Soil and Climate

Rattan Lal
President of International Union of Soil Sciences 2017-2018
Carbon Management and Sequestration Center
The Ohio State University
Columbus, OH 43210

World soils play an important role in the global C cycle. The soil C stock comprises of two related but distinct components: soil organic C (SOC) and soil inorganic C (SIC). The global SOC stock (Pg = 1 billion ton = Gt) is estimated at 704 for 0.3-m, 1505 for 1-m and 3300 for 2-m depth. The SIC stock (Pg) is estimated at 234 for 0.3-m, 722 for 1-m, and 1700 for 2-m depth. Thus, total soil C stock to 2-m depth is 5000 Pg. In addition, soils of the permafrost contain 1400-1700Pg. Thus, total soil C stock of ~6500 Pg is 8.1 times the atmospheric C stock of 800 Pg and 10.5 times that of the biotic C stock (620 Pg).

Soil can be a source or sink of atmospheric CO_2 depending upon land use and management. Conversion of natural into managed (agricultural, urban, etc.) ecosystems can deplete the SOC stock. The magnitude of depletion depends on the historic land use, management, and vulnerability to erosion and other forms of degradation.

Soils of managed ecosystems, and those prone to degradation and depletion, have a potential C sink capacity. The strategy to recarbonization of the soil is based on the concept of creating a positive soil C budget. This implies that input of biomass-C into the soil (e.g. crop residues return, cover cropping, manuring) exceeds the losses caused by erosion, decomposition and leaching. Managing soils for increasing C stock, called “soil C sequestration” refers to that of SOC or SIC. Within a landscape unit sequestration of SOC is a preferred option in humid, sub-humid, and semi-humid climates. However, sequestration of SIC, as secondary carbonates or leaching of bicarbonates, can be an option in arid and semi-arid regions and in irrigated soils.

Techniques of SOC sequestration include conservation agriculture, cover cropping, agroforestry, controlled grazing, improved pastures, integrated nutrient management, biochar etc. The rate of SOC sequestration may range from 0.1 to 1.0 MgC/ha.yr depending on climate, soil and land use. The rate of SIC sequestration as secondary carbonates may be 2-5 kg/ha.yr.

The global technical potential of SOC sequestration (PgC/yr) is estimated at 0.4-1.2 for cropland, 0.3-0.5 for grasslands/grazing lands, 0.3-0.7 for restoration of salt-affected soils and 0.2-0.7 for desertification control and avoiding soil erosion. Thus, the total technical potential of SOC sequestration is 1.2-3.1 PgC/yr or an average of 2.2 PgC/yr. In addition, there is a potential of SIC sequestration and in the vegetation biomass. The total potential of world soils to sequester C is about 80-100 Pg, equivalent to atmospheric CO_2 drawdown of 40 to 50 ppm over 25 to 50 years.

In addition to mitigating the climate change, soil C sequestration has numerous co-benefits. Important among these are: improving food and nutritional security, increasing renewability and quality of water, enhancing biodiversity etc. Thus, soil C sequestration is a win-win-win option.