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Soil resource mapping of Vellamadai Village, Coimbatore district fused (IRS 1C LISS III and PAN merged) space borne multispectral data

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Abstract: **The study deals with the utility of satellite remote sensing for soil resource studies in Vellamadai village, Coimbatore district, Tamil Nadu, India. IRS 1D LISS III merged PAN data were digitally merged using IHS approach and visually interpreted to prepare soil map after the field and laboratory studies. Based on the morphological, physical, and chemical properties, seven mapping units belonging to four soil series were identified and classified according to Soil Taxonomy. The range of clay was from 10.90 to 55.97 per cent. Soil reaction ranges from slightly acidic to saline. The soils are low in organic carbon content. Surface horizons had CEC values ranging from 13.25 to 56.27 cmol P(+) kg^{-1}. The soils were grouped under Inceptisol, Vertisol and Entisol.**

Key words: Remote sensing, large scale soil map, soil characteristics.

Introduction

Soil is a vital natural resource and a precise knowledge about its characteristics, extent and location is necessary for the socio-economic development of a country and sustainable use of its natural resources. This finite resource is currently under tremendous pressure by highly conflicting demands of an expanding population. The problem is further aggravated due to indiscriminate and unsound management practices and are manifested in various types of land degradational problems. A qualitative as well as quantitative assessment of land resources is, therefore, required for optimum use in agricultural and non-agricultural sectors and other land development programmes.

Satellite based remote sensing data has emerged as a vital tool in soil survey and generation of information, which helps to evolve the optimum land use plan for sustainable development of an area. A wide spectrum of satellite remote sensing data from Landsat-TM, SPOT, IRS-1A, IRS-1B and IRS – 1C are now available to the earth resources scientists for soil resource mapping through monoscopic visual and / or computer assisted digital analysis approaches. Mapping of soils through remote sensing data been attempted by several workers at 1:50,000 scale (Venkataratnam, 1980 and Karale *et al.* 1991). Recently micro-level developmental planning is receiving much importance. Hitherto, for village level planning large scale map on 1:12,500 is warranted. The launch of IRS 1C/1D with Linear Imaging Self Scanner III (LISS) and Panchromatic (PAN) sensor having a resolution of 23.5 m and 5.8 m heralded a new era in soil mapping programme. Soil maps at 1:12,500 scale with the abstraction level of individual soil series were prepared by merging LISS and PAN data (Rao *et al.* 1997 and Rajeev Srivastava, 1999). In this paper, an attempt has been made to study the applicability of IRS 1C LISS III merged PAN data for soil mapping at 1:12,500 scale.

Materials and Methods

Bound by geo-coordinates 11° 08'33" to 11° 11'55" N latitude and 76 58'40" to 77° 01'39" E longitude, the test site is Vellamadai village of Coimbatore district of Tamil Nadu State. Geologically it is underlain by granites. Geomorphologically the study area consists of pediment and Pediplain. The climate of the area is subtropical with mean annual rainfall of 612 mm. The maximum and minimum temperatures are 32°C and 21.5°C respectively. The major crops cultivated include sorghum, maize and pulses in the rain fed conditions and onion, turmeric, banana, coconut and sugarcane under irrigated conditions.

Table 1. Soil series and soil mapping units of Vellamadai village

Soil series	Mapping Unit	Extent	
		Ha	Per cent
Periyanaickenpalayam (Pyk1)	(1) $\frac{\text{Pyk1-c-d}_5}{\text{A-e}_2}$	240.57	13.62
Periyanaickenpalayam (Pyk2)	(2) $\frac{\text{Pyk1-c-d}_5}{\text{A-e}_1}$	259.77	14.71
Attipalayam (Apm)	(3) $\frac{\text{Apm-c-d}_5}{\text{A-e}_1}$	36.12	2.04
Vellamadai (Vld)	(4) $\frac{\text{Vld-c-d}_4}{\text{A-e}_2}$	201.40	11.40
Vellamadai (Vld)	(5) $\frac{\text{Vld-scl-d}_4}{\text{A-e}_2}$	584.82	33.13
Kalipalayam (Kpm)	(6) $\frac{\text{Kpm-(g)ls-d}_4}{\text{B-e}_2}$	321.82	18.23
Kalipalayam (Kpm)	(7) $\frac{\text{Kpm-(g)ls-d}_3}{\text{C-e}_3}$	115.81	6.56
	Water body	4.84	0.27
	Total	1765.16	100

Mapping unit numbers is indicated in paranthesis

The data used for the study included Survey of India toposheet (1: 50,000 scale), cadastral map of the Vellamadai village (1: 8000 scale) and IRS-I C PAN and LISS III digital data of March, 2000.

