

# Soil Resource Inventory and Mapping using Geospatial Technique

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## Abstract

Soil is one of the Earth's most important resources. There are many differences among the soils of plains-like and hilly terrains, and therefore, accurate and comprehensive information on soil is essential for optimum and sustainable soil utilization. However, information on the soil of the hilly terrains of the Eastern Ghats of Tamil Nadu, India, is limited or absent. In the present study, Kolli hill, one among the hills of the Eastern Ghats, was soil-inventoried and mapped using a ground survey and remote sensing. Soil samples were collected and their physico-chemical properties analyzed according to the United States Department of Agriculture (USDA) standards. The soils were classified up to the family level. As a result of this study, 30 soil series belonging to ten sub-groups of five great groups and three sub-orders and orders each, were identified (classified to the family level) and mapped. Entisols, Inceptisols and Alfisols were the three orders, among which Entisols was the major one, occupying 75% of the area. Among the five great groups, Ustorthents occupied majority of the area (73%). Lithic Ustorthents and Typic Ustorthents were the two major sub-groups, occupying 40% and 26% of the total area, respectively. The present soil resource mapping of the Eastern Ghats of Tamil Nadu is a pioneer study, which yielded valuable information on the soil in this region.

Keywords : Soil Inventory, Soil Mapping, Kolli hill, Geospatial Technique

## 要 旨

지구상에서 가장 중요한 자원 중 하나인 토양은 지형조건에 따라 서로 다른 다양한 형태를 가지고 있기 때문에 최적화되고 지속 가능한 토양 자원의 활용을 위해서는 정확하고 포괄적인 정보가 필요하게 된다. 그러나 연구대상지역인 인도 Tamil Nadu지역의 경우 지형적인 영향으로 토양에 대한 정보가 많이 누락되어 있었다. 따라서 본 연구에서는 Tamil Nadu 지역 Eastern Ghat의 Kolli Hill에 대한 지형 측량과 원격탐측을 통한 토양조사와 지도제작이 이루어졌으며 토양 샘플의 물리화학적 특성은 미국 농무부 (USDA) 기준에 따라 분석이 이루어졌다. 연구 결과로 토양을 5개의 대분류와 10개의 부분류로 구분할 수 있었으며 토양의 분포 특성을 보면 Entisol, Inceptisol 그리고 Alfisol의 세 계층 중 Entisol의 경우 전체 지역에 대하여 75%의 분포를 보였으며 5개의 대분류에 대해 Ustorthent가 73% 로서 대부분 지역에 나타나고 있다. 또한 Lithic Ustorthents(40%), Typic Ustorthents(26%)의 분포를 나타내었다. 앞으로도 대상지역에 대한 토양자원에 대한 지속적인 연구가 요구되며 이를 통하여 토양에 대한 많은 정보를 활용할 수 있을 것이다.

핵심용어 : 토양 자원, 토양 지도, Kolli Hill, 지형 공간 정보 기술

## 1. Introduction

Soil, one of the major resources, forms the foundation for any region's developmental activities. The

various physico-chemical properties of soil determine not only environmental conditions and economic viability, but also, thereby, the success or failure of management and developmental strategies(Ziadat et

2008년 12월 1일 접수, 2008년 12월 29일 채택

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al. 2003). Thus, understanding of the properties and potentials of soil becomes vital for sustainable management and utilization of resources. The nature, extent and spatial distribution of soils, along with their potentials and limitations are required for agricultural development, engineering, sanitation, recreational, aesthetic, and other uses(Dwivedi and Sinha 1999). There are major differences between the soils of plains-like and hilly terrains. Generally, the plains soil is well developed, having minimal limitations with respect to the physical properties related to depth and texture, whereas hills soil can present problems owing to the steepness of the slope, and ground cover. Therefore a clear understanding of the physico-chemical properties of the soil of such terrains is a pre-requisite for any developmental activities. With regard to the hilly terrains of India, detailed soil surveys has yet to be carried out, with the result that the information available is insufficient for formulating better land utilization plans. The Soil Survey and Land Use Organization in India, for example, generally name the soils in hills as hill soils(Samuel et al. 1975). The recent work done by the State Ground and Surface Water Resources Data Centre(SGSRDC 2001) in Namakkal district amounted to a detailed assessment of the soil and water potentials for that area. However, Kolli hill was omitted from this study, which considered its soil to be simple hill soil.

