Soil Resource Assessment of Kumaon Himalayan Mountains of India

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Abstract
A study was undertaken to identify the different physiographies and soil resources and to assess the soil organic carbon (SOC) stock in Kumaon Himalayan Mountains of India. Main physiographies are summits/ridge tops, side/reposed slopes, river valleys and piedmont plains. Soils of summits/ridge tops and side/reposed slopes are mainly shallow to medium deep, coarse textured, underdeveloped/partially developed having A-C horizons (Entisols) followed by deep, fine textured and comparatively developed soils (Inceptisols). Soils of river valleys and piedmont plains are mainly medium deep to deep, loam to clay loam with structural B horizon and belong to Inceptisols followed by Entisols. Soils of summits/ridge tops contain more SOC stock in comparison to other physiographies. The same trend was seen in higher elevations as in lower ones.

Key Words
Western Himalayas, physiographic units, remote sensing, landform, soil organic carbon.

Introduction
The main problems of mountains are their peculiar geographical conditions and the resultant physical and human constraints. Himalayas represent one of the most fragile mountain ecosystems of the world. For the past few decades, a sequence of changes has emerged in the traditional resource use due to population pressure and increasing demand for food, fodder, fuel wood, grazing areas, etc. in the region. Thus, management of natural resources, especially soils has become urgent though their study has been very difficult as most of the areas are inaccessible to humana. A New generation of remote sensing satellites has opened up possibilities for this type of study (Ahuja *et al.* 1992; Saxena *et al.* 2000). Soil organic carbon (SOC) is an important component for agro-ecosystem as it influences various soil properties (Batjes and Sombroek 1997; van Keulen 2001). Thus, the present research work has been undertaken to assessthe soil resources of Kumaon hills of India using remote sensing techniques.

Materials and Methods
The study area belongs to Almora district of Uttarakhand state, spread over 29^{o} 26' to 30^{o} 20' N latitudes and 79^{o} 3.5' to 80^{o} 11' E longitudes covering 3083 sq. km. geographical area. The area is under warm humid lesser Himalayan agro-ecoregion. The altitude ranges from 600 to 3000 m msl. Data from IRS, ID, LISS III, FCC generated from bands 2, 3, 4 on 1:50,000 scale was used for visual interpretation. Base maps were prepared by using Survey of India topographical sheets at the same scale. Landforms identified were further divided into physiograpic units based on their elemental characteristics and slope functions of landform. Soil survey was conducted using this physiographic map. Soil sampling was done in all the physiographic units by studying mini-pits and master profiles. Soil samples were collected from each diagnostic horizon of representative pedon for physiochemical analysis. Different soil series identified in different physiographic units were classified using Soil Taxonomy (Soil Survey Staff 2003).

Results and Discussion
On the basis of image data interpretations and field check different physiographic units viz. steeply, moderately steeply and moderately sloping summits/ridge tops, very steeply, steeply and moderately steeply sloping side/reposed slopes, river valleys and piedmont plains have been identified in the study area (Figure 1).