Methodology

A collative approach involving on-the-screen visual interpretation of IRS 1D LISS III and PAN merged image in conjunction with ground truth and ancillary information was employed to derive information on soils. Initially, IRSID LISS III and PAN data were digitally merged using IHS approach. Physiographic units were initially delineated based on image elements, namely colour, texture, size, shape, pattern, association etc. and further divisions within each broad physiographic unit were based on soil erosion and slope. Physiography – soil relationship was established using intensive ground truth data to prepare soil map. Soil profiles were dug on different physiographic units and examined for their morphological characteristics. Horizon – wise soil samples were collected from the representative soil series for physical and chemical analysis as per standard procedures (Jackson, 1973 ; Piper, 1966). Soils were classified according to Keys to Soil Taxonomy (Soil Survey Staff 1998). The soil mapping units gives the details of types and phases of soils.

Table 2. Morphological and physical properties of pedons

Horizon	Depth (cm)	Colour	Texture	Structure	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	33kPa (%)	1500kPa (%)	AWHC (%)
Pedon 1 : Periyanaickenpalayam series (Fine, montmorillonitic, isohyperthermic, Typic Haplusterts)											
Ap	0-22	10 Yr 3/2	c	3msbk	1.18	47.25	11.87	40.88	34.01	14.43	19.58
Bwkss1	27-52	10 Yr 3/1	c	3cabk	0.79	45.23	12.10	42.67	32.63	14.77	17.86
Bwkss2	52-72	10 Yr 3/1	c	3cabk	1.30	40.74	14.23	45.30	36.58	16.85	19.73
Bk1	72-105	10 Yr 4/1	c	3csbk	2.11	33.75	15.27	50.71	33.65	16.92	16.73
Bk2	105-141+	10 Yr 4/1	c	3csbk	4.33	28.99	15.34	55.67	28.48	14.44	14.04
Pedon 2 : Attipalayam series (Fine, mixed, isohyperthermic, Vertic Haplustepts)											
Ap	0-19	10 Yr 4/2	c	2asbk	7.29	44.89	13.87	41.24	39.61	20.68	18.93
Bwk1	19-49	10 Yr 3/2	c	2msbk	1.59	44.53	12.64	42.83	34.82	19.33	15.49
Bwk2	49-84+	10 Yr 4/1	c	2msbk	3.66	37.00	14.07	48.93	29.35	15.30	14.05
Pedon 3 : Vellamadai series (Fine loamy, mixed, isohyperthermic, Typic Haplustepts)											
Ap	0-13	10 Yr 2/1	c	2csbk	5.05	38.25	18.24	43.51	36.38	17.75	18.63
Bw	13-34	5 Yr 3/3	c	3csbk	11.02	43.81	15.95	40.24	35.98	19.65	16.33
B3	34-50+	5 Yr 4/6	cl	2msbk	15.70	65.95	8.53	25.52	15.32	8.30	7.02
Pedon 4 : Kalipalayam series (Loamy skeletal, mixed, isohyperthermic, Typic Ustorthents)											
Ap	0-23	10 Yr 4/4	ls	2msbk	32.44	79.45	6.23	14.32	17.83	9.32	8.51
A12	23-41	2.5 Yr 3/6	sl	2csbk	22.17	71.87	9.20	18.93	14.31	7.83	6.48
A13	41-59	2.5 Yr 3/4	ls	1msbk	72.29	81.65	6.13	12.22	9.68	4.69	4.99
A14	59-81	2.5 Yr 3/4	ls	2msbk	67.10	84.52	4.58	10.90	9.21	6.33	2.88

Soil texture : sl - Sandy loam; ls - loamy sand; cl - Clay loam; c - Clay

Soil structure : m - Medium; c - coarse; 1 -weak; 2 - moderate; 3-strong; sbk - subangular blocky, abk -angular blocky.

