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Soil Resource Information System for N.E. India

Interview

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Soil Resources Information System in GIS Environment for Land Use Planning in Mountainous Regions

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Abstract

The soil resource inventory of Nagaland state of North Eastern Hamalayan region was carried out. Data generated from soil survey and lab analysis were subsequently used to create a database for soil and thematic information in geographical information system. Soil maps on 1:250,000 scale were digitized using table digitization techniques. Toposheets were merged and edge- matched for bringing out the soil polygon maps. Attributewise map reclassification was done for thematic maps. Land use planners, policy makers and development agencies urge for such information for planning. This soil information system will be helpful in land use planning.

Introduction

Soil is one of the important non-renewable basic natural resources that supports living beings including mankind on the earth surface. Hence, maintenance of the valuable resource in a state of high productivity on sustainable basis and to save it from degradation is the primary necessity of the present time. Therefore, the knowledge of soils, in respect of their extent, distribution, characterization and use potential, is extremely important for optimized land utilization (Maji et al., 1993). However, the land use pattern in hilly and mountainous region of our country markedly differs with that of the plain regions. Sloping hill surface, erosion hazard and local crop preferences determine the land use pattern of mountainous zones and thus needs special attention and technologies towards natural resources inventory. Qiguo (1999) has suggested application of '3S' technologies in sustainable agricultural development and land use planning in mountainous region. The three technologies are Remote Sensing (RS), Geographical Information System (GIS) and Global Positioning System (GPS). Application of such technologies help in erosion and degradation monitoring and land use planning. Soil survey based database in GIS for land use planning has been elucidated by Zinck and Valenjuela (1990). Computerised land evaluation of hill lands has been reported by Maji et al., (1993). The National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) undertook the task of resource inventory of the soils of the state for generating a soil database, aiming at providing information for planning a viable land use. Soil information system for Nagaland state using SPANS GIS is presented here.

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Geographical Setting

The state of Nagaland is situated between latitudes of 25o06' to 27o04' N and longitudes of 93o21' to 95o21' E. It covers an area of 166,000 ha . The state is bounded by Assam in the north and west Myanmar and Arunachal pradesh in the east and Manipur in the south. It has 7 administrative districts with Kohima as its capital. The area can broadly be divided into four distinct physiographic regions. The zone at higher elevation is the greater Himalayas with snow-capped mountains with altitudes rising upto 5500 m above mean sea level (MSL). Below this zone comes the lower Himalayas range up to 3500 m in altitude. The Sub-Himalayas belt including the Siwalik hills (altitude up to 1500 m above MSL) comprises the third physiographic zone. These are the plains of the eastern continuity of Assam. The climate of Nagaland is hot to warm sub tropical in areas below 1000 m MSL and are sub-temperate in high altitudinal areas. Annual rainfall is about 1000 mm. Temperature varies 0oC to 10oC in winter and 25oC to 40oC in summer.

Methodology

Soil Survey and Mapping

Soil survey was undertaken following a 3-tier approach comprising image interpretation, field surveys and laboratory analysis (Sehgal et al., 1987). Landsat images (1:250,000 scale) wereinterpreted for landform analysis and transferred on Survey of India toposheets to prepare the base physiographic map for soil survey. Soil survey was carried out following sample strip, grid and random observation. Sample strips were examined with 30 nos. of profiles for in-depth soil information. Grid samples were taken at 10 kms interval. Random observations were taken for unrepresented physiographic units. In total, about 350 observations were recorded (in accessable areas) on each toposheet. Soil samples, collected horizonwise, were analysed for various physico-chemical and morphological properties. Soils were characterised and mapped (Maji et al., 2000).

