EGU General Assembly 2021

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EDI

Land degradation in savanna environments - assessments, dynamics and implications

INCORPORATING VEGETATION TRENDS TO THE MEDALUS-ESA APPROACH FOR ASSESSING ENVIRONMENTAL SENSITIVITY: THE CASE OF KENYA

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LAND DEGRADATION IN SUB-SAHARAN AFRICA

Land degradation (LD):

- ~ ¼ of world's lands affected
- ~3.2 billion people live and depend on degraded lands
- ~US$ 10.5 trillion loss / year, ~ 1/6 of world's GDP

United Nations Convention to Combat Desertification (UNCCD):

- "*Sub-Saharan Africa is on path to experiencing some of the strongest increases in pressures on land and land-based resources than any other continent*"

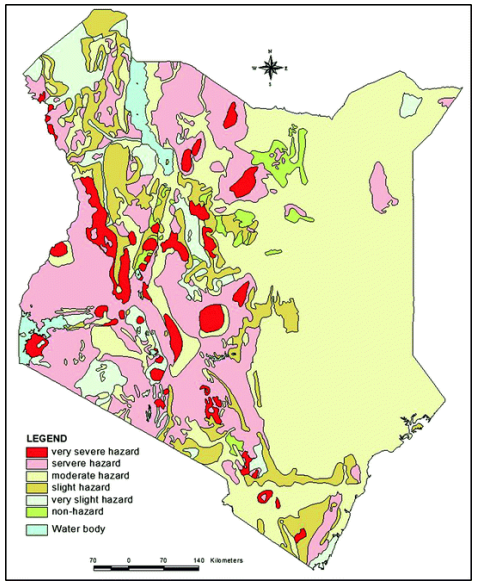
Assessing sensitivity of African countries to LD is important for:

- identifying areas of concern
- setting baseline for national land degradation neutrality (LDN) targets
- prioritisation of mitigation measures

LAND DEGRADATION IN KENYA

- LD is a major environmental concern since 1960s, mainly due to soil erosion
- LD presents formidable threat to food security and sustainability of agropastoral production
- However:
  - Estimates of extent of LD vary depending on source and methodologies of calculation

LAND DEGRADATION IN KENYA PREVIOUS ASSESSMENTS

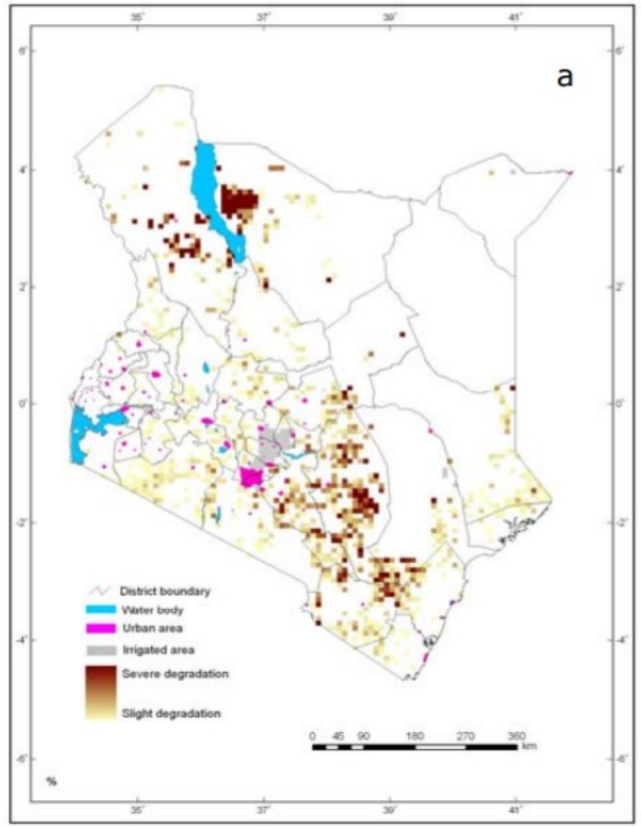


- Kenya Soil Survey (from Mulinge et al. 2015)
  12.3 % = severe degradation
  52 % = moderate degradation
  33 % = vulnerable to LD

- Bai et al. (2008)
  18 % of Kenya's total land area is degrading (1981 - 2003)

