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Land Resources Characterization of Kangayam Block in Tamil Nadu Uplands under Dry Semiarid Eco-region

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Abstract: A detailed soil survey was carried out to characterize and classify the soil resources of Kangayam block, Tiruppur district represented by hot dry semiarid eco-region of Tamil Nadu uplands (AESR, 8.1). Seven landform assemblages *viz.* isolated structural hills and ridges, local rises, upper sectors of pediplains, middle sectors of pediplains, lower sectors of pediplains, valley fringes, and the Noyyal-Amaravathi river valley floor, were identified. Typifying pedons of twelve soil series identified were analyzed for physical and chemical properties for their characterization and classification. The soils were shallow and moderately deep, well to moderately well-drained, developed from granite-gneiss and its colluvial and alluvial parent material. The sand, silt, and clay content of the soils varied from 11.2 to 88.2, 2.3 to 49.4, and 6.7 to 39.4 per cent, respectively. The soils were slightly acid to strongly alkaline (6.23 to 8.92) and non-saline (0.03 to 0.85 dS m^{-1}). Soil organic carbon content varied from 0.09 to 0.86 per cent and the soil calcium carbonate equivalent was in appreciable quantities in sub-soils (maximum of 38.5%). The soil cation exchange capacity varied from 2.5 to 38.8 cmol (p+) kg^{-1}. The soils were classified under Alfisols, Entisols, and Inceptisols soil orders as per USDA Soil Taxonomy.

Keywords: *Detailed soil survey, landforms analyses, characterization and classification, soil resource management, Tamil Nadu uplands*

Introduction

Soil is one of the most important natural and national resources, which need to be maintained properly for the socio-economic welfare of the farming community as well as for the country's economy. In recent times, soil degradation is increasing while productivity and fertility are declining rapidly due to the extensive use of soil with unscientific management practices, such as irrational and imbalanced use of inputs (Kanwar 2004 and Sharma 2006). It is estimated that out of the 328 m ha of the total geographical area in India, 173.65 m ha are degraded, producing less than 20 per cent of its potential capacity (GOI 1990). Thus, the primary strategy for increasing food production lies in improving the economic productivity of the land for vertical expansion by managing the soil resources efficiently. However, it should be carefully considered the main strategic aspects of increasing productivity, restoring productivity, and preventing deterioration of productive capacity (Kanwar 1982). Such sustainable management practices are needed for increasing the use efficiency of soil resources and to preserve the production potential of agricultural lands. This is possible through a proper understanding of morphological, physical, and chemical characteristics of the soils, which give a greater insight into the dynamics of the soil resources. Soil survey provides scientific information about the soil resources of a particular

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region, their type, nature, composition, and also their extent and distribution. It also provides information on their characteristics, potentials, and limitations that are useful for land resources management and development (Manchanda *et al.* 2002). Thus, detailed soil surveys were carried out to characterize and classify the soil resources of Kangayam Block, Tiruppur district that comes under the dry semiarid region of Tamil Nadu uplands.

Materials and Methods

The study area, Kangayam block (77°27'06" and 77°43'19" E; 10°54'55" and 11°07'39" N) with a total geographical area of 33,805 hectares (Fig. 1). The mean annual precipitation is 523 mm of which 226 mm received by the Northeastern monsoon. The mean maximum and minimum temperatures are 33.5 °C and 25.5 °C, respectively and the mean annual PET is 1685 mm. Geology is granite-gneiss. The length of growing period is 10 weeks, which starts from the middle of September to the end of November. The study area has a very old unique silvipastoral system, which was established around 1800 (Buchanan 1807) which is known as Kangayam grasslands. The crops like horse gram, sorghum, pearl millet, and naripayaru and grasses such as *Cenchrus ciliaris* and *Phaseolus trilobus* were cultivated in between *Acacia leucophloea,* which is a

