Of the 9.9 Pg C yr^{-1} emitted into the atmosphere, only 4.2 Pg of 43.75 percent of the anthropogenically emitted CO_2 remains in the atmosphere primarily owing to unspecified terrestrial sinks that sequester atmospheric CO_2 and play an important role in the global C cycle. Terrestrial ecosystems comprise a major C sink owing to the photosynthesis and storage of CO_2 in live and dead organic matter. Terrestrial C sequestration is often termed as a win-win or no-regrets strategy (Lal *et al.*, 2003) because of its numerous ancillary benefits (e.g. improved soil and water quality, restoration of degraded ecosystems, increased crop yield). It offers multiple benefits even without the threat of global climate change.

Sequestration of CO_2 by plants occurs both in terrestrial and inland aquatic ecosystems (or wetlands). CO_2 sequestration in terrestrial ecosystems is significant in protected areas and in extensively and intensively managed land-use systems, but to different degrees depending on vegetation, soil types and conditions. Managed ecosystems include the world's croplands, grazing lands, forest lands and urban lands. Restoration of degraded/desertified lands, and drastically disturbed ecosystems (i.e. mined lands) comprise an important sink for atmospheric CO_2. Important strategies for aquatic ecosystems are the management and restoration of wetlands (peat soils and their permanent vegetation). Although fertilization of oceans using iron is technically possible, there are environmental concerns (Kintisch, 2001).

Natural processes of C sequestration in terrestrial and aquatic ecosystems (e.g. soils, vegetation, wetlands) contribute to increased biomass, improved soil health and function, including nutrient cycling, water infiltration, soil moisture retention as well as water filtration and buffering in wetlands. Thereby these processes enhance the resilience of ecosystems and the adaptation of these systems to climatic disruptions with the attendant changes in temperature, precipitation and frequency and intensity of extreme events.

Most soils under the managed ecosystems contain a lower SOC pool than their counterparts under natural ecosystems owing to the depletion of the SOC pool in cultivated soils. The most rapid loss of the SOC pool occurs in the first 20-50 years of conversion from natural to agricultural ecosystems in temperate regions and 5 10 years in the tropics (Lal, 2001). In general, cultivated soils normally contain 50-75 percent of the original SOC pool. The depletion of the SOC pool is caused by oxidation or mineralization, leaching and erosion. Thus, soil C sequestration implies increasing the concentration/pools of SOC (and SIC as secondary carbonates) through land-use conversion and adoption of recommended management practices (RMPs) in agricultural, pastoral and forestry ecosystems and restoration of degraded and drastically disturbed soils. Formation of charcoal and use of biochar as a fertilizer is another option (Fowles, 2007). In contrast with geological sequestration, which implies injecting CO_2 at a depth of 1–2 km, the SOC sequestration involves putting C into the surface layer at a depth of 0.51 m using the natural processes of humification.

Technical potential of soil carbon sequestration using recommended management practices

Transfer of atmospheric CO_2 into the pedologic pools by use of judicious management of soils and vegetation, involves numerous agronomic interactions. Principal agronomic techniques include:

- reduction or elimination of mechanical tillage and adoption of no-till (NT) or minimum till;
- use of crop residues or synthetic materials as surface mulch in conjunction with incorporation of cover crops into the rotation cycle;
- adoption of conservation-effective measures to minimize soil and water losses by surface runoff and accelerated erosion bioengineering;

- enhancement of soil fertility through integrated nutrient management (INM) that combines practices for improving organic matter management (in situ), enhancing soil biological processes involving biological nitrogen fixation (BNF), and mycorrhizae, and additions of organic wastes (biosolids, slurry) and synthetic fertilizers;

- conservation of water in the root zone to increase the green water component by reducing losses through runoff (blue water) and evaporation (grey water), and increasing use efficiency through application of drip irrigation/fertigation techniques;

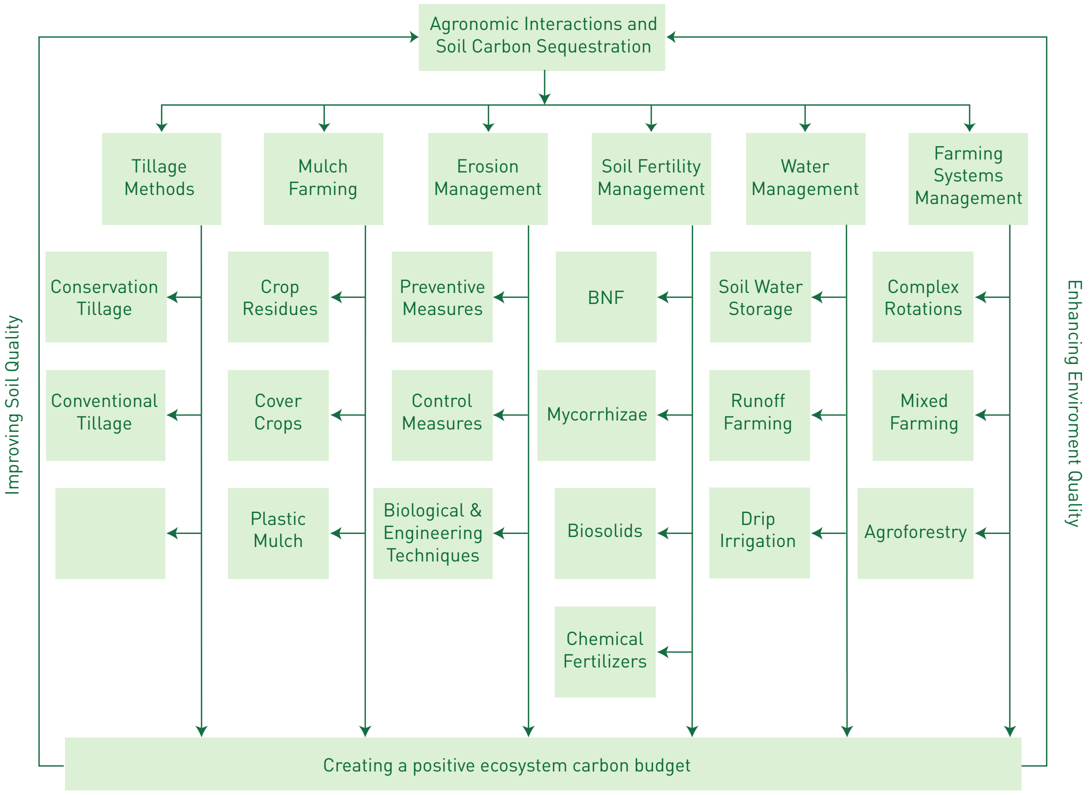
- improvement of grazing systems that enhance the diet of livestock and reduce their enteric emissions; and

