Spatial assessment of land degradation in semi-arid zone of central Tanzania

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Abstract

The United Nations Convention to Combat Desertification (UNCCD), ratified by 195 countries, identifies land degradation (LD) and desertification as one of the most pressing environmental concerns of our times. Sustainable land management practices can help to reverse and halt LD and achieve food security. In order to take action, spatial explicit information on LD hotspots is first needed. Following the Good Practice Guidance of UNCCD this study used remote sensing to find the major drivers of LD. Preliminary results shows that in the last 15 years, land productivity declined in over 70% of the Kongwa & Kiteto districts and croplands are more affected by degradation. No significant changes were detected for land cover and soil organic carbon that is a result of the coarse resolution of input data.

Keywords: Land degradation neutrality, remote sensing, spatial targeting

Introduction

Land degradation (LD) is one of the major challenges for people's livelihoods, food security and resilience of agro-ecosystems in Tanzania. Studies suggest that nearly half of the country is affected by LD and that the costs sum up to $2.3 billion per year. LD is defined by UNCCD (UNCCD94) as the re-duction or the loss of the productivity of the land due to land use (LU) practices. UNCCD proposed a LD neutral (LDN) world by 2030. The Sustainable Development Goal (SDG) 15.3.1 focus on tracking LD. Sustainable land management (SLM) is key to stop and reverse LD, especially in semi-arid regions like in central Tanzania. The goal of this study is therefore to create a spatial explicit LD-index for Kongwa and Kiteto (KK) districts to guide spatial targeting of land rehabilitation programs such as agroforestry and other soil and water conservation practices.

Materials and Methods

The study area comprises the two KK districts in central Tanzania, which have a semi-arid climate with a unimodal precipitation distribution. Land degradation is assessed using TrendsEarth plug-in of QGIS and Google Earth Engine. Following the UNCCD Good Practice Guidance (GPG 17) for SDG indicator 15.3.1, three sub-indicators of LD: Land Cover (LC), Soil Organic Carbon (SOC) and Land Productivity (LP), were assessed. Change in LC is assessed using the ESA-CCI LC classification for 2000 and 2015 with 300 m resolution. Transitions from cropland to forest are evaluated as improvement, whereas changes from grasslands to settlements are classified as degradation. SOC is based on the modelled ISRIC SoildGrids250m. LC conversions triggers corresponding changes of SOC values with time delay of up-to 20 years, based on certain LC coefficients.

