Soil information system of Arunachal Pradesh in a GIS environment for land use planning

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ABSTRACT

Arunachal Pradesh, the largest mountainous state of India, is situated in the northeastern part of the Himalayan region and characterized by high annual rainfall, forest vegetation and diversity in soils. Information on the soils of the state is essential for scientific land use planning and sustainable production. A soil resource inventory and subsequent database creation for thematic mapping using a Geographical Information System (GIS) is presented in this paper. Physiographically, Arunachal Pradesh can be divided into four distinct zones: snow-capped mountains (5500 m amsl); lower Himalayan ranges (3500 m amsl); the sub-Himalayan Siwalik hills (700 m amsl); and the eastern Assam plains. Soils occurring in these physiographic zones are Inceptisols (37 percent), Entisols (35 percent), Ultisols (14 percent) and Alfisols (0.5 percent). The remaining soils can be classed as miscellaneous. Soil resource inventory studies show that the soils of the warm perhumid eastern Himalayan ecosystem, with a 'thermic' temperature regime, are Inceptisols and Entisols; and that they are highly acidic in nature. Soils of the warm perhumid Siwalik hill ecosystem, with a 'hyperthermic' temperature regime, are also Entisols and Inceptisols with a high to moderate acidic condition. The dominant soils of the northeastern Purvachal hill ecosystem, with 'hyperthermic' and 'thermic' temperature regimes, are Ultisols and Inceptisols. Inceptisols and Entisols are the dominant soils in the hot and humid plain ecosystem. Steeply sloping landform and high rainfall are mainly responsible for a high erosion hazard in the state. The soil erosion map indicates that very severe (20 percent of TGA) to severe (25 percent of TGA) soil erosion takes place in the warm per-humid zone, whereas, moderate erosion takes place in the Siwalik hills and hot, humid plain areas. This is evident from the soil depth class distribution of Arunachal Pradesh, which shows that shallow soils cover 20 percent of the TGA of the state. Most of the the state is covered by hills and agricultural practices are limited to valley regions. However, the soils of other physiographic zones (lower altitudinal, moderately hilly terrain) provide scope for plantations, such as orange, banana and tea plantations.

INTRODUCTION

Soil is one of the important non-renewable basic natural resources that support life on the earth. Hence, maintenance of this valuable resource in a state of high productivity, so that it can provide the ever-increasing population with its basic needs, is a primary necessity. Natural erosion cycles and the increasing influence of human-induced processes pose a threat to the conservation of soils. Therefore, knowledge of soils with respect to their extent, distribution, characterization and use potential is very important for optimized land utilization [Maji *et al*, 1993].

The National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) undertook the task of surveying the soils of Arunachal Pradesh to generate a soil database [Nayak *et al*, 1996] that could provide information for planning viable land use on a sustainable basis. Similar work has been done for the entire northeastern region, comprising Meghalaya [Singh *et al*, 1999], Manipur [Sen *et al*, 1996] and Tripura [Bhattacharya *et al*, 1996]. A GIS approach was adopted to generate a soil resource database at 1:250,000 scale with soil families as the basic mapping units, and to reclassify the master soil map. Several thematic maps were prepared to provide the basic information needed for land use planning.

STUDY AREA

LOCATION AND EXTENT

The state of Arunachal Pradesh is situated between latitudes of 26°30' to 29°28' N and longitudes of 91°25' to 97°24' E. It covers an area of 8.37 million hectares (Figure 1). The state is bounded by China and Tibet in the north, Assam in the south, Myanmar and the state of Nagaland in the east, and Bhutan in the west. It has 11 administrative districts, with Itanagar as its capital.

PHYSIOGRAPHY, RELIEF AND DRAINAGE

The study area can broadly be divided into four distinct physiographic regions. These are:

- the greater Himalayas, with snow-capped mountains rising up to 5500 m above mean sea level (amsl);

- the lower Himalayan range, rising up to 3500 m amsl;
- the sub-Himalayan belt, including the Siwalik hills, with elevation up to 1500 m amsl;
- the plains of the eastern continuity of Assam.

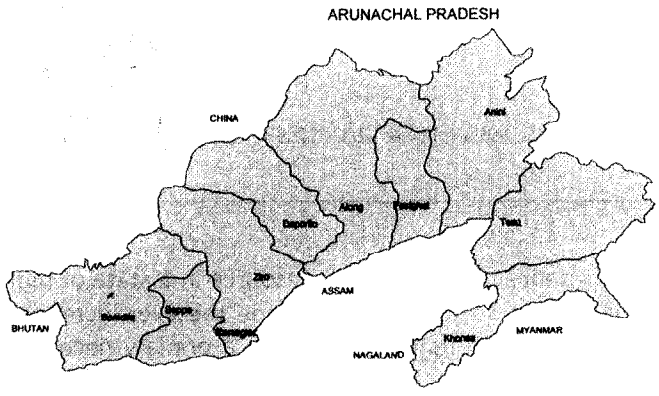

FIGURE 1: Location of the study area

The greater Himalayas encompass snow-capped mountains covering the northern part of the districts Lohit, Dibang valley, East and West Siang, Lower and Upper Subansiri, East and West Kameng and Twang. In the Kameng and Twang districts, the ranges are well known for peaks like Gorichen (6538 m) and Kangte (7090 m). The area is characterized by its very rugged topography with very steep and highly dissected hill slopes. Major rivers, such as the Tenga, Bichom, Subansiri, Kamala, Siyam, Siang and Lohit, originate in the greater Himalayas and flow into the plains of the Assam valley through the central and lower Himalayan ranges.