Until the late 1920s, soil surveys had been carried out according to the conventional approach, which is tedious, time consuming, cost-prohibitive and impractical for inhospitable terrain(Venkataratnam 1980; Dwivedi and Sinha 1999). The development of aerial photographs and interpretation techniques, however, improved this situation. Several authors(Krishnamoorthy and Srinivasan 1974) successfully used aerial photographs for soil mapping. Subsequently, too, technological development in remote sensing and the availability of high-resolution data simplified processes, overcoming the difficulties entailed in soil resource mapping by the conventional approach. Remote sensing tools are used for identification, delineation and characterization of soils and for land evaluation(Reddy et al. 1990). Satellite data providing enhanced spec-

tral and spatial characteristics indeed offer information pertinent to soil boundary delineation, even in the case of intensively cultivated areas(Roundabush et al. 1985; Thompson et al. 1984). Many researchers have used remote sensing data in soil map preparation(Dwivedi 1985; Singh and Dwivedi 1986). Such soil maps have been used as input in generating derivative maps such as those indicating land capability, land irrigability and suitability for specific crops, and ultimately have been utilized in preparing action plans for land and water resources development(Rao et al. 1996; 1997).

Kolli hill, a mountainous region in the Eastern Ghats of Tamil Nadu, India, is highly vulnerable. Indiscriminate felling of trees, as well as forest fires, soil erosion, and other factors, further weaken the already fragile ecosystem(Jayakumar et al. 2002; Ramachandran 2007). The results are soil degradation and soil-quality decline; in fact, there is evidence that a high percentage of soils are, to varying degrees, degraded, potentially jeopardizing the food supply of the people of Kolli hill. Indeed, these tribal people depend on agriculture for both food and their economy, but the yields they are able to produce are very poor. Although poor yields can be attributed to a number of causes, the main one appears to be soil limitations. Thus, understanding of the physico-chemical properties of those people's soil resources is indispensable not only to conservation, but also to optimal utilization. As there is no soil report available for the terrain of Kolli Hill, the present study was undertaken to systematically sample, analyze and map those soil resources using a ground survey coupled with remote sensing.

## 2. Study area

Kolli Hill, the study area, lies between 11° 10' 54" - 11° 30' 00" N latitude and 78° 15' 00" - 78° 30' 00" E longitude(Fig. 1).

It is situated in the Namakkal District of Tamil Nadu above the River Cauvery, and covers an area of about 503 km<sup>2</sup>. Physiographically, it is a hilly region with an altitude ranging from 180 to 1,415m, at the foothills and the plateau, respectively(Fig. 2).

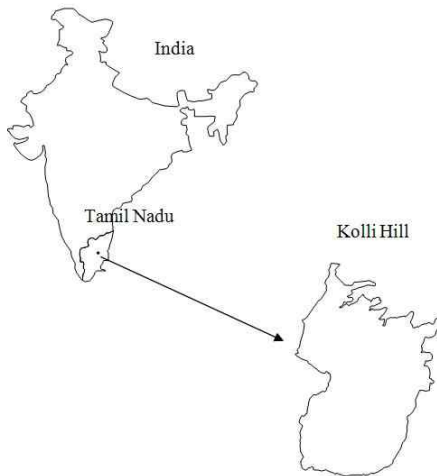


Fig. 1. Map of study area

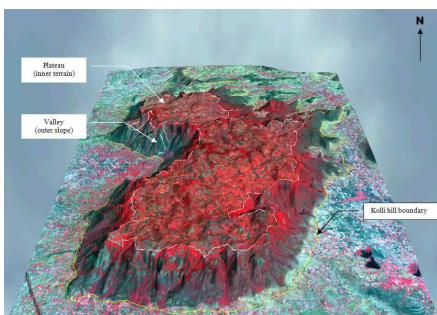


Fig. 2. Digital terrain model(DEM) of study area showing complexity of terrain(prepared using ERDAS IMAGINE software - Position details: Above ground level(AGL) = 13,153 meters, Field of View(FOV) = 50, Pitch = 33 and Azimuth = 0)

