IEAGHG Information Paper; 2014-IP11: Soil Organic Carbon Sequestration

A recent paper by Sommer and Bossio[1] on the dynamics and climate change mitigation potential of soil organic carbon (SOC) sequestration puts data published in other publications into perspective, indicating that the potential might be lower than previously thought.

According to Sundermeier et al. (2004)[2], soil organic carbon sequestration is the process of transferring CO_2 from the atmosphere into the soil through crop residues and organic solids, in a form that it is not immediately re-emitted. It can be accomplished by several land management practices, continuous no-till farming being a prime example.

The following sections provide a summary of the paper by Sommer and Bossio (please note that the concerned publication uses tonnes of carbon and not tonnes of CO_2).

Each year, land use change (incl. deforestation, burning of forests, soil degradation and loss of SOC) sets free about 2 Gt of carbon. Estimations exists that the upper 1m of soils holds about 2000-2500 Gt of carbon, with 60% being SOC, which is about three times the amount of carbon bound in the aboveground biomass.

This leads to the assumption that soils could act as major carbon sinks. However, carbon storage capacity of soils is limited as many ecosystems are already at equilibrium. Mainly soils, in which SOC has been depleted in the past centuries, show potential for SOC sequestration. Hence, not all soils can be turned into notable carbon sinks and within a desired timescale because implementation of SOC will take considerable time.

The two main questions that the authors want to answer in their paper are:

1) What is the annual per hectare sequestration potential of arable land and pastures?
2) How quickly can worldwide effort be put into place?

The authors developed a pessimistic and an optimistic SOC sequestration scenario, which differ in terms of sequestration rates and assumed increase in included land area. A key objective of the study is to address the dynamic nature of soil organic carbon sequestration.

Figure 1 shows the main results of the paper, i.e. the SOC sequestration potential as a function of time. SOC sequestration is highly dynamic, as sequestration rates start at a modest level and peak at a maximum value around 2035. Then they decrease significantly again as less new land will be available for sequestration and soils saturate with carbon. This illustrates that SOC will increase only over a limited time, up to the point where a new SOC equilibrium is reached. In addition, adoption of SOC sequestration measures will take time, as such schemes can only be implemented gradually at a large scale.

The projected 87-year (2014-2100) global SOC sequestration potential of agricultural land ranges between 32 and 64 Gt C (this translates to 1.9-3.9% of projected emissions of the IPCC Special

---

[1] Sommer, R. and Bossio, D. Dynamics and climate change mitigation potential of soil organic carbon sequestration. Journal of Environmental Management 144 (2014), 83-87. http://www.sciencedirect.com/science/article/pii/S0301479714002588 (open access)

[2] Sundermeier, A., Reeder, R. And Lal, R. Soil carbon sequestration fundamentals. Science 304 (2004), 1623-1627.

Report on Emissions Scenarios storyline family A2 (SRES-A2)[3] or 4.4-8.9% of annual global emissions in 2009).

Analysis of SOC sequestration by country shows the highest potential for China, USA, India and Russia but global potential over the 87-year period is still modest: 1.8-3.1 Gt C in the pessimistic and 3.7-6.4 Gt C in the optimistic scenario (numbers are per country). 30 years after starting SOC sequestration the rates would halve, thus SOC sequestration is not a measure that can contribute significantly towards mitigating climate change on a constant basis.

Subsequently, the authors discuss the deviation between their findings and a study by Smith et al. (2008)[4]. Smith et al. included further management practices (such as agroforestry, restoration of organic soils or degraded lands), which added significantly to the carbon sinks, thus SOC sequestration potential in Smith et al. is 5-15% of total global C emissions, compared to 4.4-8.9% in this study.

Finally, Sommer and Bossio address the limitations of their study. They did not consider the importance of maintaining or increasing SOC for sustaining soil health, agro-ecosystem functioning, and productivity. In addition, CO_2 emissions from drain peat/wetlands and CH_4 emissions from thawing permafrost soils could outweigh any SOC sequestration efforts. Analysis of the economic viability of SOC sequestration, permanence of the sink and its eligibility for the Clean Development Mechanism (CDM) were beyond the scope of this study but are important areas for future studies.

My conclusion after reading this publication is that although the potential might be lower than previously thought and there are open questions regarding the permanence, SOC sequestration should be implemented because it can also improve soil quality, agricultural productivity and help move towards more sustainable land management practices. In addition, we need every option feasible to reach our climate change mitigation targets.