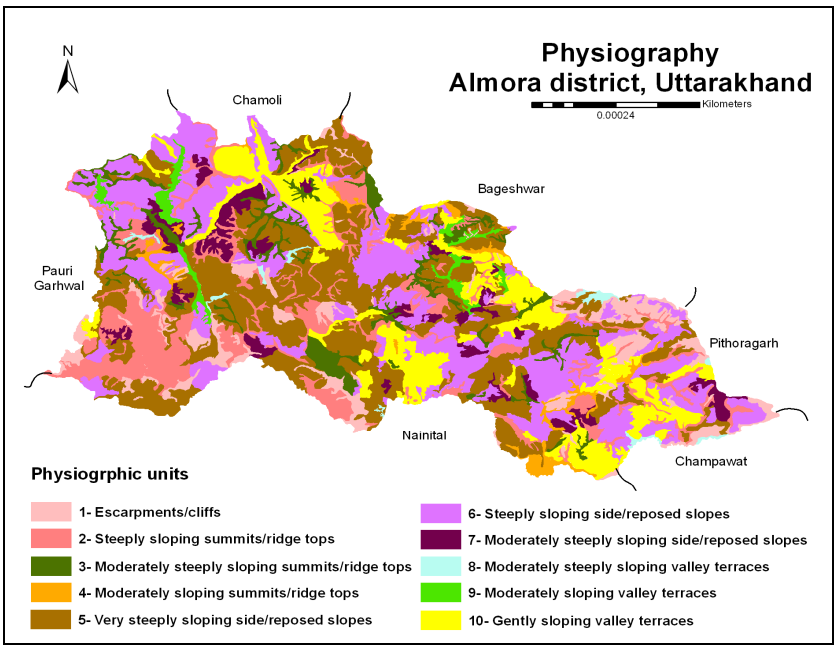

Figure 1. Physiography

After correlation of different soils observed in the area fifteen different soils have been identified. Soils of moderately steep to steeply sloping summits/ridge tops are very shallow to moderately deep(Figure 2), coarse textured, underdeveloped/partially developed having only A-C horizons and belong to Entisols (Lithic and Typic Ustorthents) whereas on moderate slopes of summits, soils are fine textured, comparatively well developed having structural B (cambic) horizons and belong to Inceptisols (Typic Dystrudepts). They are covered with forest, rock outcrops and cultivation on terraces. Main problems are low to medium available water capacity (AWC) and nutrient retention capacity, severe to very severe erosion and stoniness. Soils of side/reposed slopes are shallow to medium deep, excessively drained, sandy loam, moderately acidic and belong to mainly Entisols (Lithic and Typic Udorthents) followed by Inceptisols (Typic Dystrudepts). They are low in water holding capacity and fertility status and have low productivity potential. Other constraints are limited depth, stoniness and severe erosion.

Soils of river valleys occur on gentle, moderate and moderately steep slopes and are deep, somewhat excessively drained, sand with low AWC and nutrient retention capacity and developed on colluvium/alluvium originated from sandstone (Typic Ustipsamments) along with loam to clay loam, with medium AWC and nutrient retention capacity and developed on colluvium/alluvium of mica/quartzite (Typic Dystrudepts). They are cultivated with agricultural crops like wheat, mustard, millet and paddy. Soils of piedmont plains occur on gentle to moderate slopes and are deep to very deep, well to somewhat excessively drained, clay loam to silty clay loam, brown with medium AWC and nutrient retention capacity (Typic Dystrudepts).

The organic carbon stock in the soils of major landforms has been assessed. The data reveals that in general, all the soils are rich in organic matter in surface layers and decreased with depth, as also obtained by earlier workers (Sehgal 1973 and Mahapatra *et al.* 2000). It has been observed that the immature soils and forest soils, developed on steep slopes, have high percentage of SOC stock though the soils are shallow in depth. Soils of summits and ridge

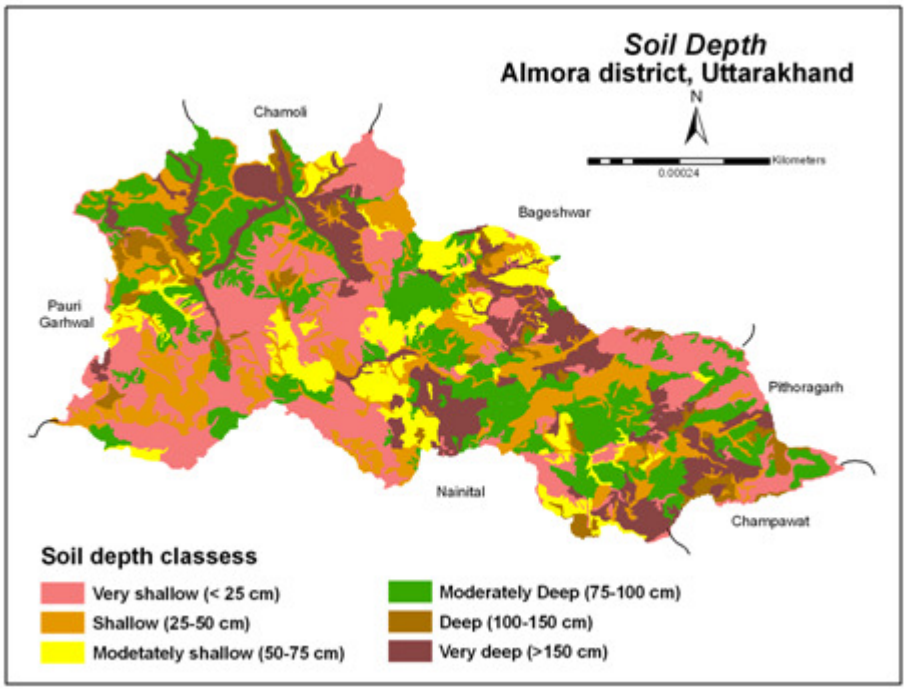

Figure 2. Soil Depth

tops are found to have more SOC stock in comparison to the soils occurring on other physiographic units. Besides, soils at higher altitudes contain more SOC than those at lower elevations. In deeper soils, although soils have less carbon in lower horizons, the total carbon stocks are sufficient. Hence, it is observed that physiographic position, land use and elevation play important roles in the status of SOC stocks, which is thus a key factor for sustainable land use planning in such a mountainous area.

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