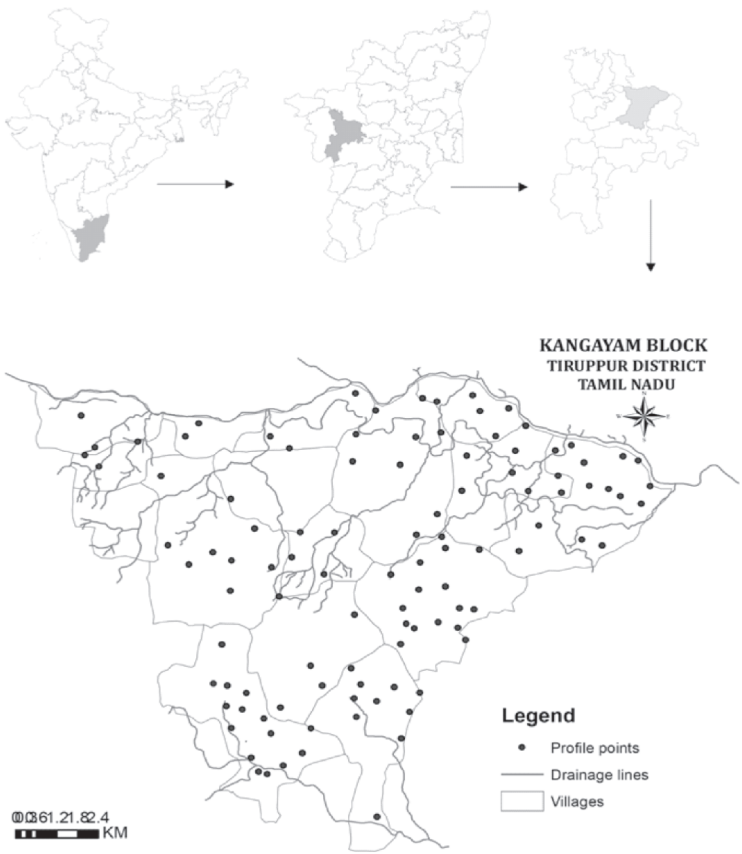

Fig. 1. Location map of the study area

nitrogen-fixing leguminous tree. The major land uses in the low land are paddy, sugarcane, and vegetable crops and natural vegetation include Neem, *Acacia spp.* and *Prosopis spp*.

A detailed soil survey was conducted in the Kangayam block as per the standard procedure given by Singh *et al*. (2016). Landform analysis was done using the IRS-P6 LISS IV image and the slope, hill shade, and contour map derived from ASTER DEM along with SOI toposheets. A total of 110 geo-referenced soil profiles were studied for their morphological properties and grouped into twelve tentative soil series (Table 1). The