Jasmin Kemper
08/07/14

[3] IPCC (Intergovernmental Panel on Climate Change (IPCC), 2000. IPCC Special Report Emissions Scenarios. Summary for Policy Makers. A Special Report of IPCC Working Group III. 27 pp.

[4] Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O'Mara, F., Rice, C., Scholes, B., Sirotenko, O., Howden, M., McAllister, T., Pan, G., Romanenkov, V., Schneider, U., Towprayoon, S., Wattenbach, M., Smith, J. Greenhouse gas mitigation in agriculture. Phil. Trans. R. Soc. B 363 (2008), 789-813.

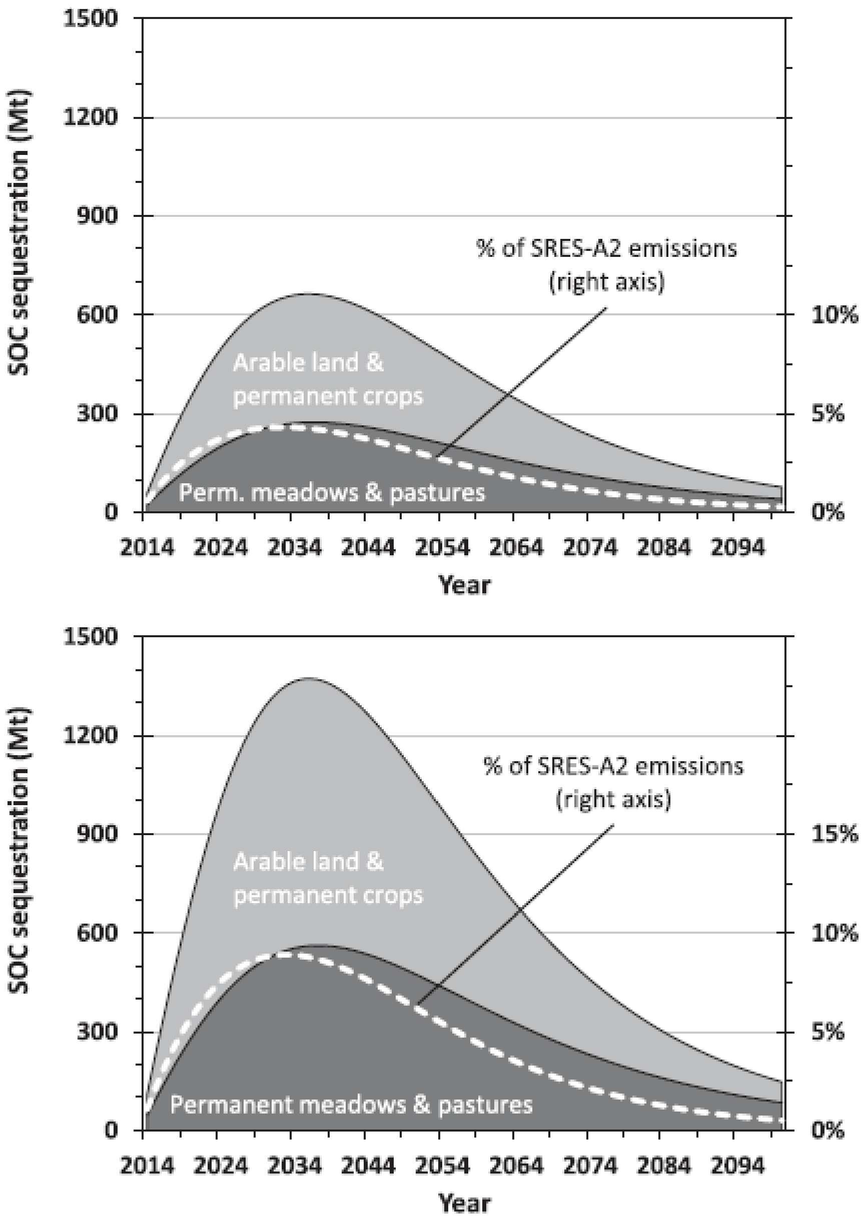

Figure 1 Temporal dynamics of SOC sequestration potential under pessimistic (top) and optimistic (bottom) assumptions (Sommer and Bossio, 2014)