- Le et al. (2014)
  22 % has degraded between 1982 and 2006

Kenya: hot spots of land degradation between 1981 and 2003



- Mulinge, W. *et al*. Economics of Land Degradation and Improvement in Kenya. In *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*, Nkonya, E.; Mirzabaev, A.; von Braun, J., Eds. Springer International Publishing: Cham, 2016; pp 471-498.
- Bai, Z. G., Dent, D.L., Olsson, L., & Schaepman, M. E. (2008). *Global assessment of land degradation and improvement 1: Identification by remote sensing*. Report 2008/01. Rome/Wageningen: FAO/ISRIC.
- Le, Q. B., Nkonya, E., & Mirzabaev, A. (2014). Biomass productivity-based mapping of global land degradation hotspots. *ZEF-Discussion Papers on Development Policy*, 193.

LAND DEGRADATION IN KENYA

Recent attempt from UN: Sustainable Development Goal (SDG) 15.3:

"restore degraded land and strive to achieve an LD-neutral world"

- Indicators suggested for addressing lack of spatial information on extent and magnitude of LD
  - land cover
  - land productivity
  - soil organic carbon content

BUT: 3 indicators of LD are unable to capture all aspects of LD

We propose the use of the MEDALUS Environmental Sensitivity Area Index (ESAI) augmented with:

- country-specific parameters related with land degradation
- a dynamic assessment of vegetation condition and trends

SOLUTION?
MEDALUS ENVIRONMENTALLY SENSITIVE AREA INDEX (ESAI)

Originally proposed in the framework of MEDALUS = Mediterranean Desertification and Land Use

- series of international cooperation research projects funded by the EU

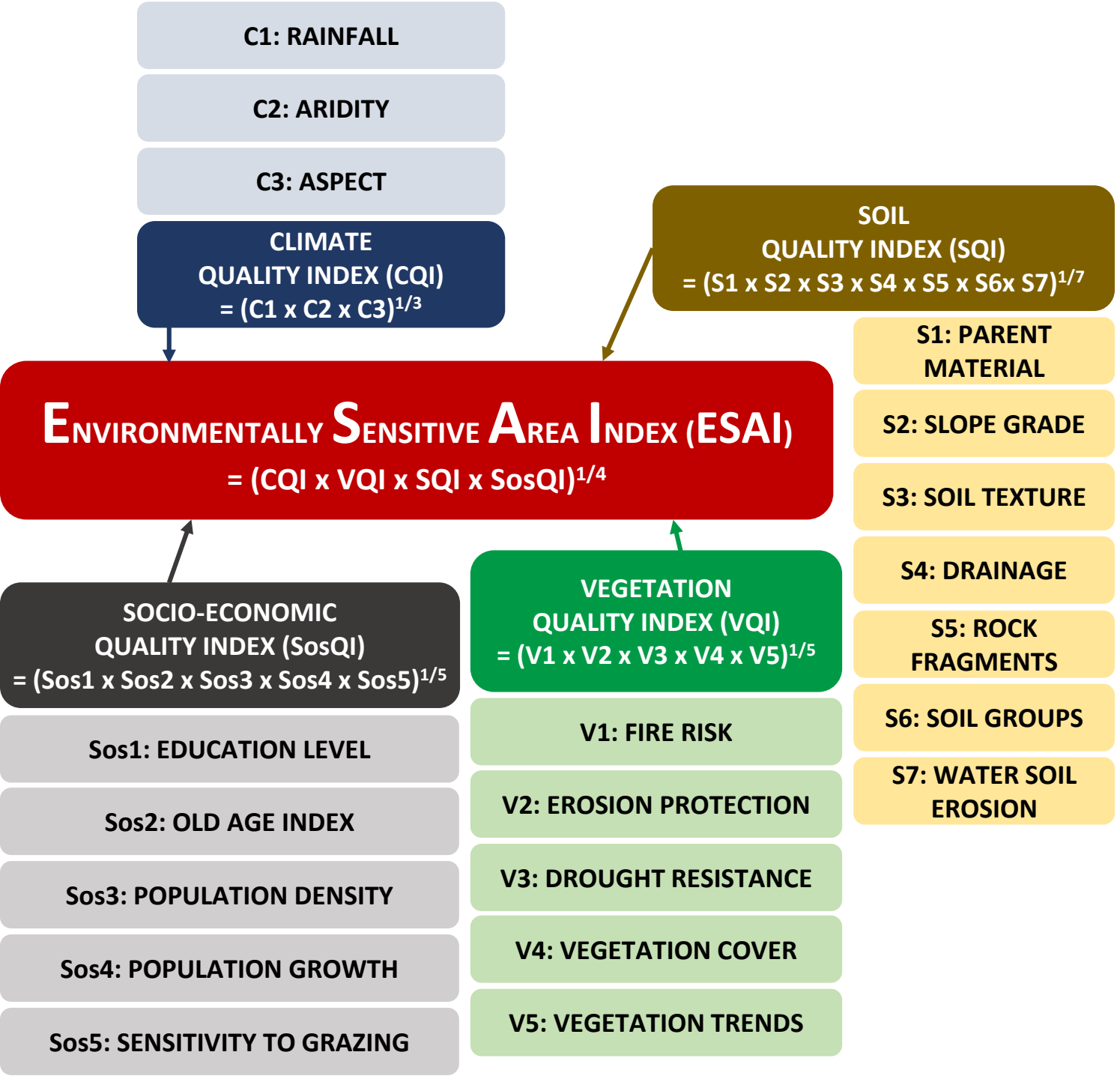
Used worldwide to identify 'sensitive areas' that are potentially threatened by land degradation