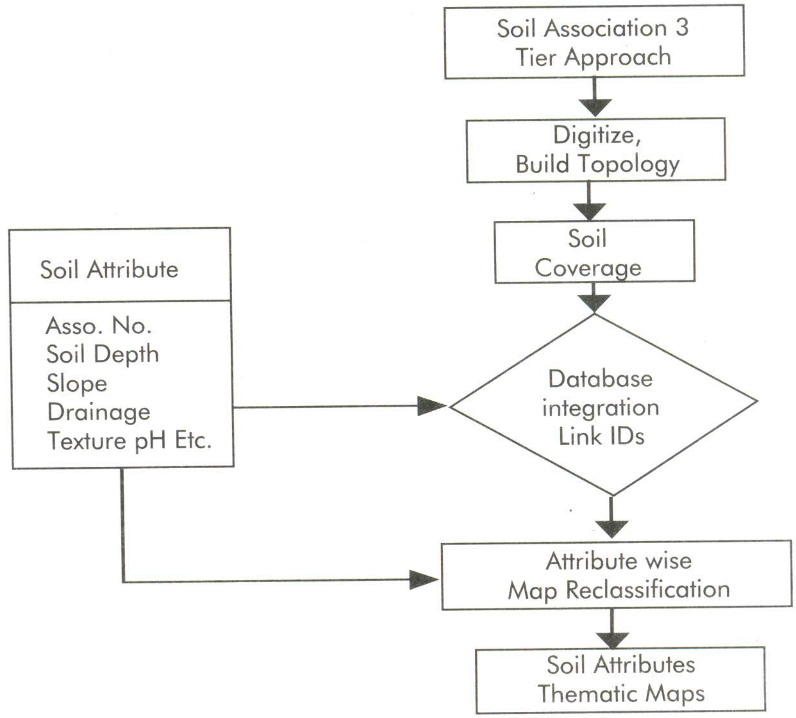

Fig: 1. Flow chart for thematic mapping generation

GIS Applications

The soil map formed the basic spatial database. The attribute database contained various parameters of site characteristics, physical, morphological and chemical properties of both dominant and sub-dominant soils of each map unit (Soil family association). These datasets were used to generate various thematic maps. The database has been developed in MS-Excel. The identified soil association units on 1:250,000 scale (toposheets) were digitized in SPANS GIS. The adjacent vector soil layers were edge matched and polygon topology was built and Ids were assigned to polygon layer. The cover was projected to real world coordinates in polyconic projection system, with geographic extents in latitudes/longitudes. The properties like pH, depth, texture, soil taxonomic class, erosion, and physiography with their respective classes were assigned to the soil association units. These were subsequently dissolved to prepare thematic layers. Area analysis was performed for these layers using statistical module. A flow chart for thematic map generation is depicted in figure 1.

Soil Resource Information System

We need consistent and comparable information about soils in a manner that, those are arranged in logical order and analysed and interpreted for objective specific querries. Thus, the information arranged in GIS framework is useful. Mc Cloy (1995) has described different information systems using GIS. These are, Land Information System (LIS), Facilities Information System (FIS), and Natural Resource Management Information System (NRMIS). The soil information system, a component of NRMIS, is a computerized database management system, which in addition to simple storage and retrieval for reporting, include other functions such as manipulation and dissemination of information to various users. The information system is composed of sets of files in GIS in two different formats, viz. spatial and non-spatial. The soil units are of spatial nature and the characteristics of the soils in each polygon (map units) are non-spatial.

The soil map thus produced, as shown in Fig.2. It is observed that different kinds of soils, identified in Nagaland, vary widely due to the variability in climate, physiography, geology and vegetation that influence the soil development. 36 soil family associations are spread over the state. Area analysis shows Inceptisols as dominant with coverage of 66 per cent followed by Alfisols (3 per cent), Ultisols (23 per cent) and Entisols (7 per cent) of total geographical area (TGA) of the state.

Thematic Maps in Identifying Problems and Potential

Thematic map plays an important role to understand the spatial nature of a particular theme and helps to interpret them for loand use planning and deciding about the ameliorative or conservation measures. These maps have been generated to cater to the needs of variou user agencies. The attributes chosen were those, which influence land use relationships.

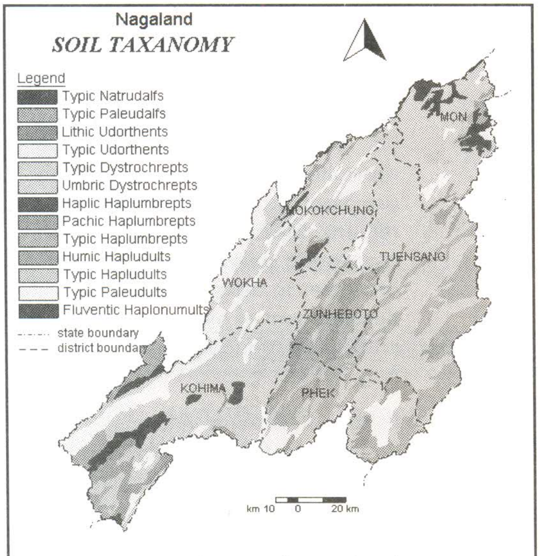

Fig. 2 Soil map of Nagaland

The maps of landform, soil depth, texture, erosion, and soil reaction (pH) have been prepared using reclassification technique in GIS. A few thematic maps are presented in the text. These maps help in identifying the problems and potential of the area.

Landforms

Landform analysis map shows that the state is dominated by dissected land (42 percent) and steep lands (39 percent). Rolling lands occupy about 7 percent of TGA. Gently sloping land accounts for only 2 percent of TGA. As landform influences the land management in mountainous region, this map will be helpful to identify and prioritize areas for conservation measures, agro-forestry, silvi-pasture and forest cover.

Depth

Effective soil depth is an important soil parameter, which decides the growth and performance of crops. Among the five depth classes, shallow soils cover about 20.7 per cent and moderately shallow soils record an area of 6.7 per cent of the total area of the state. Spatial distribution of different depth classes is shown in fig.3.