Table 3. Chemical properties of pedons

Horizon	Depth (cm)	pH (1:2)	EC dSm^{-1}	OC (%)	$CaCO_3$ (%)	CEC cmol P(+) kg^{-1}	Exchangeable cations cmolP (+) kg^{-1}				BSP	ESP
							Ca	Mg	Na	K		
Pedon 1 : Periyanaickenpalayam series (Fine, montmorillonitic, isohyperthermic, Typic Haplusterts)												
Ap	0-22	7.80	3.20	0.63	5.75	43.81	21.42	18.24	1.95	0.32	93.68	2.42
Bwkss1	27-52	8.00	0.42	0.44	5.50	48.20	26.55	15.56	0.53	0.42	90.76	2.53
Bwkss2	52-72	8.10	0.24	0.36	5.50	51.31	32.80	12.32	0.72	0.45	91.85	3.04
Bk1	72-105	8.30	0.56	0.22	11.38	52.57	33.82	14.83	1.12	0.51	96.79	3.27
Bk2	105-141+	8.30	0.74	0.15	9.00	56.27	35.22	6.83	1.14	0.51	32.91	3.47
Pedon 2 : Attipalayam series (Fine, mixed, isohyperthermic, Vertic Haplustepts)												
Ap	0-19	7.90	0.18	0.52	11.25	41.92	22.00	14.50	0.76	0.80	90.80	1.82
Bwk1	19-49	8.40	0.18	0.38	13.50	43.37	25.40	12.00	1.39	0.48	90.55	3.21
Bwk2	49-84+	8.20	0.32	0.23	18.63	48.20	28.60	14.85	1.70	0.32	94.33	3.52
Pedon 3 : Vellamadai series (Fine loamy, mixed, isohyperthermic, Typic Haplustepts)												
Ap	**0-13**	**7.80**	**0.20**	**0.33**	**4.75**	**36.51**	**19.00**	**11.50**	**0.71**	**0.90**	**87.93**	**1.94**
Bw	13-34	7.60	0.10	0.41	1.25	32.31	18.50	9.00	0.65	0.51	88.72	2.02
B3	34-50+	7.80	0.18	0.30	1.88	27.57	15.00	4.50	0.54	0.19	73.40	1.97
Pedon 4 : Kalipalayam series (Loamy skeletal, mixed, isohyperthermic, Typic Ustorthent)												
Ap	0-23	6.70	0.02	0.21	0.88	14.72	7.50	3.00	0.22	0.19	74.11	1.48
A12	23-41	6.50	0.12	0.27	0.75	16.92	8.00	4.00	0.22	0.16	73.15	1.28
A13	41-59	6.30	0.28	0.30	0.25	13.57	5.62	3.20	0.38	0.32	70.16	2.80
A14	59-81	6.70	0.12	0.27	0.13	13.25	6.21	3.50	0.54	0.26	79.32	4.10

Result and Discussion

Physiography and soils

Physiographically, the area has been characterized into Pediment, Pediplain shallow weathered and Pedi plain moderately weathered, which were further subdivided, based on erosion and slope categories. Based on physiography - soil relationships seven mapping units were identified. The soil map of Vellamadai Village is given in figure. 1. The extent of each soil mapping unit is given in Table 1. The soil mapping units were grouped under four soil series. They well Periyanaickenpalayam (pedon 3), Attipalayam (pedon 2), Vellamadai (pedon 1) and Kalipalayam (pedon 4) series.

Morphological features of pedons

The soils of gently sloping pediment (pedon 3) are moderately shallow, well drained, non-calcareous and severely eroded. The soils of nearly level pediplain shallow weathered (pedon 4) are moderately deep, moderately well drained, non calcareous and moderately eroded. On the contrary, the soils of pediplain moderately weathered are very deep, (Pedon 2), moderately well drained calcareous, clayey and slightly eroded. The soils of pediplain moderately weathered (pedon 1) are very deep, moderately well drained, calcareous clayey and slightly to moderately eroded. These soils develop deep and wide cracks on drying and have shining slickenside in the subsurface horizons.