Multidimensional index (*ESA Index* or *ESAI*) composed of 4 main indicators:

- **Soil Quality Index (SQI)**
- **Vegetation Quality Index (VQI)**
- **Climate Quality Index (CQI)**
- **Management Quality Index MQI)**

$$ESA_{ij} = \left(SQI_{ij} \cdot VQI_{ij} \cdot CQI_{ij} \cdot MQI_{ij}\right)^{1/4}$$

each consisting of a number of variables



DATA SOURCES

SOILS: **ISRIC** African SoilGrids, **250m**

- Sand (%), silt (%), clay (%), organic matter (%)

DEM: SRTM DEM, **90m**

LAND COVER:

- MODIS ***MOD44B Vegetation Continuous Fields*** (sub-pixel-level representation of surface vegetation cover estimates), **250m**
- MODIS ***MCD12Q1 Land Cover Type*, 500m**

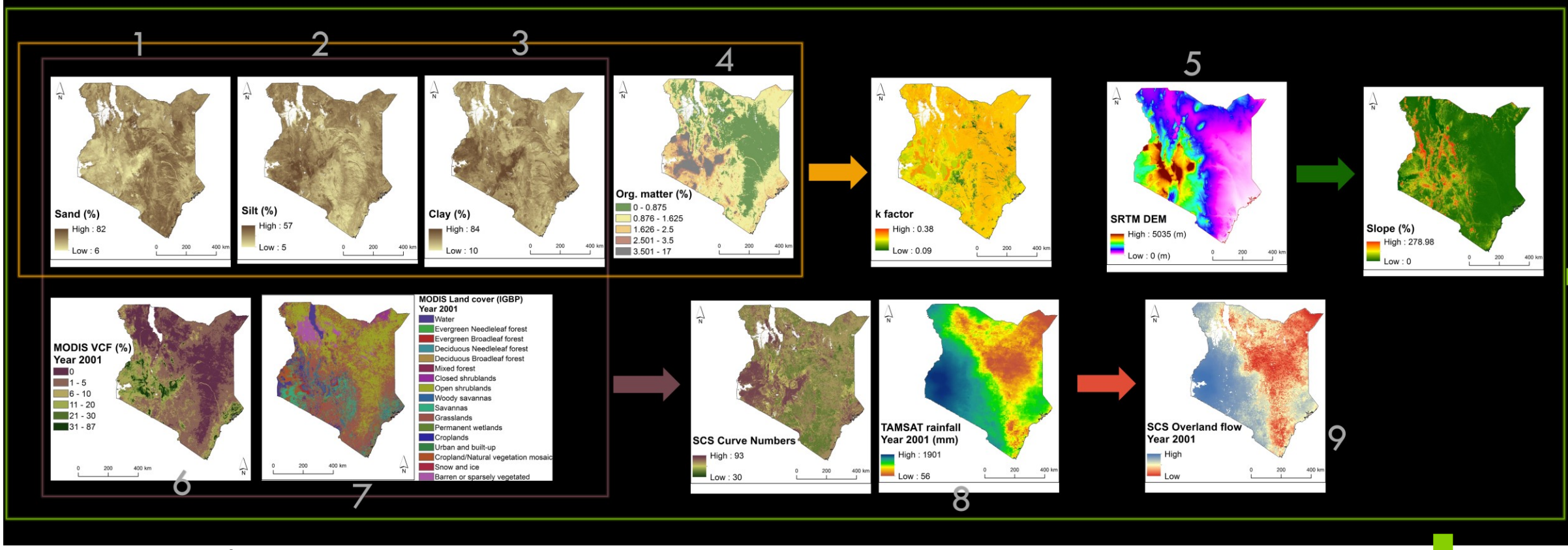
PRECIPITATION: CHIRPS (0.05° = ~**5km**)

