

Table 2. Differences between the stratospheric ozone and climate change problems

Stratospheric ozone depletion	Climate change
20 countries were involved in the original negotiations	~180 countries participate in climate negotiations
Clinching scientific evidence in the form of 'Antarctic ozone hole'	No smoking gun; evidence is incremental and cumulative
Term 'ozone hole' is evocative	Term 'climate change' is neutral
All countries expect to lose	Both losers and (at least initially) winners
Three scientific assessment panels inside the formal Montreal Protocol process for advice	Three IPCC Working Groups outside the formal Convention Process provide advice
US (and UNEP) leadership	EU leadership
US Senate ratified Montreal Protocol 87–0	US Senate opposed Kyoto Protocol 95–0
Costs of developing substitutes reasonable	Substitutes to fossil fuels for electricity and transport currently expensive
Developing countries were perceived by northern countries to be aid recipients	Developing countries perceived to be competitive threats
Northern legislatures willing to transfer technology and resources to developing countries	Northern legislatures unwilling to transfer technology and resources to developing countries

hole. Scientists have identified several potential candidates of such 'tipping elements' in the Earth's climate system where tiny perturbations can qualitatively alter the state or evolution of the system¹⁴. Monsoon is one of the well-known 'tipping elements'. Burns *et al.*¹⁵ have shown that monsoon transitions from dry to wet have occurred very rapidly in the Indian Ocean about 50,000 years ago. Data from the Socotra Island in the Indian Ocean have shown that the transition from weak to strong monsoon can occur in less than 25 years. This shows that concerns about abrupt climate change in the 21st century are serious¹⁶.

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- While the globe can be warming on an average, climate change allows for the possibility that local cooling can occur because of say, changes in persistent wind directions. Besides changes in surface air temperatures, climate change allows for changes in precipitation and in mean sea level. Unlike stratospheric ozone depletion which had only negative impacts, the expression climate change connotes both negative or positive regional impacts, such as a longer growing season in temperate zones.
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Soil fertility in physically degraded lands: are we overestimating?

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During the green revolution, intensive agriculture increased food production on one hand and decreased soil fertility on the other. But reduced soil fertility is currently threatening the total food production of the country by stagnating or reducing productivity. It is now obvious that if high productivity has to be sustained, not only should the productive capa-

cities of cultivated lands be increased, but hitherto uncultivated, physically degraded lands (henceforth referred as degraded lands) should be brought under cultivation. All this has to be achieved without compromising soil fertility. This is especially relevant in the wake of discussion on launching the second green revolution. Improving soil health is pos-

sible only when soil fertility is accurately estimated and suitable corrective measures are adopted. In our opinion, the present methodology for soil fertility estimation may be unsuitable for degraded soils. Here, we explain this methodological problem and highlight the possible consequences of adopting the present method for degraded soils.

Soil, a medium for plant growth, has inorganic mineral particles, reactive and stable forms of organic matter, myriad living organisms, water and gases. The solid portion of soil, made up of coarse fragments (>2 mm) and fine earth (<2 mm), contributes for plant nutrients through exchange and dissolution mechanisms, and the void portion is important for air and water movement. In effect, fine earth (clay, silt, sand and the adsorbed soil organic matter), due to high surface area per unit mass (specific surface area; $\text{m}^2 \text{g}^{-1}$ soil), contributes to the bulk of the total soil fertility. Hence, soils with greater proportions of clay and organic matter are fertile. The loss of soil fines due to erosion, resulting in accumulation of coarse fragments, would lead to soil degradation^{1,2}.

Relative proportions of solid and void spaces significantly influence the volumetric soil mass, also called bulk density (BD). These proportions are determined by soil texture, which refers to the relative distribution of sand, silt and clay fractions. As the proportion of coarser fragments like sand increases, the total porosity of soil decreases. It is well-established that BD is directly proportional to the weighted mean particle diameter and inversely proportional to total porosity. Therefore, sandy textured soils will have higher BD compared to clayey textured soils. In other words, mass of

soil spread over one hectare area to a depth of 15 cm (this is generally called hectare furrow slice, haFS) of a sandy soil would be more than clayey soil.