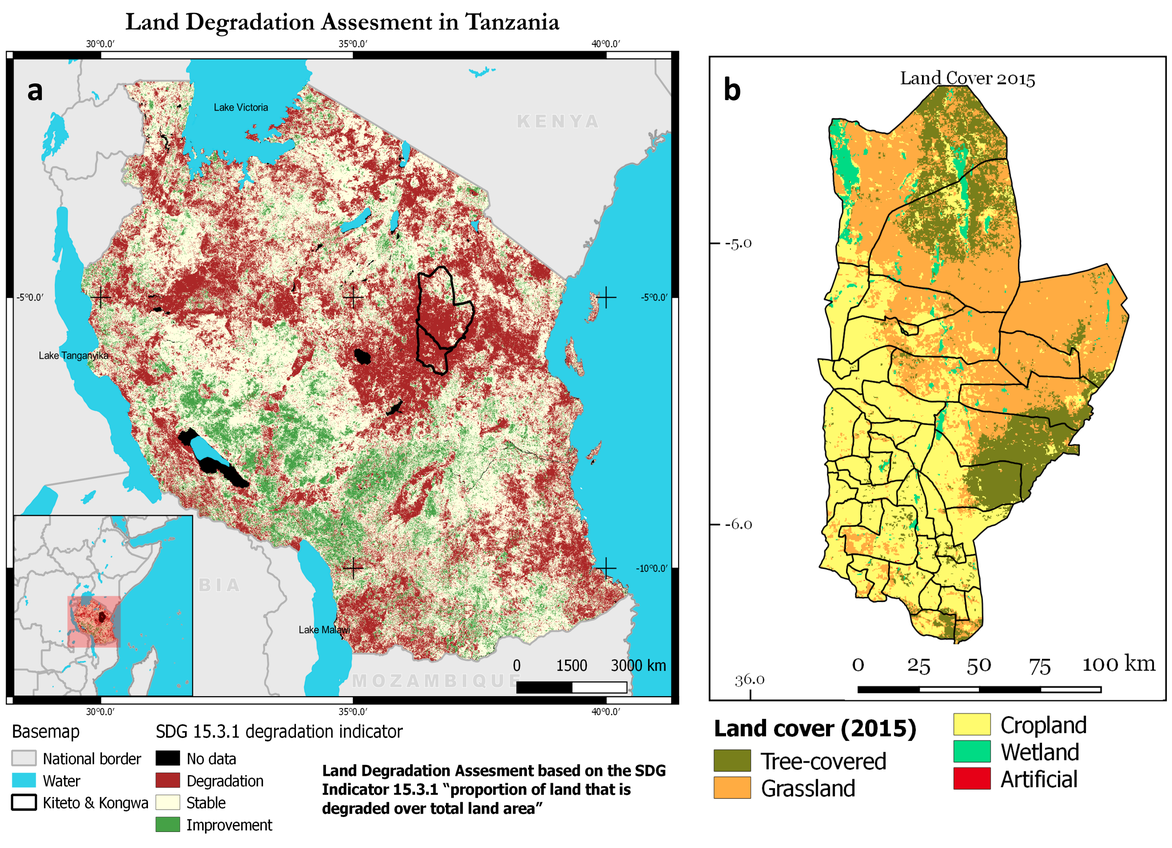

Fig. 1: (a) Spatial distribution of land degradation hotspots in Tanzania with KK is highlighted, (b) Land cover classes in KK districts in 2015

LP is measured with the Normalized Differences Vegetation Index (NDVI), which serves as a proxy for net primary production (NPP). Annual NDVI-integrals are calculated based on the MODIS bi-weekly products. LP consists of three individual sub-indicators, namely trajectory, performance and state. Trajectory indicator measures the rate of change over time based on a linear regression and the significance is determined using a Mann-Kendall test. Water use efficiency was considered to account for influence of climatic variability i.e. precipitation and evapotranspiration on NPP. The state sub-indicator detects recent changes of LP by comparing the last three years to the preceding period. Annual integrals of NDVI are classified into 10% percentiles and transitions of more than two classes between the baseline and recent period are flagged as improvement or de-gradation. The performance sub-indicator compares the local LP with other similar vegetation types in comparable LC types and soils in the study area. If the NDVI is lower than 50 % of the maximum value, then it is assessed as degraded. The three sub-indicators are finally integrated into one indicator of LP using the "one out, all out" (1OAO) approach.

Results & Discussion

The study area consists mainly of three land cover types: Grasslands, croplands and forest lands with around 41, 39 and 17%, respectively (Fig. 1b). Assessment with global data indicated no change in LC & SOC in 99% of the area in KK districts. This could be due to coarse resolution of input LC and SOC.

LP experienced a major decline compared to baseline period. More than 70% of the area showed signs of degradation that was mainly driven by the state and trajectory sub-indicators of LP. Based on the 1OAO-principle LP emerged as the major driver for LD. Croplands were most affected with nearly 90% of its area being degraded. This have negative repercussions on food security in the two districts. However LP need to be assessed with NDVI integrals for only growing season (November – May) rather that calendar year integrals.

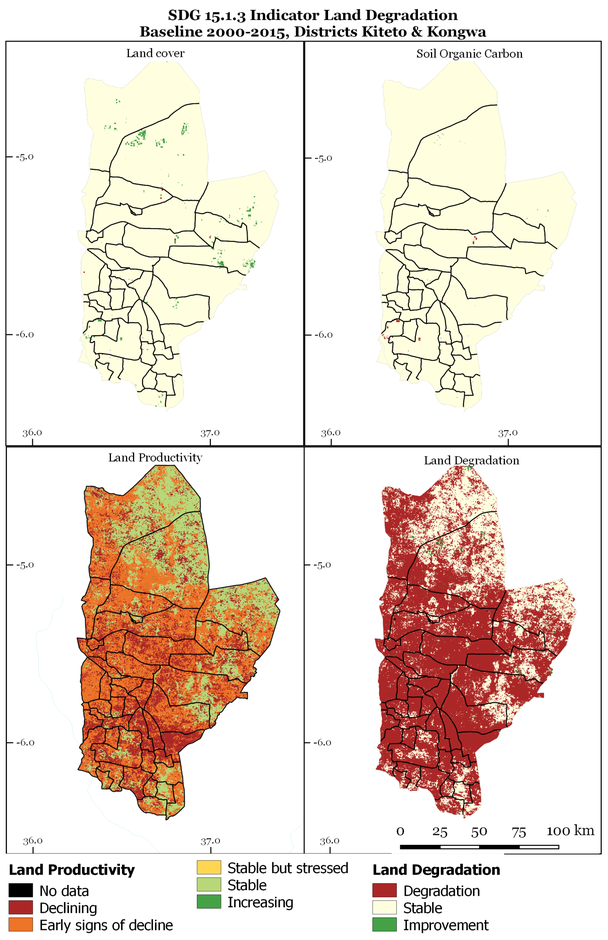

Fig.3: Trends in the sub-indicators for land degradation in Kongwa and Kiteto Districts of Tanzania.

Use of higher spatial resolution NDVI dataset such as those from Sentinel-2 (20 m) or Landsat (30 m). However the issue of cloud cover of optical sensors can be addressed through data fusion with higher temporal resolution dataset from MODIS.

Conclusion and Recommendations

- Decline in land productivity is the main driver of land degradation in KK and croplands were the most degraded
- LP need to be assessed with higher resolution NDVI integrals for only growing season (November – May) rather that calendar year integrals
- Land cover and soil organic carbon were stable but this need to be ascertained with higher spatial resolution remote sensing data and validation with ground truth in KK districts

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