VEGETATION (TRENDS): GIMMS3g (~8km)

GRAZING: FAO Africa Ruminants Tropical Livestock Units (TLU) **~1km**

POPULATION: WorldPop Gridded population density (UN adjusted) ~1km

PARAMETERISATION



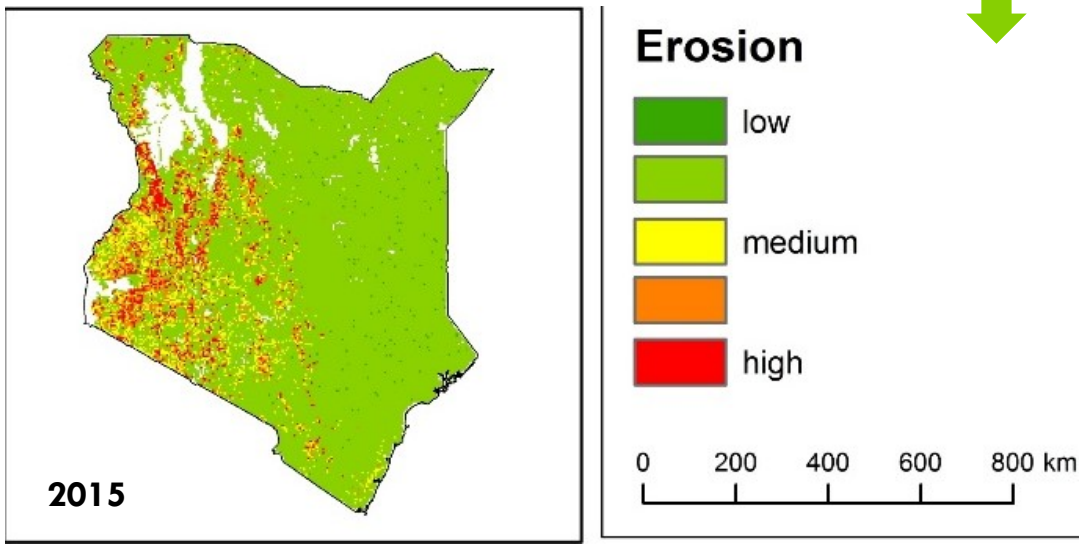
Example "*S7: Soil Water Erosion*"

Apply Thornes (1990) model: $E = k\,Q^2\,s^{1.67}\,e^{-0.07vc}$

E: erosion (mm)
k: soil erodibility coefficient
Q: overland flow (mm; SCS 1972; Fig. 9)
s: slope (%)
vc: vegetation cover (%)

Apply sensitivity scores to output (from 1 to 2):

