Updating traditional soil maps with DSM techniques

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DG JRC
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Why is it important to be able to update traditional soil maps?

1. Local knowledge on soils contained in traditional soil maps

2. Usually, no associated guidelines on soil distribution rules

3. Soil surveyors are now retiring and field expertise will be lost soon

4. Due to lack of formalism of soil distribution, soil maps contain uncertainties which need to be removed
Objectives

1. ‘Extract the soil distribution rules’

Soil covariates
(RS images, DEM…)

2. Update the soil map

Original soil type map

New soil type map
Two applications

1. Updating the Asian part of the FAO Soil Map (1988)  ➤ **No change in time**

   - Soil map
   - New soil type map
   - Soil covariates

2. Updating potential soil erosion assessment  ➤ **Change in time**

   - Soil erosion map ($t_0$)
   - New soil erosion map ($t_1$)
   - Soil covariates $t_0$
   - Soil covariates $t_1$
Based on the DRIS (Diagnosis Recommendation Integrated System) Approach (Beaufils, 1973)

**Purpose:** to evaluate through indices the effect of each nutrient on the nutritional balance of the plant (agronomic issue) \(\{< 0 = \text{deficit}; 0=\text{optimal}; >0 = \text{excess}\}\)

**Premises**

(a) Ratios among nutrients are usually better indicators of nutrient deficiencies than isolated concentrations values

(b) Some nutrient ratios are more important or significant than others

(c) Maximum yield are only reached when important nutrient ratios are near the ideal or optimum values (obtained from high yielding-selected populations)

(d) As a consequence, the variance of an important nutrient ratio is smaller in a high yielding (reference population) than in a low yielding populations and the relations between variances of high and low yielding populations can be used in the selection of significant nutrient ratios

(e) The DRIS indices can be calculated individually, for each nutrient, using the average ratio deviation obtained from the comparison with the optimum value of a given nutrient ratio
Main steps of DRIS Approach

1. Dividing the population into two groups: high yield (reference population) and low yield

2. Calculation of norms using the variance largest ratio among high and low yielding populations

3. Calculation of nutrient indices based on the comparison between actual nutrient ratio and optimal nutrient ratios

Consider 3 nutrients (A), (B) and (N)

\[
\text{Index } A = \frac{\sum f(A/B) + f(A/C) + f(A/D) \ldots + f(A/N)}{Z},
\]

\[
\text{Index } B = \frac{-f(A/B) + f(B/C) + f(B/D) \ldots + f(B/N)}{Z},
\]

\[
\text{Index } N = \frac{-f(A/N) - f(B/N) + f(C/N) \ldots - f(M/N)}{Z},
\]

\[
Z = 3
\]

where

\[
F(A/B) = \frac{(A/B - 1) \times 1000}{a/b \times CV}
\]

Or, when \( A/B \) is smaller than \( a/b \),

\[
F(A/B) = \frac{(1 - a/b) \times 1000}{A/B \times CV}
\]

\[
CV = \frac{\sigma}{\mu} \times 100\%
\]
DRIS for updating soil erosion map
The original soil erosion map

Soil Map of erosion of Tamil Nadu region (NBSS & LUP, 1997)

NCSS, 07/06/06

Selvaradjou et al.
Legend transformation

Legend
- None to slight
- Moderate
- Severe
- Rock land
- Misc. land
- Water bodies
- Settlements

Soil erosion class
- 1 (none to slight)
- 2 (moderate)
- 3 (severe)
- 4 (rock and other lands)
- Urban area
- Water bodies
Soil erosion is a function of

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Predictors</th>
<th>Source</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mean annual temperature</td>
<td>WORLDCLIM 1.4</td>
<td>Hijman et al., (2006)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Methodology: Hijman et al., (2005)</td>
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<td></td>
<td></td>
<td>Methodology: Hijman et al., (2005)</td>
</tr>
<tr>
<td>4.</td>
<td>Seasonality of rainfall (variation of rainfall over the year)</td>
<td>WORLDCLIM 1.4</td>
<td>Hijman et al., (2006)</td>
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<td></td>
<td></td>
<td></td>
<td>Methodology: Hijman et al., (2005)</td>
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<tr>
<td>5.</td>
<td>Soil crusting</td>
<td>Derived from 1:5 million scale FAO-UNESCO soil map</td>
<td>FAO, 1988</td>
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<tr>
<td>6.</td>
<td>Soil erodibility</td>
<td>Derived from 1:5 million scale FAO-UNESCO soil map</td>
<td>FAO, 1988</td>
</tr>
<tr>
<td>7.</td>
<td>Soil organic carbon content</td>
<td>Derived from 1:5 million scale FAO-UNESCO soil map</td>
<td>FAO, 1988</td>
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<tr>
<td></td>
<td></td>
<td>Derived from MODIS spectral bands provided by The Global Land Cover Facility, University of Maryland: Department of Geography</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Land cover %</td>
<td></td>
<td>Townshend et al., (2001)</td>
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</tbody>
</table>
Division of the population

High yield ~ none to slight erosion \{class 1\}
Low yield ~ From slight to severe erosion \{classes 2 to 4\}

<table>
<thead>
<tr>
<th>Factor ratio expressions</th>
<th>Equilibrium domain</th>
<th>Non equilibrium domain</th>
<th>$\frac{\sigma^2_{eq}}{\sigma^2_{neq}}$</th>
<th>Choice of expression</th>
</tr>
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<tbody>
<tr>
<td>$Z_{ntemp}/Z_{meantf}$</td>
<td>0.06</td>
<td>0.07</td>
<td>0.258</td>
<td>0.728</td>
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<td>$Z_{ntemp}/Z_{ntemp}$</td>
<td>1.61</td>
<td>1.60</td>
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<td>$Z_{tseason}/Z_{ntemp}$</td>
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<td>$Z_{ntemp}/Z_{crust}$</td>
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<td>0.07</td>
<td>0.144</td>
<td>0.679</td>
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<td>$Z_{ntemp}/Z_{ooc}$</td>
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<td>$Z_{cover}/Z_{ntemp}$</td>
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<td>$Z_{ntemp}/Z_{alt}$</td>
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<td>2.596</td>
<td>1.06</td>
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<td>$Z_{ntemp}/Z_{slope}$</td>
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<td>$Z_{ntemp}/Z_{tmoles}$</td>
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<td>$Z_{ntemp}/Z_{meantf}$</td>
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<td>0.11</td>
<td>0.262</td>
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<td>$Z_{tseason}/Z_{meantf}$</td>
<td>0.09</td>
<td>0.09</td>
<td>0.326</td>
<td>0.827</td>
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<td>$Z_{crust}/Z_{meantf}$</td>
<td>0.003</td>
<td>0.004</td>
<td>0.303</td>
<td>0.889</td>
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<tr>
<td>$Z_{erod}/Z_{meantf}$</td>
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<td>0.005</td>
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<td>$Z_{meantf}/Z_{ooc}$</td>
<td>776</td>
<td>672</td>
<td>0.474</td>
<td>0.713</td>
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<tr>
<td>$Z_{cover}/Z_{meantf}$</td>
<td>0.050</td>
<td>0.05</td>
<td>0.261</td>
<td>0.926</td>
</tr>
</tbody>
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