The slope of this region varies from gentle to very steep. Geologically the soil of the study area is composed of acid charnockite with minor bands of pyroxene granulate and magnetite quartzite(Mani, 1976). The top portion of the hill is highly undulating, cut by a network of streams, most of them semi-perennial or seasonal, flowing in all directions but mostly east and southeast, and ultimately draining into the Ayyar River. The mean annual rainfall is 1,318mm, which is received largely between May and December (Harikrishnan, 1977). The annual mean maximum and mean minimum temperatures are 35° and 18° C, respectively(Harikrishnan, 1977). The population of Kollu Hill is chiefly(94.8%) tribal(Census India, 2001).

### 3. Materials and methods

In the present study, IRS 1D Linear Imaging Self-scanning Sensor(LISS) III(23.5 m spatial resolution and four spectral band) digital data from path 101 and rows 65 and 66 of 25th February 2002, as well as IRS 1C PAN(5.8 m resolution and panchromatic, 0.5~0.75 $\mu$ m) digital data from path 101 and row 66 of 9th January 1999(Fig. 3) were used as high spectral resolution and high spatial resolution data, respectively.

The IRS 1C/1D satellite data were used because they provide data at a finer spatial resolution than SPOT(Kalyanaraman et al. 1995) data. The LISS III and PAN were selected for the present study because, after merging, they are very effective for land use and other classifications(Ray 2004). Satellite data for February was selected owing to the nature of the study area, evergreen and deciduous forest in the valleys, with various types of agricultural development underway on the plateau. One of the basic requirements for merging is that the acquisition date of two satellite sensor datasets be as close as possible(Raptis et al. 1998). The PAN data of January 1999 was the only cloud-free data available during that season. Survey of India(SOI) topographical maps, a Munsell color chart, equipment for soil sample collection, pol-

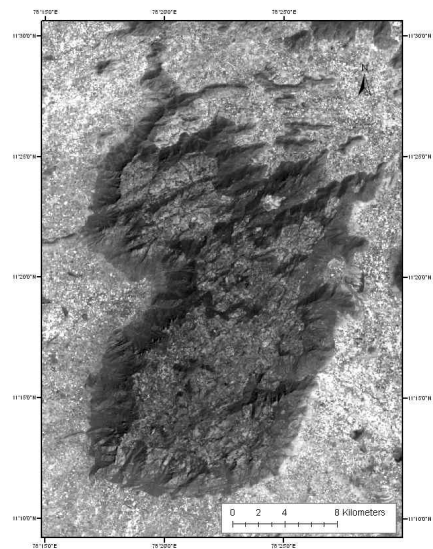


Fig. 3. IRS 1C PAN data of the study area

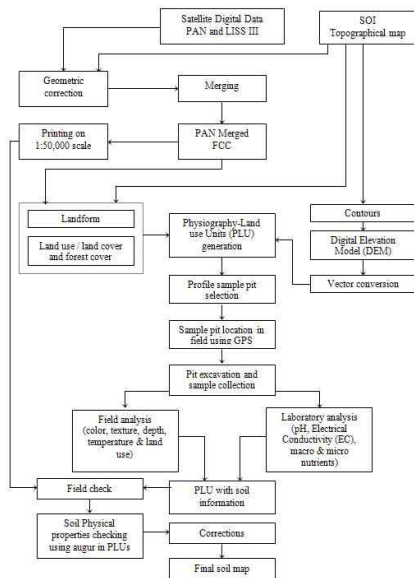


Fig. 4. Stages of preparation of soil resource maps

ethylene bags for soil sample storage, labels, and a Leica GS 20 PDM Global Positioning System(GPS) were used. The methodology is illustrated in Fig. 4.

### 3.1 Soil sample collection and mapping

The steps adopted from NBSSLUP(<http://nbsslup.nic.in>) to generate a soil map of the study area include: (i) generation of PAN merged data; (ii) interpretation of merged data to derive information on land use/land cover and physiography; (iii) generation of physiography-landuse units(PLUs); (iv) soil sample collection from large and mini pits and physico-chemical analysis; (v) soil mapping, ground-truth collection to develop PLU-soil relationship and finalize soil map.