Low = 1.0
Medium = 1.5
High = 2.0



PARAMETERISATION

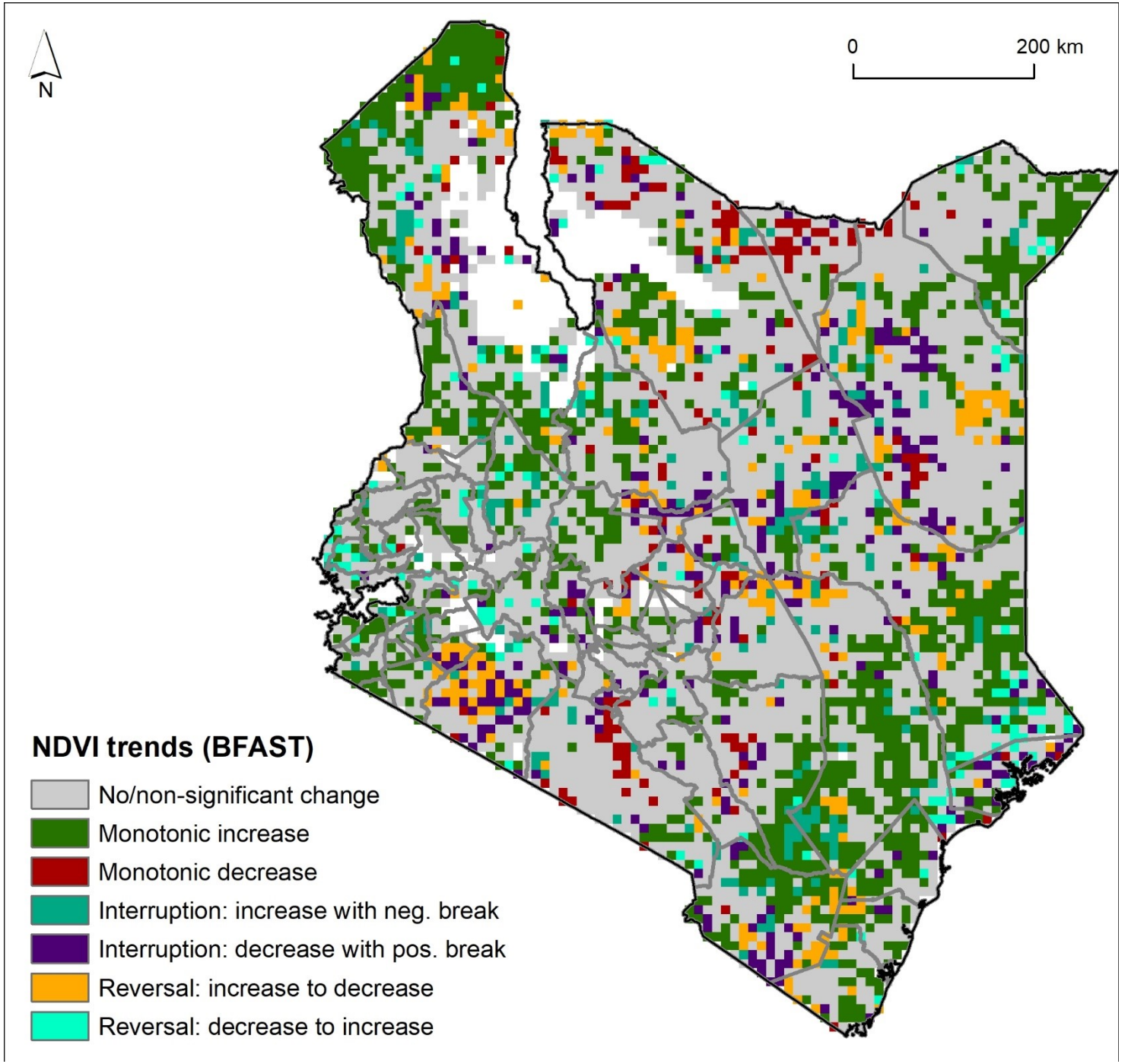
Example "*V5: Vegetation trends*"

Apply BFAST trend and breaks analysis technique (Verbesselt et al. 2010)

GIMMS3g NDVI data 1982-2015

Assign ESAI sensitivity scores to output (from 1 to 2):

- Monotonic increase: score = 1
- Interruption: increase with negative break: 1.2
- Reversals: 1.5
- Interruption: decrease with positive break: 1.8
- Monotonic decrease: 2



Verbesselt, J., Hyndman, R., Newnham, G. and Culvenor, D., 2010. Detecting trend and seasonal changes in satellite image time series. *Remote sensing of Environment*, *114*(1), pp.106-115.