The lower and central Himalayas include the ranges between the greater Himalayas and the sub Hiamalayan range (Siwalik range). In the Lohit and Dibang valley districts, the ranges (up to 3000 m elevation) are densely forested. The relief of the areas is extremely rugged and the side slopes of the hills are moderately steep to steep. Some areas are severely eroded.

The sub Himalayan belt, embracing the Siwalik hills, includes the southern part of the hill ranges along the Kameng, Subansiri and West Siang districts. In the Kameng district, the Siwalik sub-Himalayan tracts rise up to an elevation of about 1500 m amsl. The relief is extremely rugged in steep hill ranges and it is normal in the foothills.

The plains areas (eastern continuity of the Assam plains) include the plains of the Lohit, Tirap, Dibang and Siang rivers. The northern part is gently sloping to undulating and during the rainy season receives heavy stream loads through feeder streams. The southern part, adjacent to the Assam plains, is nearly level to very gently sloping. Elevation in the region varies from 80 to 210 m amsl. The various areas are drained by the Siang, Lohit, Dibang, Kamlong, Nao-Dihing, Tirap, Namchik and Manphuk (Buridihing), Dirak and Namsing rivers.

GEOLOGY

The geology of the state is characterized by the presence of sedimentary and metamorphic rocks [Anonymous, 1974]. Some important rock groups are the (1) Sela group, consisting of schist, magnetites, quartzite and amphiboles; (2) Tenga formation, consisting of low grade metamorphic rocks, such as schists, amphiboles, phyllites and sericite, and quartzite; (3) Bichom group of sedimentary rocks, composed of quartzites, phyllites, shales, sandstone, dolomite, etc.

CLIMATE

The climate of Arunachal Pradesh is humid to perhumid subtropical, characterized by the high rainfall and high humidity of the sub-Himalayan belt. However, a temperate climate prevails in the lower Himalayan region and the greater Himalayan region is perpetually covered with snow. The average annual rainfall varies from 1380 to 5000 mm. The minimum temperature is around 0°C in winter months in the Bomdila and Twang areas, while it rises to 35°C during summer months in the Namsai and Tezu areas of Lohit district. The mean annual air temperature is 23.8°C in the plains and 16.2 °C in the hilly regions.

LAND USE AND AGRICULTURE

Land use statistics of Arunachal Pradesh [Anonymous, 1985] indicate that 61.6 percent of the total geographical area (TGA) is under forest, while cultivated land accounts for only 1.4 percent of TGA (Table 1). The land not available for cultivation accounts for 0.4 percent, fallow land covers an area of 2.0 percent of TGA and other uncultivated land excluding fallow land accounts for 2.0 percent of the total area of the state.

TABLE 1: Land use of Arunachal Pradesh

Category	*Area (10^3 ha)*	*Percent of TGA*
Total geographical area	8374.3	-
Reported area for land utilization	5643.0	-
Unreported area	2731.3	32.6
Forest	5254.0	61.6
Land not available for cultivation	37.0	0.4
Uncultivated land	168./0	2.0
Fallow land	169.0	2.0
Net area sown	115.0	1.4
Area sown more than once	15.0	-
Net irrigated area	24.0	-
Area under shifting cultivation	250.0	3.0

AGRO-ECOLOGICAL SUB-REGIONS

There are four distinct agro-ecosystems in Arunachal Pradesh [Sehgal *et al*, 1993], based on the variability of landscape, bio-climate, length of growing period, and soils (Figure 2). Land use patterns in these ecosystems vary widely. The characteristics of these ecosystems and present land use patterns are described below.

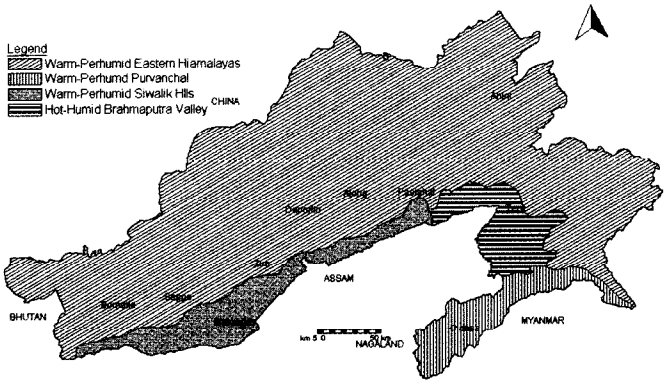

FIGURE 2: Agro-ecological sub-regions of Arunachal Pradesh

Warm perhumid, eastern Himalaya ecosystem

The climate of the region is characterized by mild summers and moderate to severe winters. The mean annual precipitation ranges from 2000 to 5000 mm. Generally, there is no period when the water requirement is greater than the water supply through precipitation. The availability of moisture to the crops generally exceeds 270 days per year. The region is typified by an 'udic' soil moisture regime (soil moisture control section is not dry in any part for as long as 90 cumulative days). The mean annual soil temperature (MAST) varies from 18° C to 22° C. The region thus represents a 'thermic' soil temperature regime. The natural vegetation comprises alpine and sub-alpine, temperate (coniferous), semi-evergreen and tropical moist deciduous forests. Rice, maize, millet, pea, beans, potato and vegetables are grown. Shifting cultivation (with slash and burn techniques, locally known as *Jhum* cultivation) is followed as a traditional farming practice.