Physical properties of soils

The coarse fragments of the pedons varied from 0.79 to 72.79 per cent. The coarse fragments were mainly of quartz fragments and lime concretions. The irregular nature of gravels suggested that they were formed in situ. The surface soils possessed loamy sand to day texture and subsurface soils possessed sandy loam to clay texture. The clay content of these soils ranged from 10.90 per cent in pedon 4 to 55.67 per cent in pedon 1. Unimodal distribution i.e., increase of clay upto certain depth and then decrease was observed in pedon 4. An increase in clay content was primilary due to illuviation. In pedons 1 and 2, the clay content gradually increased with the depth. This may be due to combined effect of insitu clay formation and illuviation. The salient physical characteristics of the soils are given in Table 2.

Moisture retention characteristics of soils

The gravimetric moisture content was found to be influenced by clay content in the soils. The low moisture content in pedon 4 was due to high content of gravel and sand fractions. The high moisture content in pedon 1 was due to high clay content in the subsoil horizon. The distribution pattern of gravimetric moisture within the pedons was influenced by the proportionate amounts of clay and sand particles (Singa Rao, 1993). The variations in moisture retention at two tensions (33 kpa and 1500 kpa) are mostly associated with variations in soil texture. Coarse texture soil (pedon 4) retained low amount of moisture at both the tensions than the fine textured soils (pedons 1,2 and 3). Pedon 1 retaind relativity high moisture at both the tensions due to the presence of smectitic clay in the soil.

Available water content was found to be the highest in Vertisol (pedon 1) and Vertic Inceptisols (peon 2) and the lowest in Entisols (pedon 4). In other soils (Inceptisols and Alfisols) which have fine texture (fine loamy / fine), the amount of available water varied from 6.78 to 7.26 per cent.

Chemicals properties of soils.

The soils are slightly acidic (pH 6.3) to saline (pH 8.4) and this variation was attributed to the nature of parent material, presence of calcium carbonate and exchangeable sodium. The electrical conductivity values (dS m^{-1}) varied from 0.02 in pedon 4 to 3.20 in pedon 1.

The free calcium carbonate varied from 0.13 in pedon 4 to 18.63 in pedon 2. The calcium carbonate increased with depth in pedon 2 due to the downward movement of calcium carbonate. The organic carbon was low (less than 0.5%) in all the pedons.