RESULTS & DISCUSSION

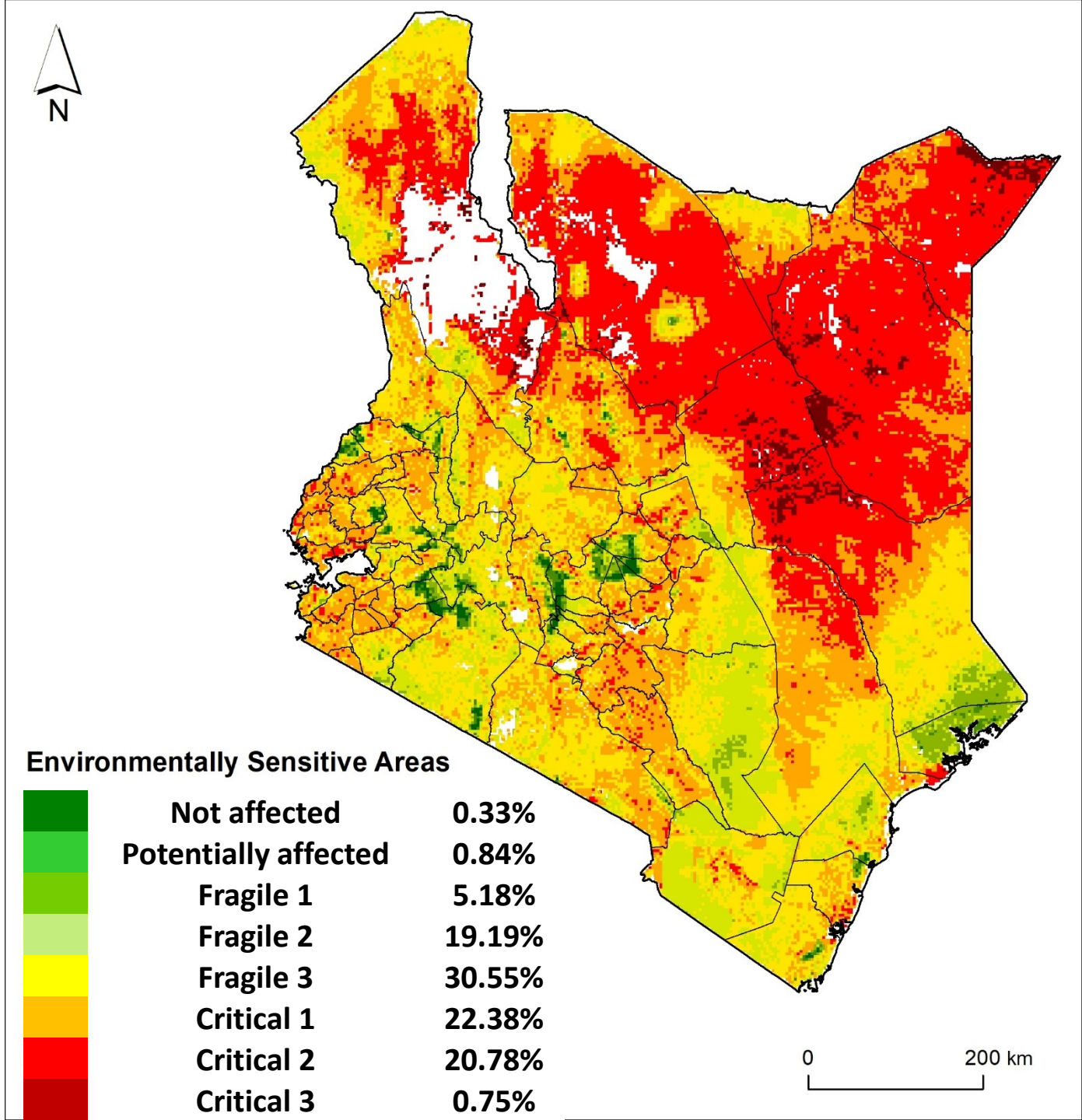
Map shows the Environmentally Sensitive Areas for 2015

Able to identify areas of concern but also those that are not affected

So far only expert knowledge has been used to validate results

Comparison with other studies is not straightforward but similarities can be found with both Le et al. (2014) and Bai et al. (2008)

Approach could be used to set baseline for the UNCCD Land Degradation Neutrality framework more accurately than relying on 3 indicators



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THANK YOU!

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