Warm perhumid, Siwalik Hills ecosystem

The climate of this region is characterized by mild summers and moderate winters. The mean annual precipitation is about 2000 mm. Precipitation exceeds the potential evapotranspiration (PET) in most years. The region occasionally experiences a short period of water deficit due to seasonal dry spells during the post monsoon period. The length of the moisture availability (growing) period is about 270 days. The area represents an 'udic' soil moisture regime and 'hyperthermic' soil temperature regime. The natural vegetation comprises wet evergreen and tropical moist deciduous forests. *Jhum* cultivation is practiced on hillside slopes. Except for a few places where maize and rice are grown, other areas have subtropical to evergreen species varying from open scrubs to thick forest cover. Rice, maize, millet, pineapple and tea are grown on hill terraces.

Warm perhumid, Purvanchal ecosystem

The climate of this region is characterized by warm summers and cold winters. The mean annual precipitation varies from 1960 to 3450 mm, which exceeds the PET in most years. The region experiences a short period of water deficit due to seasonal dry spells in the post-monsoon period. The area represents an 'udic' soil moisture regime. The soil temperature regime varies from 'hyperthermic' in valleys and ranges of low hills to 'thermic' in ranges of high hills. The hill slopes are covered with forest vegetation of moist deciduous species. *Jhum* cultivation is practiced in the region. Maize, millet and vegetables are grown on hill slopes, while rice is cultivated in valleys and hill terraces. Tea, bananas and oranges are also grown on steep foothill slopes.

Hot humid, plain ecosystem

The climate of the area is characterized by hot summers and moderately cool winters. The mean annual rainfall varies from 2590 to 3390 mm and it exceeds PET for a greater part of the year. The soils remain dry only for about a month or so. The soil moisture regime is 'udic' and the area has a 'hyperthermic' soil temperature regime as the MAST is 22° C or higher. The natural vegetation comprises semi-evergreen and moist deciduous forests. Rainfed agriculture is the traditional farming system. Rice as well as mustard, potato and tapioca are cultivated in the *rabi* (autumn to spring) season. Horticultural crops like oranges and areca nuts are found in the region.

METHODOLOGY

SOIL SURVEY AND MAPPING

A soil survey was undertaken that followed a three-tier approach comprising image interpretation, field surveys and laboratory analysis [Sehgal *et al*, 1987]. Landsat images (1:250,000 scale) were interpreted for landform analysis and then transferred onto Survey of India toposheets to prepare the base physiographic map for the soil survey. The soil survey was carried out following sample strip, grid and random observations. Sample strips were examined with 30 samples of profiles for in-depth soil information. Grid samples were taken at 10 km intervals. Random observations were taken for unrepresented physiographic units. In total, about 350 observations were recorded (in accessible areas only) per toposheet. Soil samples, collected per soil horizon, were analysed on various morphological and physico-chemical properties. Soils were characterized, classified as per Soil Survey Staff [1992] and mapped.

GENERATION OF SOIL RESOURCE INFORMATION

The soil information system is a computerized database management system, which in addition to simple storage and retrieval for reporting includes other functions such as manipulation and dissemination of information to various users. It basically constitutes a set of files in a Geographic Information System (GIS) comprising spatial and attribute data under a Relational Database Management System (RDBMS). It is capable of delivering accurate, useful and timely information for various applications.

The data on soils and their properties formed the basic database. The database format was developed for all site, soil and physico-chemical properties and was made available in MS Excel for further interfacing to GISs. To generate a spatial soil information system, the soil association units identified on 1:250,000 scale toposheets were digitized in ARC/INFO.

The adjacent vector soil layers were edge-matched, polygon topology was built and identification numbers (IDs) were assigned to the polygon layer. The cover was projected to real world coordinates in a polyconic projection system, with geographic extents in latitude/longitudes. Items were added in the Polygon Attribute Table (PAT) for all the soil attributes. Using AML script, properties such as pH, depth, texture, soil taxonomic class, erosion and physiography, with their respective classes, were assigned to the soil association units. These items were subsequently reclassified to prepare thematic layers. Area analysis was performed for these layers using a statistical module. Map compositions were prepared in an ARC PLOT environment with suitable layouts, pallets and paper scales. A flow chart for thematic map generation is depicted in Figure 3 [Maji *et al,* 1998].

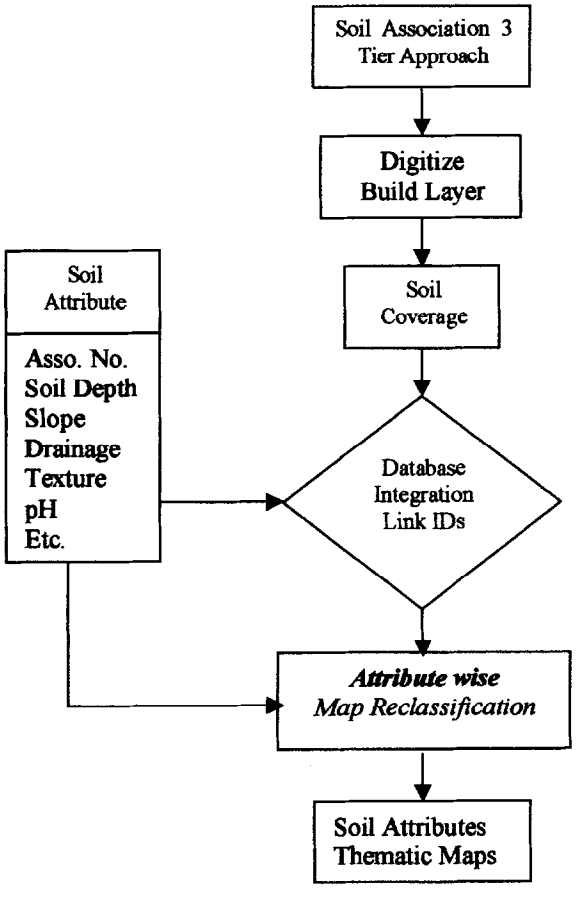

FIGURE 3: Flowchart for thematic mapping

RESULTS AND DISCUSSION

SLOPE

Slope is an important consideration in mountainous land use options. The slope map (Figure 4) of Arunachal Pradesh shows that a major part of the state has very steep slopes (26.5 percent of TGA) followed by moderately steep (24.5 percent of TGA) and steep slopes (12 percent of TGA). Very gently sloping landforms account for only 6 percent, while gentle sloping lands covers 2 percent of the area.

