Assessment of permissible soil loss in India employing a quantitative bio-physical model

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Soil degradation in all its nefarious forms has serious repercussions on crop and biomass productivity. Assessment of soil loss tolerance limits (SLTLs) (permissible soil loss) serves as a tool to gauge the potential erosion risk in a given area with regard to long-term sustainability. In this communication, SLTLs in different states of India and at the national level have been quantitatively estimated by employing a bio-physical model based upon integration of relevant attributes. The analysis has indicated that soil loss tolerance or *T*-value varies from 2.5 to 12.5 Mg ha^{-1} yr^{-1} depending upon soil quality governing soil resistibility to erosion and depth at a particular location. About 57% area in the country has permissible soil loss of less than 10.0 Mg ha^{-1} yr^{-1}, which needs to be treated with appropriate conservation measures. Highest priority needs to be accorded to about 7.5% area where the *T*-value is only 2.5 Mg ha^{-1} yr^{-1} due to soil quality constraints. The methodology and framework developed for estimating *T*-values has the potential to be applied in different regions or countries of the world. The relative efficacy of the present method was tested with productivity index-based approach. Case study evidences in different watersheds revealed that soil productivity can be maintained at sustainable levels by bringing the erosion rate within tolerance limit.

Keywords: Biophysical model, conservation planning, permissible erosion, soil degradation, soil sustainability.

THE soil resources of the world are finite, functionally non-renewable and prone to different forms of degradation due to over-exploitation and faulty management practices. Soil degradation has reached alarming proportions in many parts of the world, especially in the tropics and sub-tropics. Soil erosion caused by water is a major factor contributing to land degradation in India and many other countries, as it far exceeds the natural soil formation rates. The estimates suggest that globally about 24 bt of soil is lost annually through water erosion in excess of the natural rate of soil regeneration[1]. The balance between soil-forming and depleting processes is of utmost importance for attaining long-term sustainability in any production system. According to FAO, about 18% of the arable lands in the world could be lost forever if no measures are taken to preserve them[2]. India loses about 16.4 t of soil ha^{-1} yr^{-1}, of which 29% is lost permanently into the sea, 10% gets deposited in the reservoirs reducing their capacity by 1–2% every year and the remaining 61% gets displaced from one place to another[3]. About 30–50% of the world's arable lands are substantially degraded due to soil erosion[4], which directly affects rural livelihood[5,6]. Soil erosion also affects aquatic resources[7], lake/river sediment dynamics[8,9], global carbon cycling[10], aquatic and terrestrial biodiversity[11,12] and ecosystem services[13,14].

Soil being a non-renewable resource and the basis for 97% of all food production[4], strategies to prevent soil depletion are critical for sustainable development. For developing suitable soil conservation strategies, knowledge of the prevailing and permissible rates of soil erosion is an essential prerequisite. The acceptable rate of soil erosion (*T*-value) is defined as the maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained. Quantifying the acceptable soil loss without affecting crop productivity is a major challenge for researchers, planners, conservationists and environmentalists. If the erosion exceeds the *T*-value, it adversely affects productivity and must be brought down within the permissible rate to ensure sustainability of a production system. Conservation objectives for soil loss tolerance are based on maintaining a suitable seedbed and nutrient supply in the surface soil, maintaining adequate depth and quality of the root zone, and minimizing unfavourable changes in water availability throughout the soil[15]. The *T*-value concept does not attempt to limit allowable soil loss to the absolute rate of soil regeneration, but it is based on the assumption that desirable top soil (primarily A horizon) properties are regenerated more rapidly. It also implicitly allows some deeper soils to erode at higher rates than shallower soils. Soil physical degradation and loss of nutrients within the permissible rates of erosion are usually not enough to significantly reduce the crop yields. Thus the concept of *T*-value is compatible with the current thinking on the sustainability of agricultural systems. It is known that a given erosion rate is not equally serious on all soils. On shallow soils, a *T*-value of 5 Mg ha^{-1} yr^{-1} and prevailing erosion rate of 12.5 Mg ha^{-1} would result in rapid loss of productivity. In contrast, a *T*-value of 12.5 Mg ha^{-1} yr^{-1} in a deeper soil with similar erosion may not have much impact on crop productivity[16].

In India, a default *T*-value ranging from 4.5 to 11.2 Mg ha^{-1} yr^{-1} is generally assumed in the absence of specific criteria to compute it in different regions based upon soil quality with regard to resistance to water erosion. It is important to distinguish the intrinsic susceptibility of the soil to erosion. Potential soil indicators required to assess the intrinsic susceptibility of the soil to erosion depend on sensitivity analysis. Sensitivity analysis of the Water Erosion Prediction Project indicated infiltration rate, bulk density, erodibility factor, organic

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