#### 3.1.1 Generation of PAN merged data

Merging of multi-sensor image data produces fine spatial and spectral resolution data, which is essential to accurate classification of the Earth's structures and features(Ray 2004). Digital image processing of the satellite data was carried out using ERDAS IMAGINE 9.0. Software on an HP Workstation. The IRS 1C PAN data was geometrically corrected taking 30 ground control points(GCP) from the topographical maps using a 1st-order polynomial equation with a

0.52 pixel root mean square error(RMSE). The LISS III data was geometrically corrected by taking 35 GCPs from the PAN data using a 1st-order polynomial equation with a 0.3 pixel RMSE. The Principal Component Substitution(PCS) method, according to Prasad et al.(2001), was used to merge the LISS III and PAN data.

According to PCS-based fusion, the LISS data was first subjected to principal component(PC) analysis in order to obtain the 1st PC with maximum variance. This PC was then replaced by the high resolution image channel which had been stretched to the variance and average of PC1. This combination was then transformed back into the RGB domain by inverse principal component analysis transformation. The resulting image was subjected to a rescaling procedure(0-255), to obtain the final fused output

#### 3.1.2 Generation of land use / land cover and physiography

Following the standard visual interpretation technique, a land use / land cover map of the study area was prepared from the digital data by using the onscreen visual interpretation method(Jayakumar et al. 2002), and was finalized after a rigorous field check.

A landform map also was prepared from the satellite data, following Strahler(1964) and NRSA(1995), and finalized. From the topographical maps, contour lines(altitude details), road network(accessibility) and drainage network maps were traced. A digital elevation model(DEM) was prepared from according to the contour lines, and a digital terrain model(DTM) was prepared from the DEM and satellite data using Erdas Imagine software. The slope, in degrees, was drawn according to the DEM, using the "Slope" function of that software. The slope, ranging from 0 to 82 degrees, was recoded into 2-degree intervals and vectorised.

#### 3.1.3 Generation of physiography-landuse units (PLUs)

The land use/land cover, landform and slope(vector) maps were overlaid using overlay analysis with the "Union" function of ArcGIS software. This func-

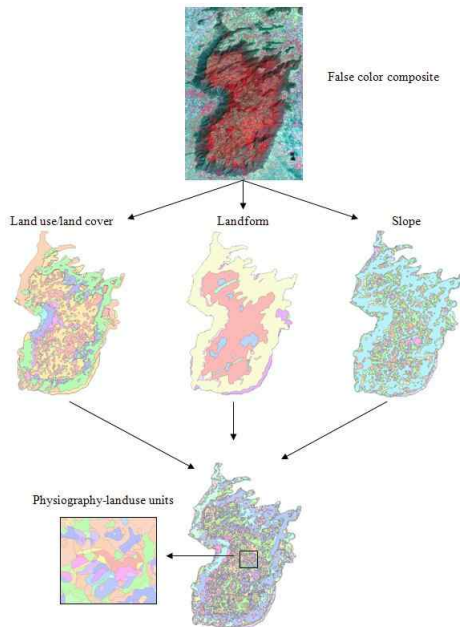


Fig. 5. Preparation of Physiography-land use units(PLUs) from various thematic layers

tion produced a polygon layer combining land use, landform and slope. The polygons with unique combinations were merged together to produce the PLUs(Fig. 5).

### 3.1.4 Soil sample collection from large and mini pits; physico-chemical analysis

Clino-sequence is a method of collecting soil samples from a study area by means of a transect, starting from a highly elevated area to low terrain, in all directions(NBSSLUP 1987). There are a minimum of 20 well dug profiles per topographical map area, on 1:50,000 scale(700 km<sup>2</sup>). The number of profile per topo map can increase, according to soil variability(NBSSLUP 1987). A total of 90 soil sample pit sites were marked on the topographical map, based on the PLUs and the geographic coordinates. Sample pit locations were determined in the field with the help of the topographical map and GPS. Profile pits were excavated at the selected sites to the dimensions 3×3×5 feet, that is, 3×3 feet to a depth of 5 feet, or until the parent rock, whichever was less. Soil samples from each horizon were collected for field and laboratory analysis. In the field, soil properties in-

cluding color(in both wet and dry conditions using the Munsell color chart), texture, slope, and others, were noted. Apart from the major profile study, soil samples were also collected and analyzed from about 150 mini pits of 1x1x1 feet. These pits were distributed between two PLUs in order to determine the boundary precisely. In the laboratory, the pH, electrical conductivity(EC), macro and micro nutrients were analyzed for each sample.

