Sustainable Management and Carbon Sequestration in Soils of Africa

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SOC AND SOIL HEALTH

Physical
I. Water
- Increase retention
- Decreases drought
- Reduces runoff and erosion
- Decreases infiltration
- Improves filtration
II. Structure
- Increases aggregation
- Improves aeration
- Reduces crusting and compaction
- Improves tilth

Chemical
I. Soil Fertility
- Reservoir of plant nutrients
- Increases N, P, S
II. CEC
- Increases buffering
- Decreases leaching
- Increases surface area

Ecological
I. Elemental Cycling
- Improves cycling (N, P, S)
- Increases physio-chemical activity
- Increases use efficiency of N, P, S, H₂O
II. Productivity
- Increases productivity
- Improves produce quality
- Enhances stability

Biological
I. Biodiversity
- Improves soil biota
- Increases cycling
- Provides energy
II. Activity
- Increase MBC
- Increases biopores

Lal (2016)
Threshold/Critical Level/Tipping Point: Soil processes and properties have threshold levels. Beyond threshold level, there is a drastic regime change. What is the threshold level of SOC in the root zone and profile for major soils of Africa for principal land uses?
## Crop Yield Increase With Increase in SOC by 1Mg C/ha

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield Increase (kg/ha/Mg C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>100 - 300</td>
</tr>
<tr>
<td>Soybean</td>
<td>20 - 50</td>
</tr>
<tr>
<td>Wheat</td>
<td>20 - 70</td>
</tr>
<tr>
<td>Rice</td>
<td>10 - 50</td>
</tr>
<tr>
<td>Sorghum</td>
<td>80 - 140</td>
</tr>
<tr>
<td>Millet</td>
<td>30 - 70</td>
</tr>
<tr>
<td>Beans</td>
<td>30 - 60</td>
</tr>
</tbody>
</table>

*Lal, 2005*
SOIL EROSION AS A CARBON SOURCE

World…….. 1.1 Pg C/y
USA…….. 15 Tg C/y
Brazil…….. 60 Tg C/y
India…….. 4.8 - 7.2 Tg C/y
Iceland….. 0.01-0.02 Tg C/y

(60-250 Tg C/1000 yr)

Emission Avoidance by Conservation-Effective Measures
GLOBAL POTENTIAL OF SOC SEQUESTRATION (Pg C/YR)

Cropland: 0.4-1.2

Grazing land: 0.3-0.5

Salt-affected soils: 0.3-0.7

Desertified soils: 0.2-0.7

Total: 1.2-3.1

Lal (2010)
Creating Positive C Budget

Soil Carbon Sequestration
- Biochar
- Compost
- Cover Crops
- Root Biomass
- Crop Residues

Gains: Erosion, Leaching, Decomposition

Gains: Residue, Compost, Root Biomass

Losses: Erosion, Leaching, Decomposition

Soil Carbon Depletion

Losses
TECHNOLOGICAL OPTIONS FOR SOIL CARBON SEQUESTRATION

Conservation Agriculture
- No-till
- Residue mulch
- Integrated nutrient management
- Cover cropping

Use of Organic Amendments
- Compost
- Manure
- Biochar
- Vermiculture

Technological Options to Create a Positive Soil C Budget

Agroforestry

Complex Farming Systems by Integration of Cropping with:
1. Livestock
2. Trees
3. Urban Ecosystems
4. Biofuel Plantations

Restoration of Degraded Lands
- Eroded landscapes
- Salinized lands
- Mined lands
- Depleted lands

Organic Agriculture

Ecological Restoration

Farmscaping
SOIL MICROAGGREGATE FORMATION (<250 µm) AND SOM STABILIZATION (MRT)

Strongly sorbed polymer

Cation bridges

(Redrawn from Tisdall and Oades, 1982. Soil Sci 33:141-163)
Mining C has the same effect on global warming whether it is through mineralization of soil organic matter and extractive farming or burning fossil fuels or draining peat soils.

Soil can be a source or sink of GHGs depending on land use and management.

The potential of elite varieties can be realized only if grown under optimal soil conditions.

Even the elite varieties cannot extract water and nutrients from any soil where they do not exist.

Soil are integral to any strategy of mitigating global warming and improving the environment.

Sustainable management of soils is the engine of economic development, political stability and transformation of rural communities in developing countries.

Sustainable management of soil implies the use of modern innovations built upon the traditional knowledge.

The biophysical process of soil degradation is driven by economic, social and political forces.

Vulnerability to degradation depends on “how” rather than “what” is grown.

When people are poverty stricken, desperate and starving, they pass on their sufferings to the land.

It is not possible to take more out of a soil than what is put in it without degrading its quality.

Only by replacing what is taken can a soil be kept fertile, productive, and responsive to management.

Marginal soils cultivated with marginal inputs produce marginal yields and support marginal living.

Plants cannot differentiate the nutrients supplied through inorganic fertilizers or organic amendments.

The strategy is of producing more from less.
The answer lies in harnessing the power of agriculture, soil, and natural resources.

Improved Agriculture Matters

Through targeted and efficient use of existing resources.
Priorities for SOC research in Africa are to establish:

1. Critical levels for diverse land uses and eco-regions,
2. Rates of net SOC sequestration and societal value,
3. Ecosystem services provisioned by SOC,
4. Transects across land uses and ecoregions,
5. Synergies between 4PT and AAA
Depleting Soil Organic C Pool, Degrading Soils, Recurring Drought, Marginal Use Efficiency of Fertilizers and Other Inputs, Low Crop Yields, Perpetual Poverty and Hunger, High Infant Mortality Due to Hunger and Malnutrition are as Real Threat to Global Peace and Security as are ICBMs and Nuclear Weapon Proliferation Because the Health of Soil, Plants, Animals, People and Ecosystems are One and Indivisible