LANDFORMS

Landform analysis (Figure 5) shows that the state is dominated by ridges (37 percent) and escarpments (33 percent), while undulating lands account for 4 percent

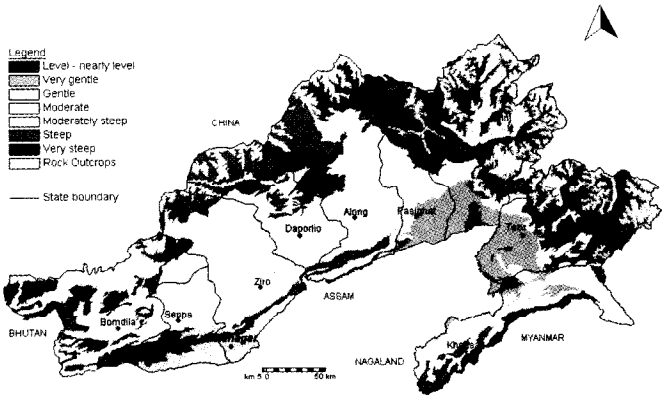

FIGURE 4: Slope classes of Arunachal Pradesh

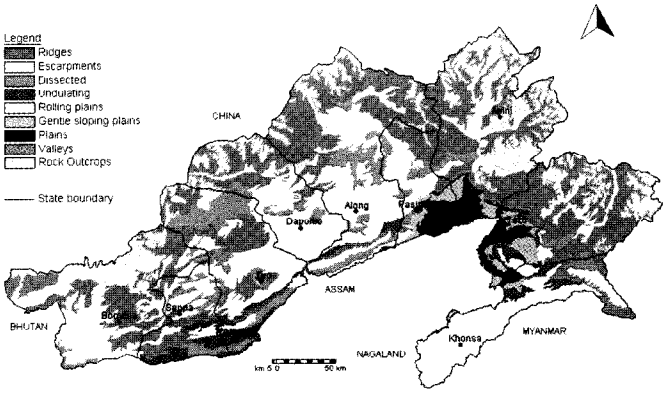

FIGURE 5: Landforms of Arunachal Pradesh

of TGA. Areas with level to nearly level and gently sloping lands, where traditional cereal crops are grown, cover only 4 percent of TGA. Dissected lands account for 9 percent of TGA and rocky lands occupy about 11 percent of TGA.

SOIL RESOURCE INFORMATION

To assess the potential and problems of different soils, and to develop rational land use options for optimizing agricultural production, we need consistent and comparable information about soils. Different kinds of soils are present in Arunachal Pradesh, due to a wide variability in factors (climate, physiography, geology and vegetation) that influence the ecosystems. Data revealed that 86 soil family associations are spread over the state. Four soil orders predominate. Inceptisols are dominant (covering 37 percent of TGA), followed by Entisols (35 percent), Ultisols (14 percent) and Alfisols (0.5 percent). Information on site characteristics, physical and morphological properties, and soil chemical properties of both dominant and subdominant soils of each map unit form the major database. These datasets were used to generate various thematic maps. A soil map (with 19 units) is presented in Figure 6. The 45 soil map units, referred to in Tables 3-6, represent associations of dominant and sub-dominant soil classes, occurring in different physiographic zones (Table 2).

THEMATIC MAPPING

Several thematic maps were generated using the soil survey data. The attributes chosen were those that influence land use relationships. The maps of landform, soil depth, texture, erosion, and soil reaction (pH) were prepared using reclassification techniques in a GIS.

DEPTH

Effective soil depth is an important soil parameter, as it determines the growth and performance of crops. Among the five depth classes, shallow soils cover about 20.7 percent and moderately shallow soils about 6.7 percent of the total area of the state. The soils in these depth classes in different map units are given in Table 3. The spatial distribution of different depth classes is shown in Figure 7.