### 3.1.5 Soil mapping, ground-truth collection to develop PLU-soil relationship and finalization of soil map

The sequence of general soil taxonomical classification is Order, Sub-order, Great group, Sub-group, Family, Series, Type and Phase(NBSSLUP 1987). Since the higher taxonomical groupings, viz., series, type and phase, have yet to be established, classification was confined to the family level, that is, the fifth level hierarchy. The family level soil class details were entered into each PLU, and the soil map was prepared. Ground-truth collection was conducted with the soil mapping in order to verify and to develop the PLU-soil relationship. In the course of the ground-truth collection, soil samples were collected in PLUs using augur, and the physical properties of the

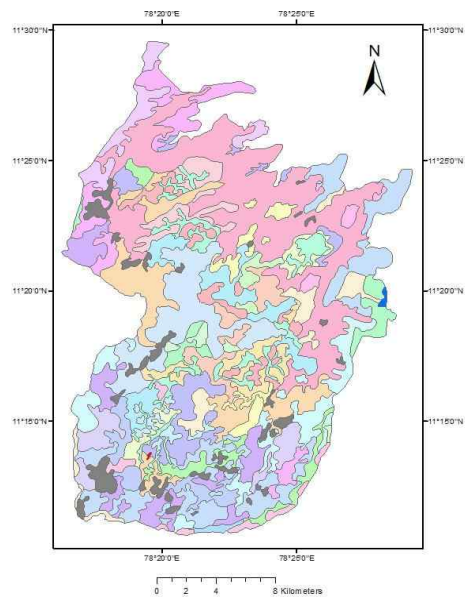


Fig. 6. Soil map of Kolli Hill



soil were tested to ascertain whether the PLUs were correctly classified under the original soil series. The boundary of each soil series was corrected based on field verification, and the soil map was finalized(Fig. 6). The family level soil groups, deemed the soil series, were named after the respective nearby and prominent villages.

#### 4. Results and Discussion

According to the results of this study, the soils of Kolli Hill belong to three orders viz., Entisol, Inceptisol, and Alfisol. Entisol occupied 75% of the total study area followed by Inceptisol(15%) and Alfisol(10%)(Fig. 7a).

##### 4.1 Entisol

Entisol was present in summit areas and steep slopes. These soils were subjected to severe weathering and severe erosion. They were shallow-depth, very recently formed soils. Weathered soils, due to the steep slopes, were transported to lower elevations and deposited, and thus were the weathered parent materials exposed. There were no well developed diagnostic horizons in the column. Neither was there any illustrious process in this soil.