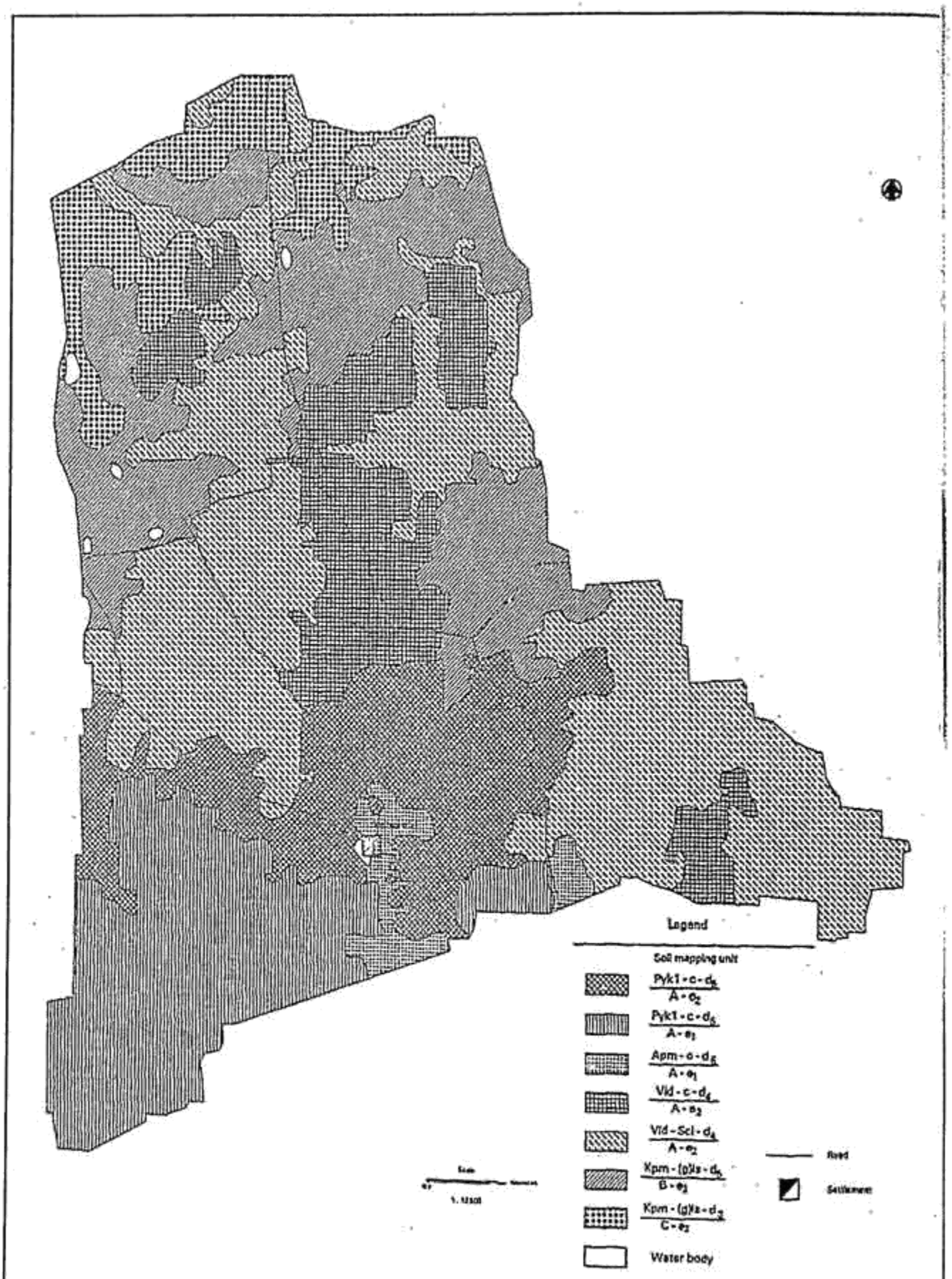

Fig.1. Soil map of Vellamadai village

The cation exchange of the soils (cmol P(+) kg^{-1}) varied from 13.25 in pedon 4 to 56.27 in pedon 1. The depth wise distribution of CEC had same trend as that of clay distribution. A significant correlation coefficient (0.420) between clay and CEC suggests that clay contributes to cation exchange capacity in these soils. Among the exchangeable cations, exchangeable calcium was predominant followed by magnesium, sodium and potassium in all the pedons. The salient chemical characteristics of the soil are given in Table 3.

Classification of soils

Based on the properties, The soils were grouped under the orders of USDA system of classification *viz.* Inceptisol, Vertisol Entisols. Pedon 1 was grouped under Vertisols due to the presence of Ochric edipedon and slicken sides within 27 to 105 cm depth. The pendon 1 qualified for Typic Haplusterts as the pedon did not possess the salic, gypsic, calcic or petrocalcic horizons. Fine textural class was proposed to the pedon, based on the high clay content (>35 per cent). Pedons 2 and 3 were grouped under Inceptisols based on the presence of Cambic subsurface horizon. Pedon 2 was placed under Vertic Haplustepts due to the presence of Vertic properties. Pedon 3 qualified for Typic Haplustepts as they possessed the central concept of Haplustepts Pedon 4 was classified under Entisols due to the absence of diagnostic horizons. The pedon 4 was placed under Typic Ustorthents as it had the soil characteristics of central concept of Ustorthents.

Conclusion

The study has vividly demonstrated the potential of space borne multispectral data in generating the base line information on soils in Vellemadai village. This information along with information of natural resources such as ground water, present land use / land cover and socio- economic information will help to generate farm level information on various natural resources and environmental degradation.

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