Soil fertility is a measure of available nutrients (potentially available for uptake by plants), which is a fraction of the total soil nutrients. As practised now, for soil fertility estimation³, fine earth is first separated from bulk soil by mechanical sieving. A small quantity of this fraction is extracted with different weak salt/acid solutions and the respective concentrations of different nutrients are determined by adopting standard procedures^{3,4}. The next step involves a gross generalization that soil mass present in the root zone is 2 million kg haFS^{-1} irrespective of the actual BD values. This generalization is rooted in an assumed BD value of 1330 kg m^{-3} , which represents the BD of a loamy soil with equal proportions of solid and void spaces. Nutrients estimated from a few grams of soil are expressed in kg haFS^{-1} , which is suitable for comparisons. It may be noted here that the proportions of fine earth and coarse fragments are inversely related, which, when put together, indicates that the quantity of available nutrients decreases with increase in the proportion of coarse fragments (Figure 1). This is because only fine earth contributes to nutrient availability⁵. Thus, soil fertility assessment based on an assumed mass of 2 mil-

lion kg haFS^{-1} would lead to overestimation of available nutrients when proportions of coarse fragments increase, as in the case of degraded soils. Though it appears pragmatic to use BD values in determining the actual soil mass, this may also mislead soil fertility interpretations. For example, estimated available nutrients will be higher for sandy soils (due to higher BD) than for clayey soils at the same level of nutrient concentration. The magnitude of such errors would be greater for degraded soils as BD will be substantially higher. Thus, adopting the generalized soil mass of 2 million kg haFS^{-1} , or using actual BD values in estimating soil fertility, might be unsuitable when degraded soils become the focus.

In order to highlight the overestimations, a hypothetical figure has been constructed (Figure 2) by varying soil organic carbon stocks (SOC) with proportions of coarse fragments in the soil. SOC was taken as 0.5 per cent, as the value is representative of most agricultural soils; SOC was estimated for one haFS. Three hypothetical situations namely (1) soil mass has been assumed to be 2.0 million kg haFS^{-1} irrespective of proportions of coarse fragments; (2) soil mass has been estimated on the basis of the respective BD values; and (3) soil mass has been estimated considering only the fine earth volume, are presented.

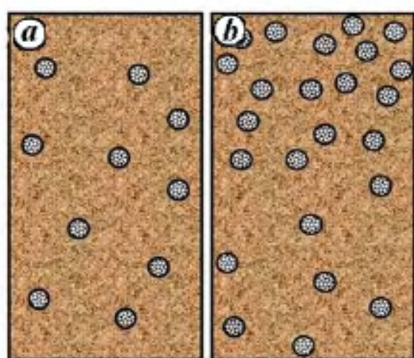


Figure 1. Hypothetical representation of vertical cross-sections of furrow slice of (a) agricultural soil and (b) degraded soil. Typical agricultural soils possess large proportions of fine earth (represented in the figure by matrix; <2 mm particle size; comprises SOM, sand, silt and clay) and small proportions of coarse fragments (represented in the figure by circles; >2 mm particle size; comprises of gravel and stones). Typical degraded soils possess relatively larger proportions of coarse fragments and less of soil fines.

