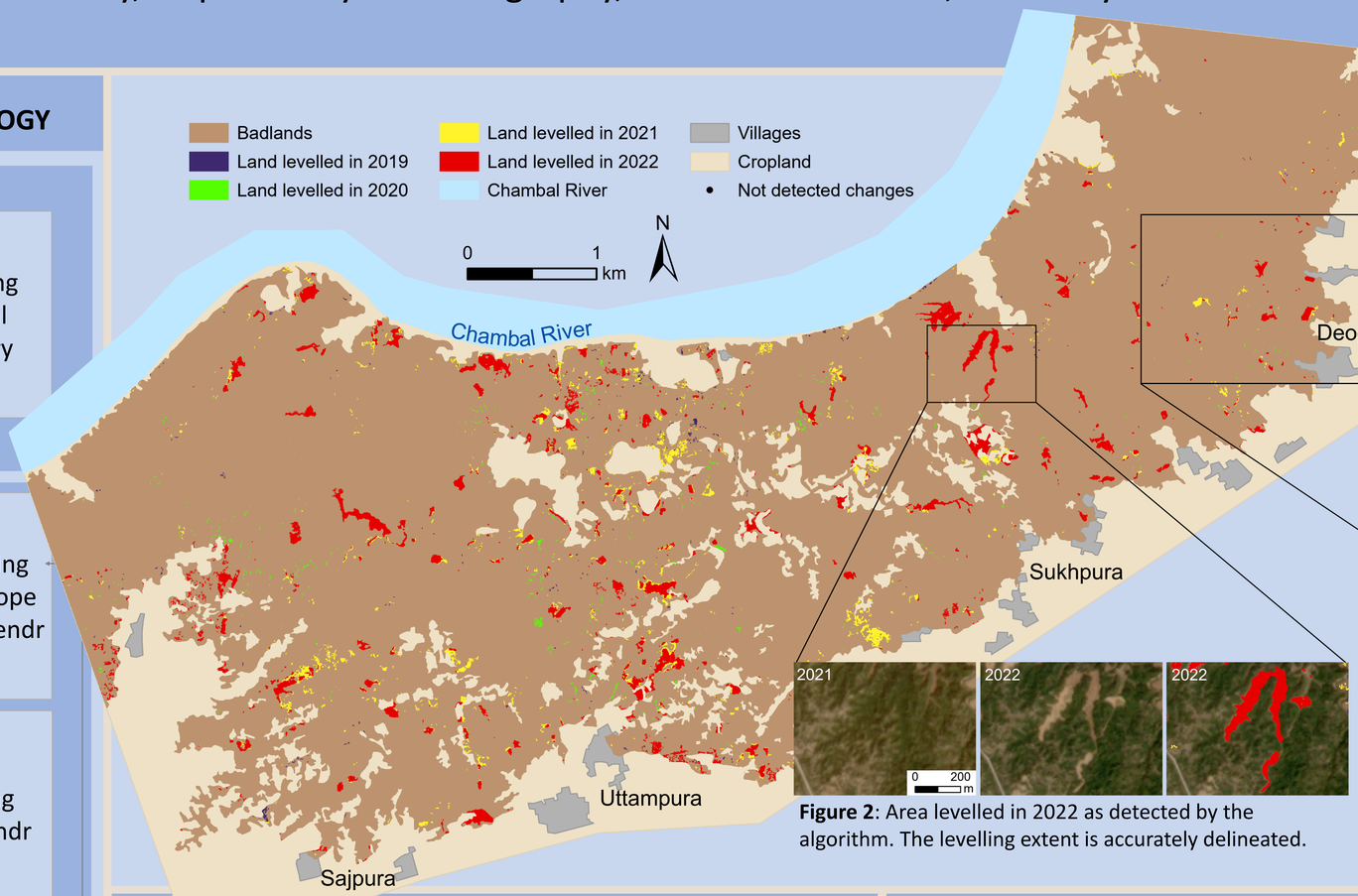


Figure 1: Land levelling mapped by the LT-GEE implementation with PlanetScope imagery.

Figure 2: Area levelled in 2022 as detected by the algorithm. The levelling extent is accurately delineated.

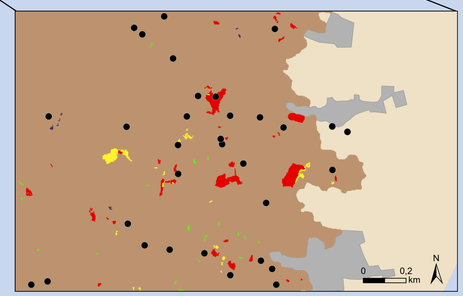


Figure 3: Example of errors of omission in the study area.

IV) Results

- The LT-GEE implementation with PlanetScope imagery was successful in detecting land levelling (Fig. 1). Spatial and temporal levelling dynamics can be inferred from the results.
- As the LandTrendr algorithm relies on trend analysis, the beginning of a time series is not well classified. The first two years, 2016 and 2017, showed high error rates and were therefore excluded from the analysis. In 2016, levelling was highly overestimated and in 2017 barely any levelling was detected.
- The classification was most accurate in 2022 when levelled areas were detected with a high degree of detail in their spatial extent (Fig. 2).
- The levelled area in 2022 amounted to 75.55 ha in a badland area of 45 km^2 (1.7 %).

V) Discussion & Outlook

- The short time series of PlanetScope data (7 years) results in higher classification errors for earlier years. Many levelling activities between 2019 and 2021 remained undetected (Fig. 3). In 2021, many cropland areas were falsely classified as levelled land.
- Additional reasons for misclassification could be the LandTrendr parameter selection as well as spatial and temporal variations in the vegetation cover.
- Future implementations of the algorithm can be expected to improve with the length of the PlanetScope time series. The possibility of extending the time series backwards with Landsat data should be explored. Furthermore, time series algorithms with a higher temporal resolution could result in more accurate mapping of newly levelled land.
- The developed method will allow to monitor future land levelling and agricultural reclamation activities in the unique geomorphological and ecological environment of the Chambal badlands.

References

Kennedy et al., 2010 (RSoE, doi:10.1016/j.rse.2010.07.008)
Kennedy et al., 2018 (Remote Sensing, doi:10.3390/rs10050691)
Marzolff & Pani, 2018 (ESPL, doi:1002/esp.4266)