Table 1. Taxonomic classification of Kolli Hill soils for order Entisol

Sl. No.	Sub-order	Great group	Sub-group	Family	Series	Area (ha)
1.	Orthents	Ustorthents	Lithic Ustorthents	Loamy skeletal, mixed isohyperthermic, very shallow, Lithic Ustorthents	Puliancholai	2265.4
2.				Fine loamy, kaolinitic, isohyperthermic, very shallow, Lithic Ustorthents	Navaladipatti	4603.7
3.				Coarse loamy, mixed, isohyperthermic, shallow, Lithic Ustorthents	Singalam kombal	2208.8
4.				Fine, mixed, isohyperthermic, shallow, Lithic Ustorthents	Chinna pallamparai	9959.8
5.				Fine loamy, mixed, isohyperthermic, shallow, Paralithic Ustorthents	Kuruvala	1318.8
6.			Paralithic Ustorthents	Loamy skeletal, mixed, isohyperthermic, shallow, paralithic Ustorthents	Moolakkadu	1125.3
7.				Fine, mixed, isohyperthermic, very shallow, paralithic Ustorthents	Kilsengadu	970.2
8.				Coarse loamy, kaolinitic, isohyperthermic, moderately deep, Typic Ustorthents	Oonanthangal	3349.6
9.				Fine loamy, mixed, isohyperthermic, moderately deep, Typic Ustorthents	Kulipatti	3398.1
10.			Typic Ustorthents	Fine loamy, mixed, isohyperthermic, deep, Typic Ustorthents	Kulivalavu	380.2
11.				Loamy skeletal, mixed, isohyperthermic, deep, Typic Ustorthents	Thenbalam	1108.4
12.				Fine loamy, mixed, isohyperthermic, very deep, Typic Ustorthents	Solakkanni	1957.9
13.				Fine loamy, kaolinitic, isohyperthermic, deep, Typic Ustorthents	Sengattupatti	1092.2
14.				Loamy skeletal, mixed, isohyperthermic, very deep, Typic Ustorthents	Navakkadu	1189.3
15.				Coarse loamy, mixed, isohyperthermic, very deep, Typic Ustorthents	Thuvrapallam	347.9
16.	Psammments	Ustipsammments	Typic Ustipsammments	Sandy, kaolinitic, isohyperthermic, moderately deep, Typic Ustipsammments	Mel Sengadu	1181.2

Entisol occupied a total of 36,456.8 ha. There were two sub-orders on the outer slopes, viz., Orthents and Psammments, but Orthents was the only sub-order on the inner terrain(Fig. 2). The Orthents occupied 97% of the total area(35,275.6 ha), and a small portion of Psammments(1,181.2 ha) was born out of the fluventic actions of streams(Table 1). The Orthents had only one great group, Ustorthents, which latter had three sub-groups, viz., Lithic, Paralithic, and Typic. Among these, the first two had a restricted column depth(<50 cm). The Lithic sub-group, having four families, occupied 53% of the total Entisol area(19,037.7 ha), followed by the Typic, 35%(12,823.6 ha), with 8 families(Table 1 and Fig. 7b). The sub-order Psammments had one great group, namely Ustipsammments, and one sub-group, Typic Ustipsammments.

##### 4.2 Inceptisol

These soils were coarse-to-medium in texture, occurring in areas of somewhat lesser slope. Distinguishing horizons development was observed in these soils, and they were slowly developing soils compared with the order Entisols. Even though the surface soils were subjected to erosion, the sub soils were intact and not subjected to the same erosion, leading to the horizon development in the soil column.

In Inceptisol, the major sub-order and great group were Tropepts and Ustrophepts, respectively. The Typic and Paralithic were the two sub-groups that were observed in the latter great group, covering 81% and 19% of the total Inceptisol area, re-

Table 2. Taxonomic classification of Kolli Hill soils for order Inceptisol

Sl. No.	Sub-order	Great group	Sub-group	Family	Series	Area (ha)
1.	Tropepts	Ustrophepts	Paralithic Ustrophepts	Loamy skeletal, kaolinitic, isohyperthermic, very shallow, Paralithic Ustrophepts	Sukkalampatti	1084.1
2.				Fine loamy, kaolinitic isohyperthermic, shallow, paralithic Ustrophepts	Moolakadu	291.2
3.			Typic Ustrophepts	Loamy skeletal, mixed, isohyperthermic, deep, Typic Ustrophepts	Pulianjolai	647.2
4.				Fine loamy, mixed, isohyperthermic, moderately deep, Typic Ustrophepts	Chinnapallamparai	1254.1
5.				Loamy skeletal, kaolinitic, isohyperthermic, moderately deep, Typic Ustrophepts	Perappanjolai	307.4
6.				Fine loamy, mixed, isohyperthermic, deep, Typic Ustrophepts	Oorumudi	1043.7
7.				Coarse loamy, mixed, isohyperthermic, very deep, Typic Ustrophepts	Thiruppuli	873.8
8.				Fine loamy mixed, Isohyperthermic, very deep, Typic Ustrophepts	Manchattupatti	1747.6

spectively(Fig. 7c). The Typic sub-group had six families and the Paralythic, two families(Table 2). On the outer slopes, the major sub-order and great group were Tropepts and Ustrophepts, respectively, the latter with two sub-groups, whereas on the inner terrain, Tropepts and Ustrophepts were the sub-order and great group, respectively, the latter with one sub-group.