Texture

Texture controls soil water retention and availability, workability of soil, infiltration and drainage conditions. Three major textural groups identified are fine, fine loamy and loamy skeletal. Substantial area is covered by fine and fine loamy soils accounting for about 43.7 and 26.0 percent of TGA respectively. Loamy skeletal surface soils record an area of 24 per cent, whereas coarse loamy soils cover only 3.6 per cent of TGA.

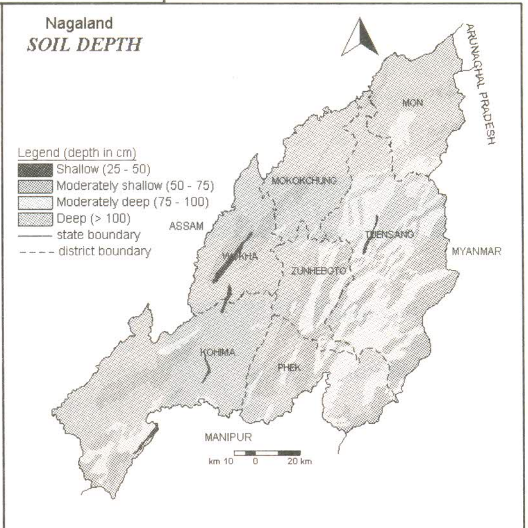

Fig. 3 Soil Depth map of Nagaland

Erosion

Soil erosion is a major soil degradation process among the various kinds of soil problems. Steep lands with high rainfall are often subjected to soil loss by water erosion and landslides in the state. The soils of the state are prone to four classes of soil erosion e.g. slight, moderate, severe and very severe . Fig.4 shows the saptial distribution of each class. 25.0 per cent of TGA suffers from severe erosion and about 65.5 per cent of total area is under moderate erosion hazard. Soil loss protection is must in the areas under severe erosional hazard.

Soil Reaction (pH)

Soil reaction governs the release of the nutrients held in exchange site of soil colloids. In Nagaland, most of the soils are acidic in nature. Strongly acidic (pH 5.1-5.5) soils cover an area of 7.1 percent, moderately acidic (pH 5.6-6.0) and slightly acidic (pH 6.1-6.5) soils record an area of 89.5 percent and 3.3 percent respectively of TGA. The limiting soil reaction (pH) classes (extremely acidic to acidic) occurring in areas under different agro-eco subregions need immediate attention for amendment.

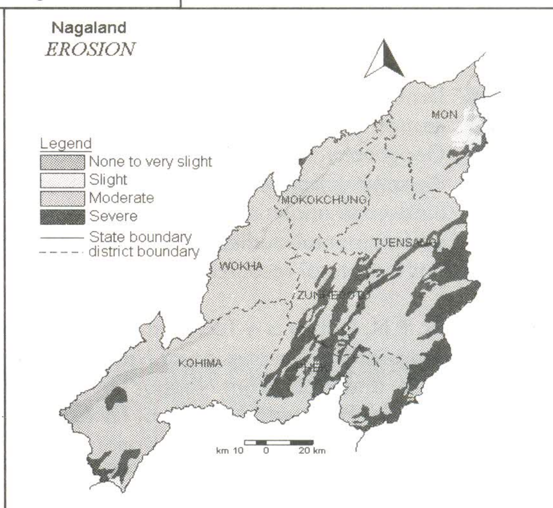

Fig. 4 Soil Erosion map of Nagaland

Conclusions

Information technology has opened up new avenues for making use of resource information in land use planning in a big way. Soil has been considered as one of the bio-physical factor and the most critical in land use planning. Soil resource inventory in a mountainous terrain is completely different from the traditional plain areas, where the production systems scenario is entirely different. and involve huge amount of money and efforts. The primary data has been generalized in view of the land use planning. Availability of data on soils resources for these regions are scanty and proper database creation has immense importance to the planners, decision makers and other non-governmental agencies involved in developmental plan.

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References

Mc Cloy, K.R. (1995). Resource management information system, processes and practice, Taylor and Francis, U.K.

Maji, A.K., Singh, R.S. and. Sehgal, J. (1993). Soils of hill lands and their suitability for land use planning, J. Hill Farming, 6: 63-68.
Maji, A.K., Dubey, P.N., Verma, T.P., Chamuah, G.S., Sehgal, J. and Velayutham, M. (2000). Soils of Nagaland for optimising land use, NBSS Publ. 47b, NBSS&LUP, Nagpur, India.

Qiguo, Zhao (1999). Application of '3S" technologies in sustainable agricultural development and land use planning in mountainous regions. Int. Symp. RS and GIS for monitoring soils and geomorphic processes to assist integrated development of mountainouse lands. Kathmandu, 22-29 Aug.1999.

Sehgal, J., Saxena, R.K. and Vadivelu, S. (1987). Field Manual, Soil Resource Mapping of different states in India. NBSS Publ. 13, NBSS&LUP, Nagpur, India.

Zinok, J.A. and Valenjuela, C.R. (1990). Soil geographic database: Structures and application examples, ITC Journal 3:270-293.

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