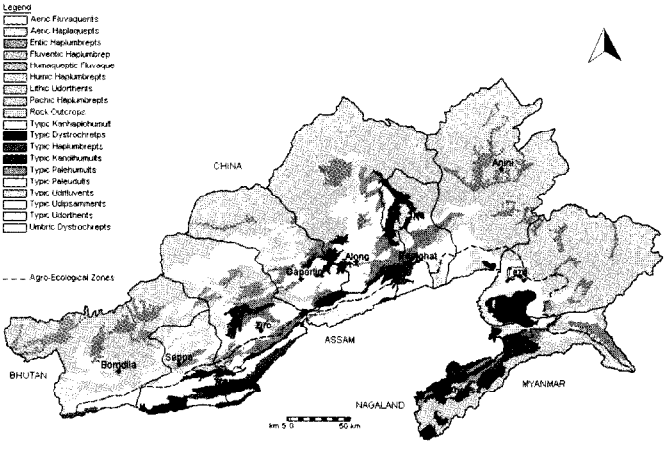

FIGURE 6: Soil map of Arunachal Pradesh

TABLE 2: Soils of Arunachal Pradesh

Map Unit (% TGA)	Description
SOILS OF GREATER HIMALAYAS	
01 (16.4)	Shallow, excessively drained, loamy-skeletal Lithic Udorthents; with moderately deep, somewhat excessively drained, loamy-skeletal Typic Udorthents
02 (6.2)	Deep, somewhat excessively drained, loamy-skeletal Entic Haplumbrepts; with moderately shallow, excessively drained, sandy-skeletal Typic Udorthents
03 (7.8)	Shallow, excessively drained, loamy-skeletal, Lithic Udorthents
04 (4.0)	Shallow, excessively drained, loamy-skeletal; with moderately deep, somewhat excessively drained, sandy-skeletal soils, sandy-skeletal Typic Udorthents
05 (3.1)	Very deep, well-drained, fine soils, Humic Hapludults; with very deep, well-drained, fine-loamy Umbric Dystrochrepts
06 (2.2)	Shallow, excessively drained, sandy-skeletal Lithic Udorthents; with moderately deep, excessively drained, loamy-skeletal Typic Eutrochrepts
07 (6.1)	Very deep, somewhat excessively drained, fine Typic Palehumults; with moderately shallow, excessively drained, fine, Typic Haplumbrepts
08 (2.3)	Moderately shallow, somewhat excessively drained, loamy-skeletal Typic Udorthents; with moderately deep, somewhat excessively drained, fine-loamy Typic Eutrochrepts
09 (6.1)	Deep, well-drained, fine Typic Kanhaplohumults with very deep, well-drained, fine-loamy Pachic Haplumbrepts
10 (4.0)	Very deep, somewhat excessively drained, fine-loamy Umbric Dystrochrepts; with very deep, well-drained, fine-loamy Pachic Haplumbrepts
11 (5.2)	Very deep, well-drained, fine-loamy Pachic Haplumbrepts; with very deep, well-drained, fine Typic Palehumults
12 (2.9)	Very deep, well-drained, fine Typic Kandihumults; with deep, somewhat excessively drained, fine Pachic Haplumbrepts
13 (0.1)	Very deep, poorly drained, fine Humaqueptic Fluvaquents; with very deep, imperfectly drained, fine Humic Haplaquepts
14 (0.7)	Very deep, well-drained, fine Typic Kanhaplohumults; with deep, somewhat excessively drained, loamy-skeletal Umbric Dystrochrepts
15 (1.4)	Very deep, well-drained, fine Typic Paleudults; with deep, well-drained, fine Umbric Dystrochrepts
16 (0.3)	Very deep, well-drained, fine-loamy Typic Dystrochrepts; with very deep, well-drained, fine-loamy Typic Paleudalfs

SOILS OF SUB HIMALAYAN REGION - SIWALIK HILLS

17 (1.6) Deep excessively drained, loamy-skeletal Umbric Dystrochrepts; with moderately deep, excessively drained, fine-loamy Typic Dystrochrepts

18 (1.0) Very deep, well-drained, fine-loamy Typic Dystrochrepts; with deep, well-drained, loamy-skeletal Dystric Eutrochrepts

19 (1.5) Deep, somewhat excessively drained, loamy-skeletal Typic Udorthents; with deep, somewhat excessively drained, fine-loamy Typic Dystrochrepts

20 (0.8) Deep, somewhat excessively drained, loamy-skeletal Typic Udorthents; with deep, well-drained, fine-loamy Typic Dystrochrepts

21 (0.6) Deep, somewhat excessively drained, fine-loamy Typic Haplumbrepts; with deep, well-drained, loamy-skeletal Typic Udorthents

22 (0.6) Deep, somewhat excessively drained, loamy-skeletal Typic Haplumbrepts; with very deep, well-drained, fine-loamy Umbric Dystrochrepts

23 (1.2) Deep, well-drained, coarse-loamy Typic Dystrochrepts; with moderately deep, somewhat excessively drained, loamy-skeletal Typic Dystrochrepts

SOILS OF LOWER HIMALAYAN RANGES (PURVACHAL)

24 (1.5) Very deep, well-drained, fine Typic Palehumults; with very deep, well-drained, fine Typic Dystrochrepts

25 (0.6) Very deep, well-drained, fine Typic Dystrochrepts; with deep, well-drained, clayey-skeletal Typic Haplohumults

26 (0.2) Very deep, well-drained, fine Fluventic Haplumbrepts; with deep, imperfectly drained, fine-loamy Aeric Haplaquents

27 (0.2) Very deep, well-drained, fine Pachic Haplumbrepts; with very deep, well-drained, fine Typic Haplumbrepts

28 (0.6) Very deep, well-drained, fine Typic Kandihumults; with very deep, well-drained, fine Pachic Haplumbrepts

29 (0.4) Moderately deep, somewhat excessively drained, loamy-skeletal Typic Dystrochrepts; with deep, well-drained, clayey-skeletal Umbric Dystrochrepts

30 (0.1) Moderately deep, well-drained, fine Pachic Haplumbrepts; with moderately deep, well-drained, fine-loamy Typic Dystrochrepts

31 (0.1) Deep, well-drained, loamy-skeletal Pachic Haplumbrepts; with deep, well-drained, fine-loamy Typic Haplumbrepts

32 (0.2) Deep, well-drained, loamy-skeletal Entic Haplumbrepts; with very deep, well-drained, fine-loamy Umbric Dystrochrepts

33 (0.5) Moderately deep, well-drained, clayey-skeletal Pachic Haplumbrepts; with deep, well-drained, fine Pachic Haplumbrepts

34 (0.6) Deep, somewhat excessively drained, clayey-skeletal Typic Dystrochrepts

35 (1.4) Shallow, excessively drained, loamy-skeletal Lithic Udorthents; with moderately deep, somewhat excessively drained, loamy-skeletal Pachic Haplumbrepts

