Food and Agriculture Organization of the United Nations

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INTERGOVERNMENTAL TECHNICAL PANEL ON SOILS

CAN CARBON (SOC) offset the Climate Change

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Climate, soils, biophysical and socio-economic systems are interconnected in complex ways. Contemporary discussions had been heavily focused on curbing emissions of fossil fuels. But a look at soil brings a sharper focus on potential carbon sinks. Reducing emissions is crucial, but soil carbon sequestration needs to be part of the picture. The relationship between climate change and soil carbon resources is of key concern to human society. **Current soil management practices may not be robust enough to cope with the impacts of climate change**. In many locations, soil management cannot satisfactorily cope even with current climate variability.

Jones (2006)
"Listen for a while
Earth is lying naked and barren
Crying for help without words
Calling so softly for carbon
There is no time to bargain"

Sustainable soil management practices can turn back the carbon clock, reducing atmospheric CO2. Recent advances in our understanding of carbon dynamics in soil allow us to design management systems that maximize the possibility of increasing soil organic carbon. Some key points from this recent research include:

- The location of SOM within the soil matrix has a much stronger influence on its turnover than its chemical composition.
- The accumulation of stabilised C with long residence times in deep soil horizons may be due to continuous transport, temporary immobilisation and microbial processing of DOC within the soil profile (Kalbitz and Kaiser, 2012) and/or efficient stabilisation of root-derived organic matter within the soil matrix (Rasse et al., 2005).
- Forest fires produce pyrogenic carbonaceous matter (PCM), which can contain significant amounts of fused aromatic pyrogenic C (often also called black C), some of which can be preserved in soils over centuries and even millennia. This was found to be the reason for similar soil organic C contents modelled for scenarios with and without burning in Australia: the loss in litter C input by fire was compensated by the greater persistence of the pyrogenic C (Lehmann et al., 2008).

Recognition of the vital role played by soil carbon could mark an important if subtle shift in the discussion about global warming, which has been "CO2 cannot be reduced to safe levels in time to avoid serious long-term impacts unless the other side of atmospheric CO2 balance is included" (Goreau,2014). The 2015 Status of the World's Soil Resources report highlights that more carbon resides in soil than in the atmosphere and all plant life combined; there are approximately 2,500 billion tons of carbon in soil, compared with 800 billion tons in the atmosphere and 560 billion tons in plant and animal life (Lal, 2015). And compared to many proposed geoengineering fixes, storing carbon in soil is simple: It's a matter of returning carbon where it belongs.

The ITPS identifies SOC as one of its four priorities for action:

"The global stores of soil organic matter (i.e. soil organic carbon (SOC) and soil organisms) should be stabilized or increased. Each nation should identify locally appropriate SOC-improving management practices and facilitate their implementation. They should also work towards a national-level goal of achieving a stable or positive net SOC balance. "

Key findings of the ITPS's SWSR report:

Conversion of forests, pastures, or grasslands to cropland in temperate and tropical regions leads to a loss of SOC of approximately 25 to 35%; conversion of croplands to these other land uses leads to a comparable increase in SOC.

The conversion of peatlands to cropland through drainage and other management tools leads to very high emissions of SOC to the atmosphere.

Soil sealing can greatly reduce SOC levels in effected areas. Soil carbon storage potential is fundamentally altered, particularly where topsoil, which normally contains about half of the organic carbon in mineral soils, is stripped off.