Table 1. Locations and site characteristics

Village name/pedon no.	Series name	Latitude (N)	Longitude (E)	Elevation (m)	Physiography	Slope (%)	Drainage	Erosion	Parent material	Land use
Ganapathypalayam (P1)	Ganapathypalyam	11° 05' 09"	77° 29' 8.3"	288	Tamil Nadu uplands	3-5	Well-drained	Severe	Granite gneiss	Grass land, *Acacia spp.*
Paranjervali (P2)	Kuttari	11° 05' 3.1"	77° 35' 33.8"	270	Tamil Nadu uplands	1-3	Well-drained	Moderate	Granite gneiss	Fallow
Palayakottai (P3)	Ramakkarapalyam	11° 03' 04"	77° 31' 11.3"	220	Tamil Nadu uplands	1-3	Well-drained	Slight	Granite gneiss	Paddy, Sorghum, Neem, Palmyra
Padiyur (P4)	Alambadi	11° 03' 26.8"	77° 29' 39.8"	290	Tamil Nadu uplands	0-1	Moderately well-drained	Moderate	Granite gneiss	Current fallow, Neem, *Acacia*, and *Prosopis spp.*
Alambadi (P5)	Marudurai	11° 02' 7.8"	77° 33' 48.3"	297	Tamil Nadu uplands	0-1	Well drained	Moderate	Granite gneiss	Coconut
Keeranur (P6)	Tamareddypalyam	11° 05' 26.3"	77° 33' 15.8"	250	Tamil Nadu uplands	0-1	Moderately well drained	Slight	Granite gneiss	Sorghum, Coconut, Neem
Kadaiyur (P7)	Kangayam	10° 58' 41.5"	77° 32' 19.6"	290	Tamil Nadu uplands	0-1	Well-drained	Moderate	Granite gneiss	*Sorghum*, Coconut, Neem, *Acacia spp*.
Sivanmalai (P8)	Padiyur	11° 03' 47.4"	77° 30' 06.0"	288	Tamil Nadu uplands	0-1	Well-drained	Slight	Granite gneiss	Jowar and Neem
Arasampalayam (P9)	Arasampalyam	11° 03' 5.3"	77° 31' 17.7"	290	Tamil Nadu upland summits	0-1	Well-drained	Slight	Granite gneiss	Coconut and *Prosopis spp.*
Keeranur (P10)	Kerranur	11° 05' 16.5"	77° 33' 08.4"	257	Tamil Nadu upland summits	1-3	Well-drained	Moderate	Granite gneiss	Fallow land
Nathakkadaiyur (P11)	Nathakadaiyur	11° 04' 38.9"	77° 33' 27.8"	234	Tamil Nadu uplands	0-1	Well-drained	Slight	Alluvium	Coconut, Groundnut, Sugarcane, Tamarind
Paranjervali (P12)	Kadaiyur	11° 06' 10.5"	77° 35' 39.5"	246	Tamil Nadu uplands	0-1	Moderately well-drained	Moderate	Alluvium	Paddy, Sugarcane, Tamarind

pedons were studied at the elevation ranging from 200-520 m above MSL with 1 to 5 per cent slope and developed from granite-gneiss parent material except pedon 11 and 12, which were from the alluvium parent material. Horizon-wise soil samples were collected, air-dried and passed through 2 mm sieve and analyzed for particle-size distribution following International Pipette method, pH and electrical conductivity (EC) in 1:2.5, soil: water suspension by potentiometric and conductometric method, respectively (Jackson 1973). Soil organic carbon was determined by the wet oxidation method (Walkley and Black 1934). Soil calcium carbonate equivalent was analyzed by acid neutralization method (Piper 1966), cation exchange capacity, and exchangeable cations by neutral normal ammonium acetate method. The soils were classified as per USDA Soil Taxonomy (Soil Survey Staff 2014).

Results and Discussion

Landform analysis

The Tamil Nadu uplands extend over an area of about 60,000 sq. km and are bounded by the Karnataka Plateau to the north, the Tamil Nadu Plains to the east, the Sahyadris (Western Ghats) to the west, and the Eastern Ghats to the south. It has an average elevation of 450 m in the west, decreasing to about 150 m in the east. The major portion is covered with Archaean granites and gneiss. The Uplands are divided into two sub-units *viz*., The Tamil Nadu hills, and the Coimbatore-Madurai Uplands. The former constitutes small but bold hill masses. Notable among these are the Javadis, the Shevaroys, the Kalrayans, and the Pachamalais. The Coimbatore upland rises gradually from 120-185 m along the Cauvery River to 370- 460 m in the west. It has a crescent shape with a gradual slope towards the interior. Here the interfluves between the Noyyal River in the north and the Amravathi River in the south are remarkable with occasional monad knocks, denuded ridges, and the remainder being pediplanation surfaces of gently to moderately sloping low hills and relief (Fig. 2). Based on the analysis of contour crenulations and the drainage morphometry as well as the photomorphic interpretations of the LISS IV image, the interfluves have been subdivided into 7 landform assemblages *viz.*, isolated structural hills and ridges, local rises, upper sectors of pediplains, middle sectors of pediplains, lower sectors of pediplains, valley fringes and the Noyyal-Amaravathi River valley floors.