SOILS OF PLAINS OF EASTERN CONTINUITY OF ASSAM

36 (0.9) Moderately shallow, well-drained, loamy-skeletal Typic Udorthents; with moderately deep, well-drained, coarse-loamy Entic Haplumbrepts

37 (1.2) Very deep, well-drained, coarse-loamy Umbric Dystrochrepts; with deep, well-drained, coarse-loamy Dystric Eutrochrepts

38 (0.5) Very deep, well-drained, fine Typic Dystrochrepts; with very deep, well-drained, fine Typic Kandihumults

39 (0.3) Very deep, well-drained, fine Typic Kandihumults; with deep, well-drained, clayey-skeletal Typic Dystrochrepts

40 (0.4) Very deep, well-drained, fine-loamy Typic Dystrochrepts; with very deep, moderately well-drained, fine-loamy Fluventic Dystrochrepts

41 (0.7) Very deep, imperfectly drained, coarse-loamy Aeric Haplaquepts; with very deep, imperfectly drained, fine-silty Typic Haplaquepts

42 (0.2) Very deep, moderately well-drained, coarse-loamy Typic Udifluvents; with deep, well-drained, coarse-loamy Typic Dystrochrepts

43 (0.3) Deep, well-drained, coarse-loamy Typic Udifluvents; with moderately deep, somewhat excessively drained, sandy Aquic Udipsamments

44 (1.1) Deep, imperfectly drained, coarse-silty Aeric Fluvaquents; with very deep, moderately well-drained, coarse-loamy Fluventic Dystrochrepts

45 (0.4) Moderately shallow, somewhat excessively drained, coated Typic Udipsamments

46 (11.4) Rocky mountains covered with perpetual snow and glaciers

TABLE 3: Soils under limiting* depth classes

Class	*Agro-eco sub-region*		*Soil map units covered*	*Area covered*	
				10^3 ha	*(% of TGA)*
Shallow (25-50 cm)	Warm eastern Himalayas	per-humid	1, 3, 4, 6	1655.0	19.7
	Warm Purbanchal	per-humid	35	79.3	0.9
Moderately shallow (50-75 cm)	Warm Eastern Himalayas	per-humid	2, 7, 8	485.9	5.8
	Hot humid plains		36, 45	76.6	0.9

* Critical to support optimum crop growth

TEXTURE

Texture is an important soil physical characteristic, which controls soil water retention and availability, workability of soil, infiltration and drainage conditions. Three textural groups identified in Arunachal Pradesh are clayey, loamy and sandy. Data indicate that a substantial area is covered by gravelly loam soils, which accounts for about 48.6 percent of TGA. Clayey surface soils cover an area of 12.0 percent, whereas, sandy soils cover only 2.8 percent of total area (Table 4).

EROSION

Soil erosion is the major soil degradation process among the various kinds of soil problems being faced. In Arunachal Pradesh steep lands with high rainfall are often subjected to soil loss by water erosion and landslides. The soils of the area were grouped into four erosion classes, *eg,* slight, moderate, severe and very severe (Figure 8). Very severe erosion occurs in an area of 1.83 million hectares (21.9 percent of TGA). Severe erosion occurs in 31.8 percent of the area; and about 25.7 percent of the total area is affected by moderate erosion (Table 5). *Jhum* cultivation and indiscriminate deforestation leads to accelerated soil erosion in Arunachal Pradesh.

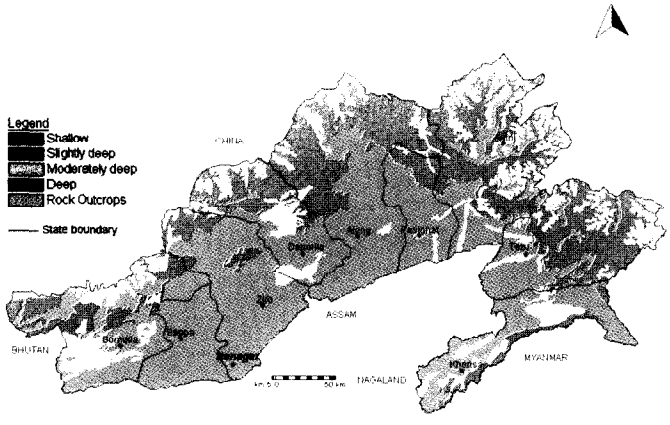

FIGURE 7: Soil depth map of Arunachal Pradesh

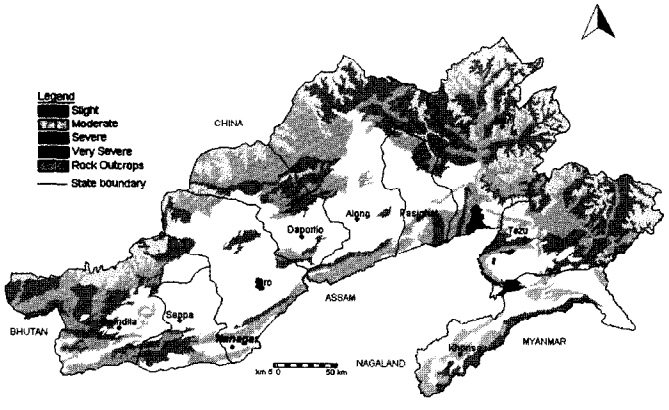

FIGURE 8: Soil erosion status of Arunachal Pradesh

TABLE 4: Soils under limiting textural classes (surface)

