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Analyzing trends of savannah degradation in Tanzania using Google Earth Engine and INLA

Joris Wiethase, Rob Critchlow, and Colin Beale

University of York, Department of Biology, J1, York, United Kingdom of Great Britain – England, Scotland, Wales
(jhw538@york.ac.uk)

Semi-arid rangelands have been identified as at high risk of degradation as a result of changing socio-ecological conditions. Tanzanian savannahs are typical and some areas have become degraded in recent years, while other areas maintain resilience. To track pathways to degradation, we developed a workflow to create annual maps of degradation for all of Tanzania, at a high spatial (30m) and temporal (30+ years) resolution, as a function of bare ground and invasive plant cover. Making use of the freely available Google Earth Engine (GEE) computing platform, we created annual composites of Landsat remote sensing data. Using GEE machine learning algorithms, trained with data from extensive field surveys conducted in 2016, we predicted degradation scores for all of Tanzania from the Landsat composites. Our models produced significant correlations at the pixel level between test predictions and observations, rather better for the bare ground component of degradation than the invasive plants cover (bare ground $r = 0.7$, invasive plant cover $r = 0.44$). The resulting map provides an unprecedented data source for degradation in terms of extent and spatial resolution for the region. Through a novel data analysis approach using Integrated Nested Laplace Approximations (INLA), we show that degradation correlates with rainfall, human population and livestock density, as well as different management strategies. This study showcases the potential of GEE for analysing savannah degradation over large geographical areas, whilst highlighting the usefulness of INLA for this type of analysis.