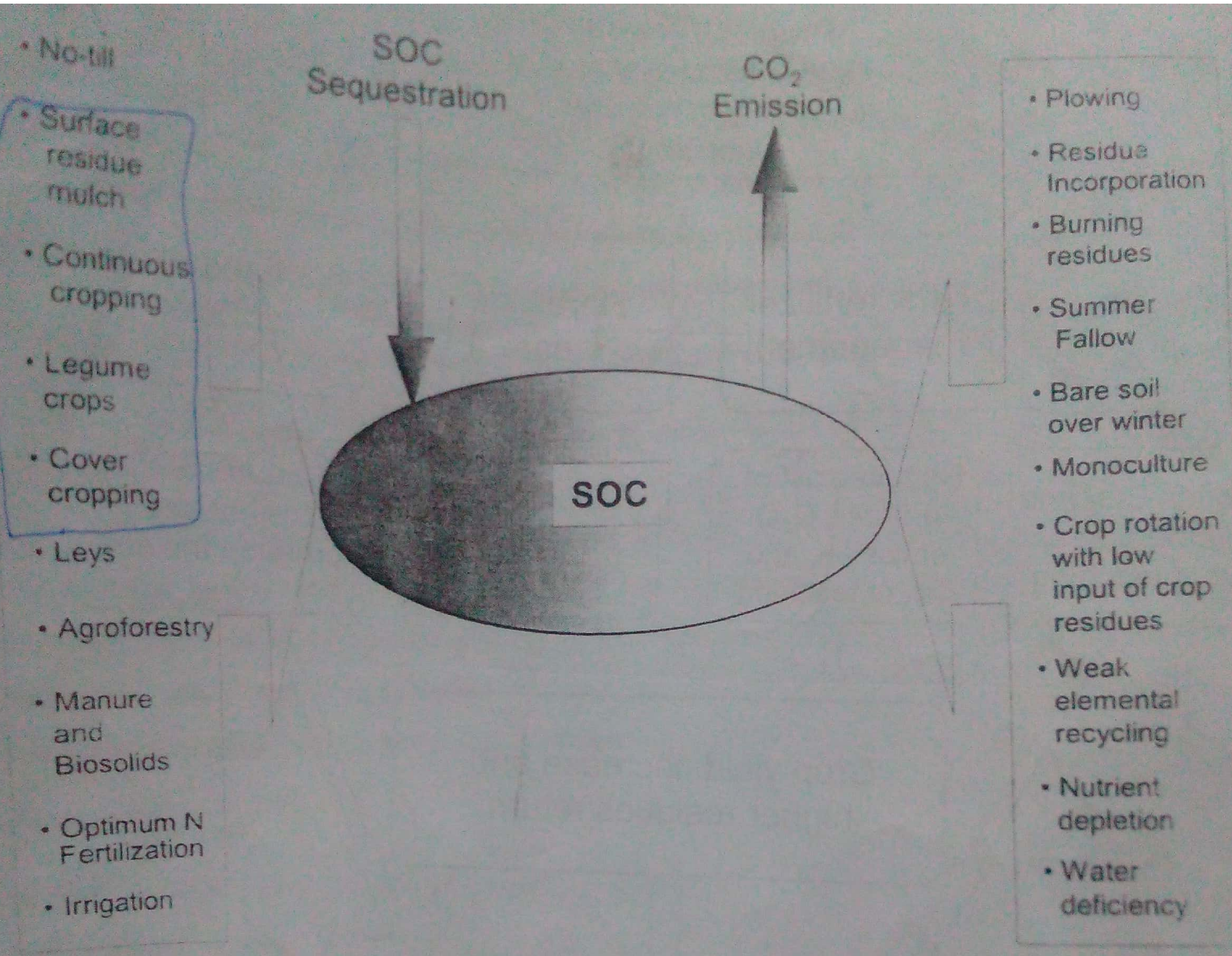
- better use of complex farming systems including mixed crop-livestock and agroforestry techniques that efficiently use resources, enhance biodiversity and mimic the natural ecosystems.

The objective of these agronomic interactions (Figure 3) is to create a positive C budget, and improve the quality and productivity of natural resources. The overall goal of sustainable management of soil, water and biological resources is to strengthen and accelerate the coupled cycles of H_2O, C, N, P, and S. Strengthening of these interlinked cycles enhances the resulting ecosystem services by increasing the soil C pool, improving soil biological activity, increasing net primary productivity (NPP), decreasing losses from erosion and leaching, and increasing the humification efficiency.

Strategies for increasing the SOC pool are outlined in Figure 3.

FIGURE 3: **RECOMMENDED MANAGEMENT PRACTICES TO SEQUESTER CARBON IN SOILS**





Effect of crop management practices on SOC sequestration.