Class	*Agro-eco Sub-region*	*Soil map units covered*	*Area covered* 10^3 *ha*	*(% of TGA)*
Sandy	Warm per-humid eastern Himalayas	4	125.7	1.5
	Hot humid plains	43, 45	105.1	1.3
Gravelly loam	Warm per-humid Eastern Himalayas	1, 2, 3, 4, 6	3195.6	38.1
	Warm per-humid Siwalik	17, 18, 19, 20, 21, 22, 23	522.8	6.2
	Warm per-humid Purvanchal	31, 32, 35	210.5	2.5
	Hot humid plains	36	54.8	0.6
Clayey	Warm per-humid eastern Himalayas	7, 9, 12, 13	761.8	9.1
	Warm per-humid Purvanchal	25, 26, 27, 28, 30, 33, 34	230.1	2.7

TABLE 5: Soils under limiting erosion classes

Class	*Agro-eco sub-region*	*Soil map units covered*	*Area covered* 10^3 *ha*	*(% of TGA)*
Very severe	Warm per-humid Eastern Himalayas	1, 2, 3, 4, 6	1660.8	19.8
	Warm per-humid Purvanchal	35	79.3	0.9
	Hot humid plains	43, 45	92.1	1.1
Severe	Warm per-humid eastern Himalayas	1, 2, 3, 4, 6, 7, 8, 12, 14, 15	2069.2	24.7
	Warm per-humid Siwalik	17, 19, 20, 21, 22, 23	313.8	3.7
	Warm per-humid Purvanchal	27, 29, 30, 31, 32, 34, 35	173.8	1.4
	Hot humid plains	36, 42, 43, 44	117.0	1.4
Moderate	Warm per-humid eastern Himalayas	5, 7, 9, 10, 11, 14, 16	1715.6	20.3
	Warm per-humid Siwalik	18, 20, 21, 22, 23	150.4	1.8
	Warm per-humid Purvanchal	24, 25, 26, 28, 30, 32, 33	121.5	1.4
	Hot humid Plains	36, 37, 38, 39, 40, 42, 43	184.2	2.1

SOIL REACTION (pH)

Soil reaction is also an important limiting factor in crop growth. It governs the uptake of nutrients held in exchange sites of soil colloids. In Arunachal Pradesh, the majority of the soils are acidic in nature. Soil acidity is caused by loss of base due to intensive leaching by high rainfall and the presence of an appreciable amount of exchangeable aluminium. The data indicate that extremely acidic (pH <4.5), very strongly acidic (pH 4.5-5.0) and strongly acidic (pH 5.1-5.5) soils cover an area of 1.4, 21.9 and 39.3 percent, respectively. Moderately acidic (pH 5.6-6.0) and slightly acidic (pH 6.1-6.5) soils cover an area of 12.2 and 10.1 percent, respectively. Neutral to slightly alkaline soils (pH ranging between 7.0 to 7.5) account for only 4.3 percent of the TGA of the state (Figure 9). The limiting soil reaction (pH) classes (extremely acidic to moderately acidic) occurring in soil map units under different agro-eco sub-regions are presented in Table 6. These soils need immediate attention for amendment by applying lime or adopting tolerant crops.

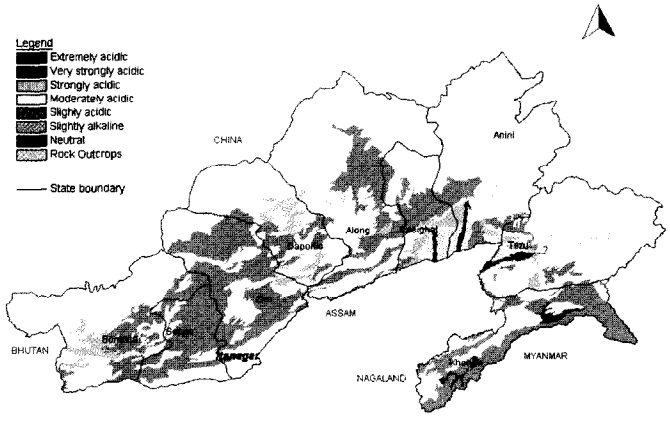

FIGURE 9: Soil reaction (ph) status of Arunachal Pradesh

CONCLUSION

Information technology has opened up new avenues for making adequate use of resource information in land use planning. Soil has always been considered as an important bio-physical factor and as one of the most critical in land use planning. Conducting a soil resource inventory in mountainous terrain in India is entirely different from doing the same in the rest of the country: it involves huge amounts of money and extraordinary efforts. The primary data have been generalized in view of land use planning, where production systems and socio-economic scenarios are typical. The area is different from the rest of the plains of the country where the lands are productive and systematic agriculture is practised. Whereas this region is thinly populated with little infrastructure hinders normal agricultural practice. Apart from these the area is rugged and remotely located. Data availability in these regions is scanty and proper database creation is immensely important for users such as planners, decision-makers and non-governmental agencies involved in developmental planning in terrain such as the eastern Himalayan eco-system.

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TABLE 6: Soils under limiting soil reaction (pH) classes

Class	*Agro-eco sub-region*	*Soil map units covered*	*Area covered* 10^3 *ha*	*(% of TGA)*
Extremely acidic	Warm per-humid Siwalik	19	71.2	0.8
	Warm per-humid Purvanchal	24, 33	50.5	0.6
Very strongly acidic	Warm per-humid eastern Himalayas	5, 7, 9, 11, 13, 16	1291.3	15.4
	Warm per-humid Siwalik	17, 18, 21, 22	193.6	2.3
	Warm per-humid Purvanchal	25, 27, 29, 32, 34, 35	210.9	2.5
	Hot humid plains	36, 38, 41	139.3	1.7
Strongly acidic	Warm per-humid eastern Himalayas	1, 5, 7, 10, 11, 14, 16	2671.3	31.9
	Warm per-humid Siwalik	17, 19, 20, 22, 23	255.8	3.0
	Warm per-humid Purvanchal	24, 27, 30, 33, 35, 36	178.6	2.1
	Hot humid plains	36, 38, 40, 41	188.2	2.2
Moderately acidic	Warm per-humid eastern Himalayas	1, 2, 8	911.6	10.9
	Warm per-humid Siwalik	20, 23	68.1	0.8
	Hot humid plains	42, 44	47.5	0.5