4.3 Alfisols

Alfisols are well developed soils having argillic horizons occurring in gentle slopes and bottom portion area. These were found to be less prone to erosion and highly fertile. Under this order there were one sub-order, Ustalfs, and two great groups, namely Rhodustalfs and Haplustalfs, having two sub-groups each. The Typic Rhodustalfs occupied the majority of the portion of the order Alfisol area(1982.2 ha), followed by Paralithic Rhodustalfs(1286.4 ha), Udic Haplustalfs(1011.3 ha) and Typic Haplustalfs(639.1 ha)(Table 3 and Fig. 7d).

This order was present on the outer slope, with the sub-order Ustalfs having two great groups, Rhodustalfs and Haplustalfs. The former had two sub-groups, viz. Lithic and Paralithic, and the latter had only one sub-group, Typic. The inner terrain comprised one great group, Haplustalfs, with two sub-groups, Lithic and Ultic.

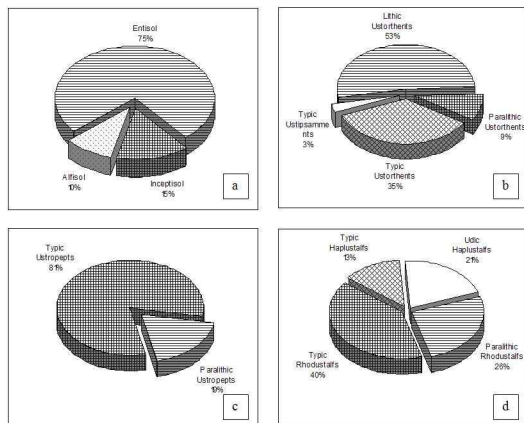


Fig. 7. Percentages of area for various soil taxonomies. a) Area under soil order, b) Area under various sub-groups of order Entisol, c) Area under various sub-groups of order Inceptisol and d) Area under various sub-groups of order Alfisol

Table 3. Taxonomic classification of Kolli Hill soils for order Alfisol

SL No.	Sub-order	Great group	Sub-group	Family	Series	Area (ha)
1.	Ustalfs	Rhodustalfs	Paralithic Rhodustalfs	Fine loamy, kaolinitic, isohyperthermic, shallow, Paralithic Rhodustalfs	Naganallur	1286.4
2.			Typic Rhodustalfs	Fine loamy, kaolinitic, isohyperthermic, deep, Typic Rhodustalfs	T. Padarpettai	1885.2
3.		Haplustalfs	Typic Haplustalfs	Fine loamy, kaolinitic, isohyperthermic, moderately deep, Typic Haplustalfs	Puliyancholai	97.0
4.			Udic Haplustalfs	Fine loamy, mixed, isohyperthermic, shallow, Typic Haplustalfs	Navaladipatti	113.2
5.			Udic Haplustalfs	Fine loamy, mixed, isohyperthermic, moderately deep, Typic Haplustalfs	Veerakanurpatti	525.9
6.			Udic Haplustalfs	Fine loamy, mixed, isohyperthermic, deep Udic Haplustalfs	Ariyur	1011.3

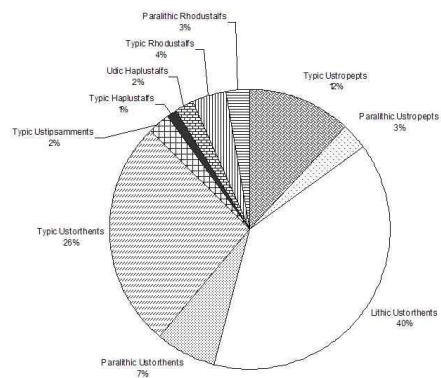


Fig. 8. Overall distribution of area for various soil sub-groups on Kolli Hill

As a result of this study, 30 soil series belonging to ten sub-groups of five great groups and three sub-orders and orders were identified and mapped. Among the 30 soil series, the Singalankombai series occupied a maximum of 9,959.8 ha, or 19% of the total area(Table 1). This series was present mostly on the northern side of the hill. Forests of various types in different density classes were present in this series. The Navaladipatti series occupied 4,603.7 ha, or 9% of the total area(Table 1). It was generally present on the southern and northeastern sides of the hill.