Morphological characteristics

Soils were shallow (22 cm) to deep (140 cm) with the distinctness of abrupt to gradual and topography of smooth to a wavy boundary (Table. 2). The soils were moderately well-drained to well-drained. Soil colour ranged from dark red to very dark yellowish-brown with hue ranged from 2.5 YR to 10 YR, value from 3 to 6, and chroma from 1 to 8. The red colour of the soil is because of leaching of bases due to high rainfall experienced in humid paleoclimatic conditions or mineralogical composition (Chandrashekhar *et al.* 2017) or also due to accumulation of more resistant sesquioxides through a relative or absolute deposition. Soil structure was found to be sub-angular blocky except in P2 and P10 which had a granular structure in surface soils. Sub-soil structure was sub-angular blocky except in P2, P11, and P12, which were granular.

Physical characteristics

Particle size analysis revealed that sand was the dominant fraction followed by silt and clay. Sand fractions ranged from 11.2 to 88.2 per cent, and it was found higher in surface soil and decreased significantly with the depth in all pedons except in P9, P11, and P12. The high sand content in the surface horizon of the pedons was either because of the illuviation of the fine particle to the sub-surface layer or removal by erosion (Pulakeshi *et al.* 2014). Soil clay content varied from 2.3 to 49.4 per cent and it was increasing with depth. The clay content was maximum in the Bt horizon and thereafter it decreased with depth due to the influence of the active weathering processes in unconsolidated parent material (Murthy 1988). The silt content varied from 6.7 to 39.4 per cent and its distribution followed the clay fraction (Sharma *et al.* 2004).