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RESUME

Arunachal Pradesh, l'état le plus montagneux d'Inde, est situé dans la partie nord est de la région Himalayenne et est caractérisé par de fortes chutes de pluies annuelles, une végétation de forêts et une diversité de sols. L'information sur les sols de l'état est essentielle pour une planification scientifique de l'utilisation de terres et une production acceptable. Un inventaire des ressources du sol et une création ultérieure de base de données pour une cartographie thématique utilisant un Système d'Information Géographique (SIG) est présenté dans cet article. Du point de vue physiographique, Arunachal Pradesh peut être divisé en quatre zones distinctes: montagnes couvertes de neige (5500 m); zones Himalayennes basses (3500 m); collines Siwalik sous-Himalayennes (700 m); et plaines est de l'Assam. Les sols que l'on trouve dans ces zones physiographiques sont Inceptisols (37 pour-cent), Entisols (35 pour-cent), Ultisols (14 pour-cent) et Alfisols (0.5 pour-cent). Le reste des sols peut être classé comme divers. Des études d'inventaire des ressources des sols montrent que les sols de l'écosystème de l'est Himalayen chaud très humide, avec un régime de température "thermique", sont Inceptisols et Entisols et qu'ils sont très acides par nature. Des sols de l'écosystème des collines Siwalik chaud très humide, avec un régime de température "hyperthermique", sont également des Entisols et des Inceptisols , avec des niveaux d'acidité allant de modéré à élevé. Les sols dominants de l'écosystème des collines nord-est du Purvachal, avec des régimes de température "hyperthermique" et "thermique", sont des Ultisols et Inceptisols. Inceptisols et Entisols sont les sols dominants dans l'écosystème de la plaine chaude et humide. Des formes de terrain à pentes raides et à forte pluviosité sont principalement responsables d'un fort risque d'érosion dans l'état. La carte d'érosion des sols indique qu'une très forte (20 pour-cent de TGA) à forte (25 pour-cent de TGA) érosion du sol se produit dans la zone chaude très humide, alors qu'une érosion modérée se produit dans les collines de Silawik et dans des plaines chaudes et humides. Ceci est évident lorsqu'on regarde la distribution de la classe profondeur des sols en Arunachal Pradesh, qui montre que des sols superficiels couvrent 20 pour-cent du TGA de l'état. La plus grande partie de l'état est couverte de collines et les cultures agricoles sont limitées aux régions des vallées. Cependant, les sols d'autres zones physiographiques (terrain modérément accidenté, à plus basse altitude) fournissent un espace pour des plantations, tels que orangers, bananiers et théiers. Le tourisme aussi offre un potentiel immense pour l'état.

RESUMEN

Arunachal Pradesh, el mayor estado montañoso de la India, se encuentra en el noreste de la región del Himalaya y se caracteriza por tener lluvia anual alta, vegetación de bosque y gran diversidad de suelos. La información sobre los suelos del estado es esencial para la planificación científica del uso de las tierras y la producción sostenible. El artículo presenta un inventario del recurso suelo y la creación de una base de datos de suelos para cartografia temática con el uso de un sistema de información geográfica (SIG). Desde el punto de vista fisiográfico, Arunachal Pradesh puede ser dividido en cuatro zonas distintas: montañas cubiertas de nieve (5500 msnm); serranías inferiores del Himalaya (3500 msnm); las colinas Siwalik del sub-Himalaya (700 msnm); y las planicies del Assam oriental. Los suelos que ocurren en estas zonas fisiográficas son Inceptisoles (37%), Entisoles (35%), Ultisoles (14%) y Alfisoles (0.5%). Los demás suelos pueden ser clasificados como misceláneos. Los estudios de inventario del recurso suelo muestran que los suelos en el ecosistema cálido perhúmedo del Himalaya oriental, con un régimen de temperatura "térmico", son Inceptisoles y Entisoles, y que estos son altamente ácidos. Los suelos en el ecosistema cálido perhúmedo de las colinas Siwalik, con régimen de temperatura "hipertérmico", son también Entisoles e Inceptisoles, altamente a moderadamente ácidos. Los suelos dominantes en el ecosistema colinoso del Purvachal nororiental, con regímenes de temperatura "hipertérmico" y térmico", son Ultisoles e Inceptisoles. Los suelos dominantes en el ecosistema de planicies muy cálidas y húmedas son Inceptisoles y Entisoles. Relieve escarpado y lluvia abundante son mayormente responsables por crear un alto riesgo de erosión en el estado. El mapa de erosión de suelos indica que la erosión de suelos es muy severa (20% del TGA) a severa (25% del TGA) en la zona cálida perhúmeda, mientras que la erosión es moderada en las colinas de Siwalik y en las planicies húmedas muy cálidas. Esto queda evidenciado por la distribución de las clases de profundidad de suelos en Arunachal Pradesh, la cual muestra que el 20% de TGA del estado se encuentra cubierto por suelos delgados. La mayor parte del estado corresponde a colinas, mientras que la producción agrícola queda restringida a los valles. Sin embargo, los suelos de las otras zonas fisiográficas (terrenos moderadamente colinosos a menor altitud) se prestan para plantaciones con cultivos tales como naranja, banana y té. El turismo también ofrece un gran potencial para el estado.