The Oonanthangal and Kulipatti series occupied 6% each of the total area. All the other series occupied less than 5% of the total area. Among the ten sub-groups, Lithic Ustorthents occupied 40% of the total area, followed by Typic Ustorthents(26%) and Typic Ustrophepts(12%)(Fig. 8). The remaining sub-

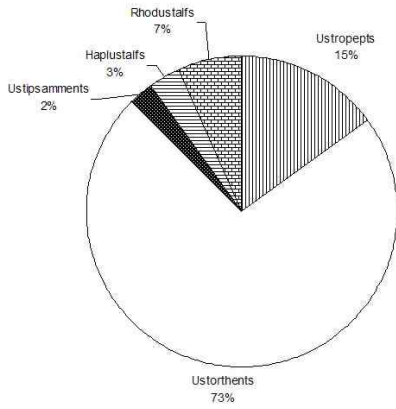


Fig. 9. Overall distribution of area for various soil great groups on Kolli Hill

Table 4. Advantages and disadvantages between conventional and RS/GIS assisted soil mapping

Sl. No	Conventional soil mapping	RS/GIS assisted soil mapping
1	No satellite data is used so very less information about the area	Satellite data is used, which gives information about soil types prior to soil mapping in an area
2	Sample pit location is determined arbitrarily without taking into account physiography, landform and land use	Sample pit location is determined accurately taking into account physiography, landform and land use
3	Planning of field work is difficult as there is no information about the location of sample pits	Field work can be planned precisely and easily based on the distribution and location of predetermined sample pits.
4	Mapping is based on soil profile details	Mapping is based on soil profile details, physiography, landform and land use / land cover
5	Boundary delineation between soil series requires more number of soil samples	Boundary delineation requires less number of soil samples
6	Mapping is done manually, which is more time consuming	Mapping is done digitally using systems and software, which is less time consuming
7	Reproduction of soil maps is difficult	Reproduction of soil maps is easy.
8	It is not possible to map soil type of inaccessible areas	It is possible to map soil type of inaccessible areas based on other details
9	Soil testing lab and cartographic materials are required	Soil testing lab, system, image processing and GIS software and printing facilities are required

groups occupied the rest of the area. Among the five great groups, Ustorthents occupied 73% of the total area, followed by Ustropepts(15%). Rhodustalfs, Haplustalfs and Ustipsamments occupied 7%, 3% and 2% of the total area, respectively(Fig. 9).

The present study, based on remote sensing(RS) and GIS assisted soil mapping, has more advantages

over conventional soil mapping, which are listed in the table 4.

### 5. Conclusion

In the present study, detailed soil resource inventorying and mapping by means of the adoption of recent technologies were carried out. The study is of value, as it is the first systematic examination of Kolli Hill soil, yielding taxonomic settings and the present status. From this study, it is clear that soil in hilly terrains cannot be grouped under one single order, namely “hill soil.” Satellite data used in the study enabled the precise and cost-effective mapping of the soil series. Physiography, landform and land use/land cover helped the delineation of boundaries between series accurately. Overall, RS/GIS assisted soil mapping made it possible to map soil series in a hilly terrain effectively in a cost effective manner. The study, however, has the following limitations. The scale of the soil map prepared was 1:50,000 scale. But for micro-level planning, larger-scale soil mapping is necessary(e.g. 1:25,000 or 1:12,500 scale). The terrain condition, moreover, was another limiting factor. For future study, large-scale soil mapping with high-resolution satellite data such as IKONOS or QuickBird should be undertaken. Also to be considered for future study is the relationship between soil physico-chemical properties and vegetation.

### Acknowledgements

Jayakumar thanks the Department of Science and Technology, New Delhi, India, for financial support through a research project administered under the SERC Young Scientist Scheme. We also thank the Tamil Nadu Forest Department for its help and permission.

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