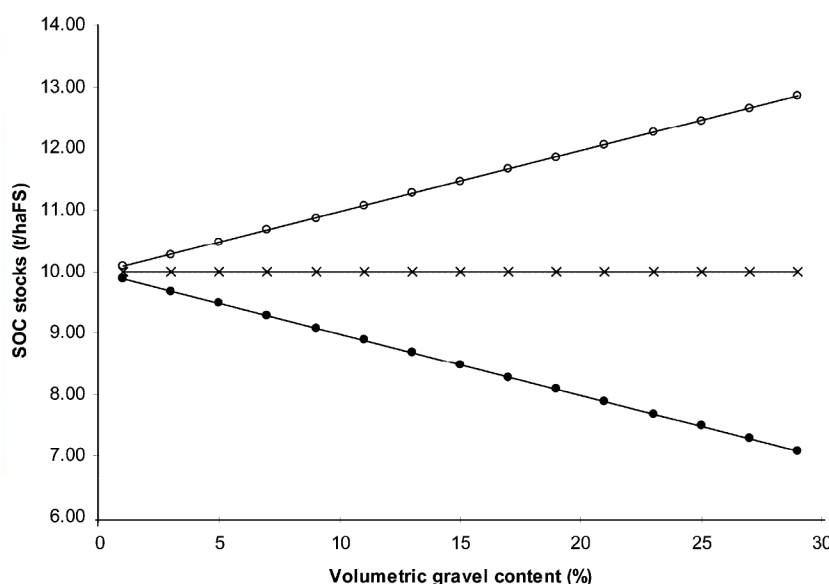


Figure 2. Variations in soil organic-C (SOC) stocks with respect to different proportions of volumetric gravel content in 1-haFS. Cross marks represent SOC stocks when soil mass is assumed to be 2.0×10^6 kg, hollow circles represent SOC stocks when soil mass is derived based on BD values and filled circles represent soil mass derived based on fine earth volume.

It is evident that the current method of soil fertility estimation, which assumes a soil mass of 2.0 million kg haFS⁻¹, did not have any effect on SOC as the impact of coarse fragments was not considered. SOC increased with coarse content when soil mass was estimated based on BD values; presence of coarse fragments in the root zone increased the BD values and thus soil mass and SOC. In the third situation where SOC was derived only for fine earth, SOC decreased with increase in coarse fragment content; reduction in the effective soil volume⁷ with increase in coarse fragment content appears to reduce SOC. Estimating SOC only from the fine earth part of soil appears to be realistic than the other situations. This is because volume of active fine earth available for SOC retention decreases with increase in coarse fragment content. In other words, the presence of coarse fragments in the bulk soil has a dilution effect on the SOC^{1,2}. This analogy holds good for estimation of all nutrients in soil. Thus, the present method of soil fertility assessment that assumes a soil mass of 2 million kg haFS⁻¹, or based on the actual BD values, would lead to overestimates. Therefore, volumetric assessment of fine earth may be important in soil fertility assessment, especially for degraded soils.

Quantifying the proportional volume of fine earth, especially for a degraded

land, could have the following implications:

- To make afforestation programmes successful in physically degraded lands, consideration of the volume of soil effectively available in the root zone would be more meaningful in terms of water and nutrient availability.
- In SOC stock assessments, quantification of proportional volume of fine soil in the bulk and then expressing it for the entire soil volume would be appropriate for realistic estimations.
- High productivity in a gravelly soil compared to a normal agricultural soil with the same level of nutrient application could be attributed to high fertigation effect. However, the risk of nutrient loss due to poor nutrient retention may mask the initial fertilization effect.

Thus, it is appropriate to make soil fertility assessments based on the proportional volume of fine earth (effective soil volume) than the conventional method.

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Save these rare ornamental trees

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India is bestowed with a variety of agroclimatic conditions ranging from tropical–subtropical to subtemperate–temperate. Ten biogeographic zones of India enthrall botanists with the diversity and endemism of flora¹. Consequently, our country is one of the 12 mega biodiversity rich centres of the world besides housing two of the 25 recognized biodiversity hotspots². There are 47,000 plant species in India including 18,000 angiosperms which form a major part of the flora³. Nevertheless, 30% of the angiosperms and 18% of the total flora are endemic to India⁴. According to the

IUCN report (2007), 45 tree species from India have been included in the *Red List of Threatened Plant Species*, and declared as ‘critically endangered’ facing high risk of extinction while 247 tree species have been declared ‘threatened’⁵. Therefore, proper conservation measures for the unique floristic wealth of India are necessary.

During the colonial era, new botanical gardens and agri-horticultural societies were established. Besides, diverse kinds of people visited India for different purposes. The westerners were greatly attracted to the botanical wealth of our

country. This eventually created a gateway for introduction of many new plant species particularly trees. However, no record exists regarding introduction of ornamental trees except mention in some old publications. Though Botanical Survey of India is closely monitoring Indian flora and furnishing status reports in the form of *Red Data Book* regularly, a closer look is required at these introduced ornamental trees and their centre of introductions. The old botanical gardens and agri-horticultural societies of India were instrumental for these valuable introductions and made significant