Monitoring Spatio-Temporal Changes of Soil Carbon in Java Using Legacy Soil Data

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Introduction

• Many studies showed that soil can serve as carbon sink, but its ability differs among region and among soil depth within a region.

• In assessing the capability of soil to sequesters carbon, soil carbon stock should be first quantified for accounting SOC change.

• To account such change, long-term research may provide such comprehensive data, however in Indonesia no soil monitoring network exists yet
• Our knowledge of the amount of C lost from soils clearly affects our characterization of the global carbon budget

• This work provides the first estimates of spatio-temporal changes of soil organic carbon (SOC) over time in Java
Methods

Peter Lendert’s Database + ICALRRD

60 % Inceptisols
Intensively farmed

-average data 0-10 cm
-aggregated data per decade
-exploration data analysis:
  grouping per regency, median
-Calculate soil carbon stocks
-plot on administration/regency map
Bulk Density

\[ \rho_{\text{om}} = 0.224 \text{ g/cm}^3 \]

\[ \rho_{m} = 0.935 + 0.049 \log(\text{depth}) + 0.0055 \text{ Sand} - 0.0000653 (\text{Sand} - 38.96)^2 \]

Carbon stock in 10 cm depth or C density (kg m\(^{-2}\)) was calculated as:

\[ \text{C density (kg m}^{-2}\text{)} = \left(\frac{\text{C}\%}{100}\right) \times \rho_b (\text{kg m}^{-3}) \times \text{soil depth (m)} \]

Carbon stock for each kabupaten (in kg) was calculated as:

\[ \text{C stock (kg)} = \text{C density (kg m}^{-2}\text{)} \times \text{Area of the kabupaten (m}^2\text{)} \]
Fig 1. Soil Observation Density per Regency in Java
**Results**

Fig. 2. Soil organic C content (%) over time for top soils (0-10 cm) in Java

Initial drop due to high conversion to plantation & food crops == rapid decline SOC 1.5% to 1960/70

Increase SOC after 1970 due to: Government program & farmer effort to remediate soil fertility: fertilizer addition, residue management, etc == SOC rise to 1.1% in 2000

**1930-1940, median SOC 2.11 % and decrease 0.75 % in 1970-1980**

<table>
<thead>
<tr>
<th>Obs.year</th>
<th>No.obs</th>
<th>C content (g⁻¹)</th>
<th>C stock (kg.m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum</td>
<td>Median</td>
</tr>
<tr>
<td>1930 - 1940</td>
<td>282</td>
<td>0.35</td>
<td>2.11</td>
</tr>
<tr>
<td>1940 - 1950</td>
<td>183</td>
<td>0.13</td>
<td>1.79</td>
</tr>
<tr>
<td>1950 - 1960</td>
<td>437</td>
<td>0.04</td>
<td>1.15</td>
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<tr>
<td>1960 - 1970</td>
<td>434</td>
<td>0.07</td>
<td>0.76</td>
</tr>
<tr>
<td>1970 - 1980</td>
<td>223</td>
<td>0.09</td>
<td>0.75</td>
</tr>
<tr>
<td>1980 - 1990</td>
<td>209</td>
<td>0.06</td>
<td>0.79</td>
</tr>
<tr>
<td>1990 - 2000</td>
<td>77</td>
<td>0.31</td>
<td>1.08</td>
</tr>
<tr>
<td>2000 - 2010</td>
<td>157</td>
<td>0.24</td>
<td>1.18</td>
</tr>
</tbody>
</table>

Then Median SOC increase 1.18 %; The rapid SOC loss during initial period to 1970—SOC slowly stabilize since 1970
Fig. 3. The evolution of organic C content for the top 10 cm soil in Java
Fig. 4. The changes in C stock over successive period for the top 10 cm soil in Java.
Summary & Conclusion

- Our study has demonstrated the use of legacy soil data particular point soil observation in monitoring spatio-temporal dynamic of SOC in Java.
- Making, improving and populating soil information system that manage legacy soil data should be promoted so that assessment soil carbon budget can be improved and extended.
- There need to be a coordinated effort to compile all existing soil databases into a national database.
Summary & Conclusion

- SOC in Java decrease up to 1970 and then increase after that time. There is also found that carbon stock change differ among region kabupaten in time and in magnitude reflecting different time adoption of best land management practices in addition to land use.
- Our analysis suggests that the human influence and agricultural practices on SOC in Java have been a stronger influence than the environmental factors.
- SOC for the top 10 cm has a nett accumulation rate of 20-30 g C m⁻² year⁻¹ (0.2 – 0.3 ton C/ha.year) during the period 1990-2000. These findings raise optimism for increased soil carbon sequestration in Indonesia.
Thank You