Utilizing Knowledge-Based Inference Mapping Approach to Digitally Map the Soils of the Uasin Gishu Plateau in Western Kenya

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1. BACKGROUND AND MOTIVATION

- There is much useful soils information for Kenya produced by traditional soil survey methods, but the scale and resolution is not sufficient for making informed decisions at scales relevant to small-scale farmers.
- Most of these soil maps consist of polygon-based map units drawn by soil scientists based on their knowledge of the survey area.
- Digital soil mapping (DSM) approaches can enhance soil mapping, particularly in areas where current soil maps are very general or nonexistent.
- The DSM knowledge-based approach works efficiently with limited data, which is often the case in developing countries.

Traditional soil map

DSM map product

2. RESEARCH RATIONALE

Our goal was to develop predictive, continuous raster soil class maps based on terrain attributes derived from a digital elevation model, existing soils information, expert knowledge, and satellite imagery.

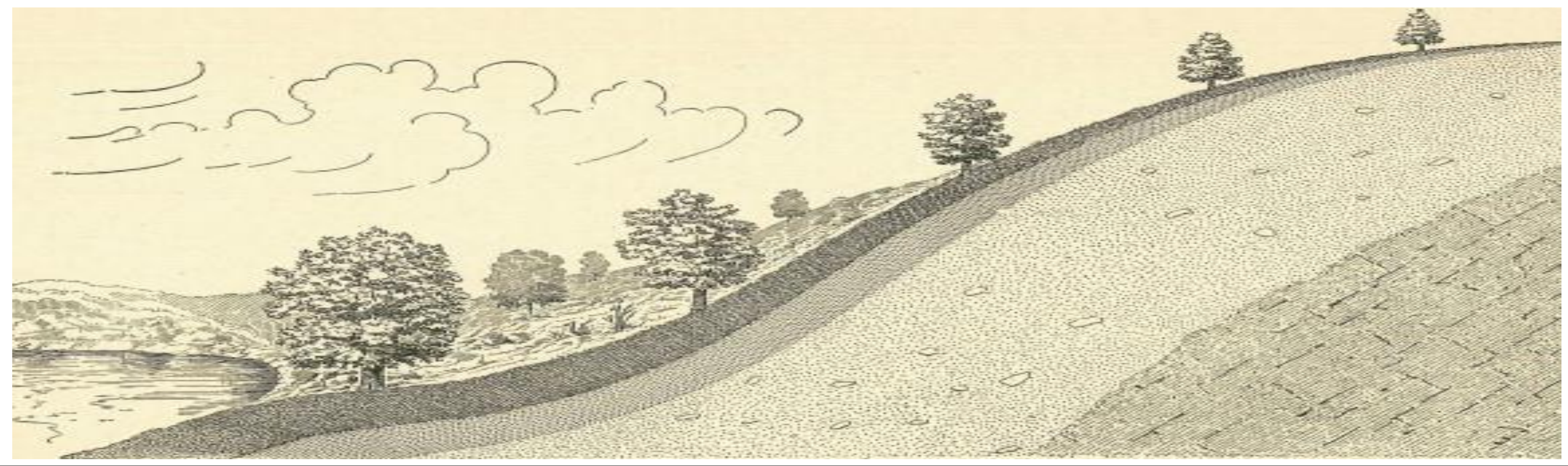
3. PROPOSED RESEARCH APPROACH

The soil state model (Jenny, 1941)

Soil Forming Factors = CLORPT
Cl= Climate
O= Organisms
R= Relief
P= Parent Material
T= Time

The catena Concept (Milne, 1935)

- Soils follow repeatable patterns related to topography

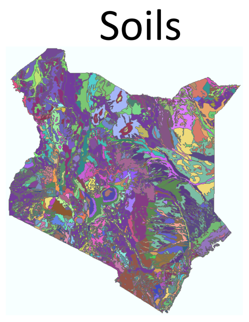


4. MATERIALS AND METHODS

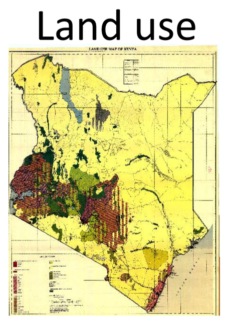
Legacy soils data

- Information on soil characteristics, soil map units, climate, geology and soil-landscape relationships for the Uasin Gishu plateau were obtained from the Kenya Soil Survey (KSS) and other sources.

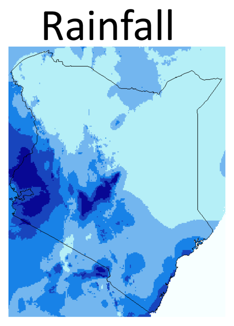
Soils



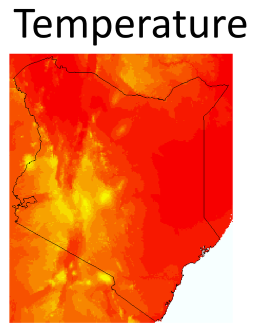
Land use



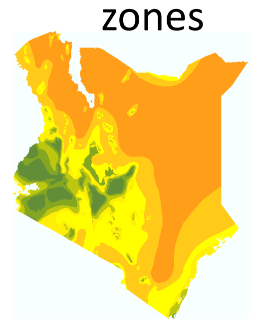
Rainfall



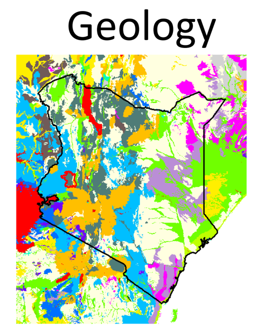
Temperature



Agro-ecological zones



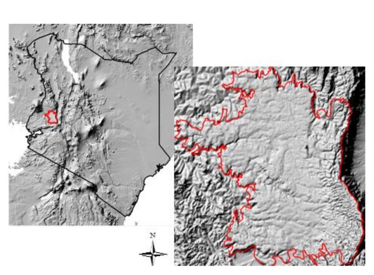
Geology



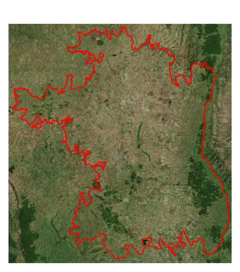
Digital elevation model (DEM) and aerial imagery