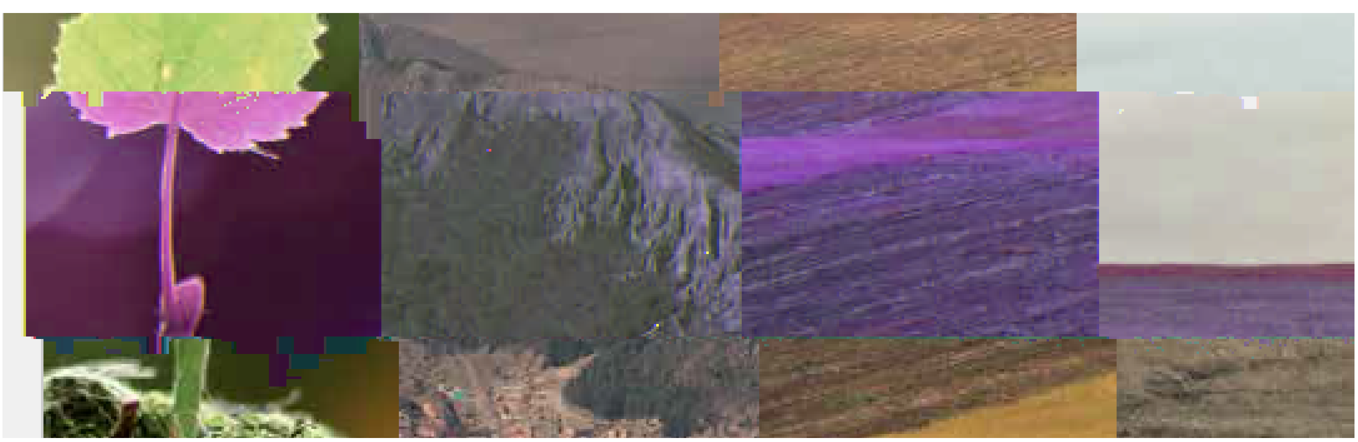
The greatest obstacle to improving SOC sequestration in Sub-Saharan Africa region is the lack of residues produced due to the low productivity of the soils. The limited supply of crop residues also highlights the need to make optimum use of all sources of organic inputs, such as animal manure and properly processed human wastes.

Carbon, N and P cycling in soils is tightly coupled because of the relatively fixed ratios of carbon, nitrogen, and phosphorus (C:N:P) in plants and microorganisms. This means that an enduring increase of carbon in soils cannot be achieved without a proportional increase in nitrogen and phosphorous (and several other nutrients). This is a fundamental consideration in any programs for carbon sequestration and land restoration because of the significant costs. Therefore, management of C and these associated nutrients needs to be planned in concert.

Management practices effective in increasing SOC stocks include: (i) improved plant productivity through nutrient management, rotations and improved farming practices; (ii) reduced or conservation tillage and residue management; (iii) more effective use of organic amendments; (iv) land use change, for example from crops to grass or trees; (v) set-aside; (vi) agroforestry; (vii) optimizing livestock densities; and (viii) planting legumes or improving the crop mix.

Across the globe, status of SOC summarized as:

Based on the seven regional assessments completed for the 2015 State of the World's Soil Resources report, the ITPS concluded that the current state of Soil Organic Carbon is Poor in six regions (Africa South of the Sahara, Asia, Europe and Eurasia, Latin America and the Caribbean, Near East and North Africa, and the Southwest Pacific) and Fair in North America. The trend for SOC is judged to be deteriorating in Africa South of the Sahara, Latin America and the Caribbean, and Near East and North Africa, variable in Asia, Europe and Eurasia, and the Southwest Pacific, and improving in North America.



Africa South of the Sahara

Africa's current major negative role in the global carbon cycle can be attributed to the substantial releases of carbon associated with land use conversion from forest or woodlands to agriculture. Appropriate land management could reverse the trend of SOM decline and contribute to soil carbon sequestration. In fact, increasing the SOM content is crucial for future African agriculture and food production. Several studies on SSA have shown that a synergetic effect exists between mineral fertilizers and organic amendments and that this synergy leads to both higher yields and higher SOC content.

Asia

Data for evaluating soil organic carbon change in Asian countries are limited because countries do not generally monitor SOC stock and changes. However, data from available literature show that where there are increases in crop yield in croplands of East and Southeast Asia, SOC is retained. SOC has also been shown to accumulate in forest areas. However, in South Asia SOC is decreasing. This is because crop residues are widely used as

Europe and Eurasia

Intensive and continuous arable production may lead to a decline of soil organic matter. In 2009, European cropland emitted an average of 0.45 tons of CO_2 per hectare, much of which resulted from land conversion soil.