- The 30m SRTM digital elevation model and aerial imagery were obtained from the USGS Earth Explorer (http://earthexplorer.usgs.gov)
- DEM derivatives (terrain attributes) quantitatively describe how water is redistributed across the landscape to bring about different soil patterns.

30m SRTM DEM



Aerial & satellite imagery

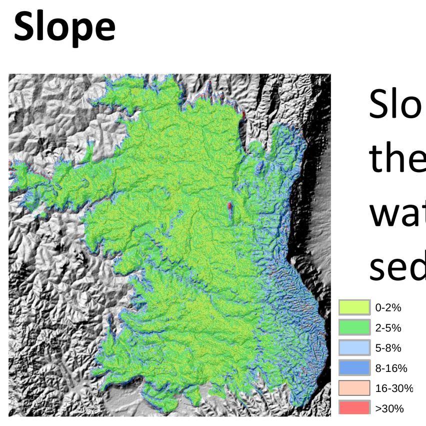


Expert knowledge and field observations

Local knowledge was acquired during the field soil survey using profile pits, auger observations, and road cuts

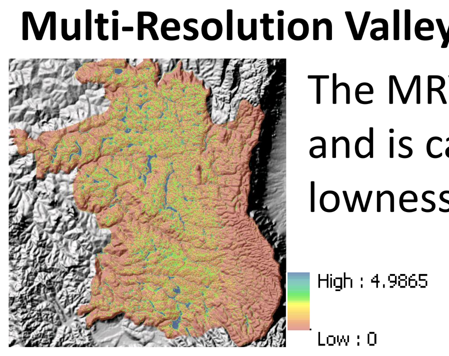
Terrain attributes

Slope



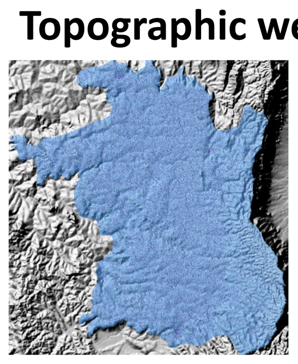
Slope influences the rate of water and sediment flows.

Multi-Resolution Valley Bottom Flatness index (MRVBF)



The MRVBF utilizes flatness of valley bottoms and is calculated as an inverse of slope and lowness.

Topographic wetness Index

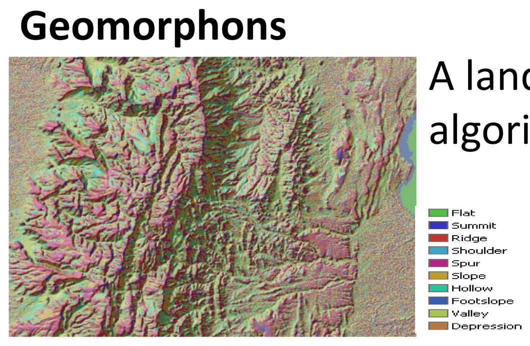


Distinguishes areas that accumulate water.

$$TWI = \ln \frac{a}{\tan b}$$

a is the upslope contributing area
b is the slope angle

Geomorphons



A landform classification algorithm

5. RESULTS AND DISCUSSION

The qualitative and quantitative soil-landscape analysis followed a catena pattern, which was interpreted as different soil patterns, or soil classes:

Summary of the catena pattern using a simple binary soil class map:

Well drained soils on uplands and mid-slopes (Ferralsols, petroferric phase (WRB))

Poorly drained soils in depressions, bottomlands and drainage ways (Gleysols (WRB))

- Integration of legacy data, expert knowledge, and terrain attributes produced a soil class map that qualitatively and quantitatively described the soil-landscape relationship.
- The soil spatial variation was captured by generating a unique prediction of the soils classes for each 30m square pixel.

6. CONCLUSIONS

- Qualitative and quantitative analysis of soil-landscape relationships is important in order to capture the different soil patterns, or variations, across landscapes.
- If climate, organisms, parent material and time are relatively uniform in a given area, soil variation is controlled by topography, or relief, which determines the energy flow and redistribution of water on a landscape to bring about different soil patterns.

7. FUTURE WORK

- Test for development of a more quantitative soil class map through the integration of additional DEM derivatives and satellite imagery (i.e., Normalized Difference Vegetation Index (NDVI))
- Accuracy assessment (validation) of the soil class maps
- Statistical analysis

8. ACKNOWLEDGEMENTS

- This project was funded by the Purdue Center for Global Food Security
- Kenya Soil Survey for providing available soils information
- University of Eldoret and other supporting organizations

9. Literature cited

- Jenny, Hans. 1941. Factors of soil formation: A system of quantitative pedology. McGraw Hill Book Company: New York, NY. 281 pp., illus.
- Milne, G (1935a) Some suggested units of classification and mapping particularly for East African soils. Soil Research, Vitoria, v.4, p.183-198.