Latin America and the Caribbean

Land use changes from forestry to urban or livestock use cause the greatest loss of soil carbon in LAC.

Near East and North Africa

There is very little information in the region relating to changes in soil organic carbon (SOC). The prevailing arid and semi-arid conditions combined with high temperatures result in very low inherent contents of SOC in most of the region.

North America

Models of SOC changes (and limited field data) currently show increases in the US and Canada. These increases in SOC are primarily due to less intensive agriculture and reduced tillage intensity. The effects of reduced tillage differ across sub-regions: for example, in the past two decades, no-till (NT) increased the storage of SOC in Mollisols (Chernozems) of the two Prairie ecoregions in Canada by about 3 Mg ha–1 but in the moister soils of central and eastern Canada, conversion to NT did not increase SOC.

Southwest Pacific

A 2010 review of replicated Australian field trials concluded that although the implementation of more conservative land-management practices will lead to a relative gain in soil carbon, absolute soil carbon stocks may still be on a trajectory of slow decline. Studies of current C stocks and the potential saturation value for the soils of New Zealand suggest there is an opportunity to increase the C stock of pastoral soils by increasing the C input rate, including deeper plant roots. Only a few studies of soil carbon dynamics have been undertaken in the countries of the Pacific.

Epilogue

A loss of soil organic carbon (SOC) due to inappropriate land use or the use of poor soil management or cropping practices can cause a decline in soil quality and potentially lead to emissions of C into the atmosphere (Lal, 2004). On the other hand, appropriate land use and soil management can lead to increased SOC and improved soil quality that can partially mitigate the rise of atmospheric CO_2 (Paustian et al., 1997, Lal and Bruce, 1999; Lal, 2004). Out of numerous strategies suggested for obtaining ecological balance and resource conservation along with sustainable crop production, putting carbon back kind of interventions have been found to bear immense potential. Appropriate land use systems have the potential to decrease soil erosion, maintain soil organic matter (SOM) and physical characteristics, augment N buildup through N_2 fixing trees and promote efficient nutrient cycling, where trees are integrated extensively with crop.

Land use and soil management may affect SOM fractions, but the magnitude of these changes is poorly known. Therefore, more explicit account needs to be taken of the impact of soil type, management and local climate on SOC accumulation rates, labile pools of SOC and on suitability of land for different land management options (Smith et al., 2000). Because of the current interest in characterizing, predicting, and potentially managing soil C dynamics and sequestration, greater attention is currently being on certain fractions of SOC which are likely to respond more rapidly than total soil C to land use change and management. It has been shown that C and N present in particulate organic matter (POM) can accumulate rapidly under land management systems that minimize soil disturbance and may also provide an early indicator of changes in C dynamics and total soil C under different land use and management practices (Cambardella and Elliott, 1992; Franzluebbers and Arshad, 1997; Franzluebbers and Stuedemann, 2002). Furthermore, differences in C fractions under different land use practices can yield important information about the mechanisms of C sequestration (Six et al., 2002).

Intergovernmental Technical Panel on Soils - ITPS

The ITPS is composed of 27 top soil experts representing all the regions of the world. The main function of the ITPS is to provide scientific and technical advice and guidance on global soil issues to the Global Soil Partnership primarily and to specific requests submitted by global or regional institutions. The ITPS will advocate for addressing sustainable soil management in the different sustainable development agendas.

Global Soil Partnership - GSP

The GSP aims to improve governance of the limited soil resources of the planet in order to guarantee healthy and productive soils for a food secure world, as well as support other essential ecosystem services, in accordance with the sovereign right of each State over its natural resources. It also develops awareness and contribute to the development of capacities and facilitate/contribute to the exchange of knowledge and technologies among stakeholders for the sustainable management and use of soil resources

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