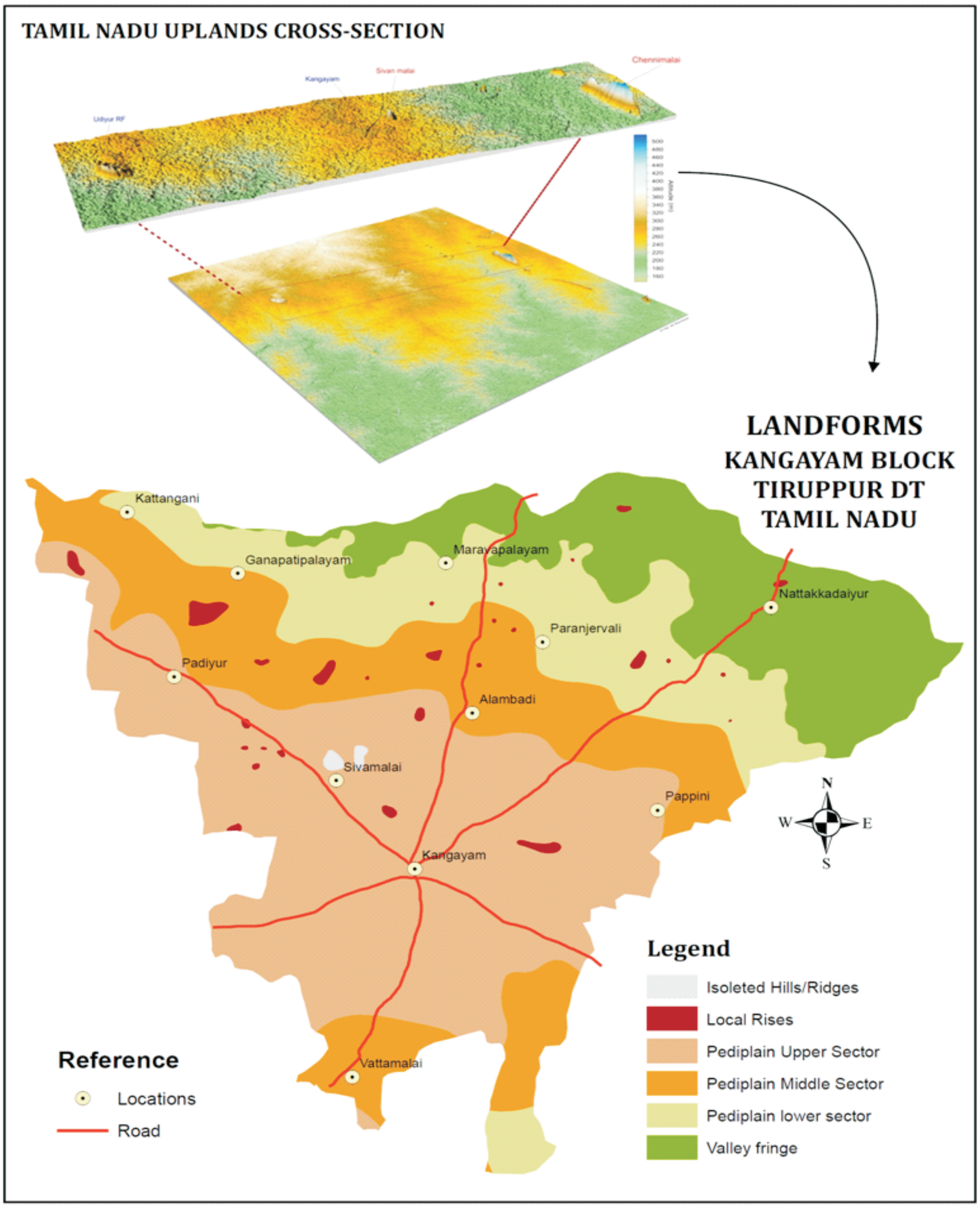

Fig. 2. Landform cross-section of the Tamil Nadu uplands and the identified landforms of Kangayam block

Table 2. Morphological and physical characteristics of soils

Pedon no. and Horizon	Depth (cm)	Soil colour (M)	Soil boundary	Structure			Sand	Silt	Clay	Particle size class
				S	G	T	------------(%)---------			
1	2	3	4	5	6	7	8	9	10	11
P1- Loamy-skeletal, mixed, isohyperthermic Typic Rhodustalfs										
Ap	0-14	2.5YR 3/6	cs	f	1	sbk	86.4	7.9	5.7	ls
Bt1	14-39	2.5YR 3/6	gs	m	2	sbk	64.7	16.5	18.8	sl
P2- Loamy-skeletal, mixed isohyperthermic Typic Rhodustalfs										
A	0-11	7.5YR 4/4	cs	f	1	gr	88.3	7.1	4.6	s
Bw	11-19	5YR 4/6	as	f	1	gr	84.3	8.2	7.5	ls
Bt1	19-33	2.5YR 3/6	cs	m	2	sbk	72.6	10.5	16.9	sl
Bt2	33-42	2.5YR 3/3	aw	m	1	sbk	73.1	8.9	18	sl
C	42-56	2.5YR 4/8	-	Massive			76.4	9.7	13.9	sl
P3- Loamy-skeletal, mixed, calcareous isohyperthermic Calcic Haplustalfs										
Ap	0-15	5YR 3/4	as	m	2	sbk	68.8	14.2	17	sl
Bt1	15-47	5YR 4/4	cs	m	2	sbk	62.1	14.3	23.6	scl
Bt2	47-52	5YR 4/6	-	m	1	sbk	73.2	12.7	14.1	sl
P4- Loamy-skeletal, mixed, calcareous isohyperthermic Typic Haplustalfs										
Ap	0-13	10YR 3/4	cs	m	2	sbk	41.7	30.8	27.5	cl
Bt1	13-32	7.5YR 3/4	gs	m	2	sbk	39.4	30.4	30.2	cl
Bt2	32-67	5YR 3/4	gs	m	2	sbk	18.6	36.5	44.9	c
Bt3	67-90	5YR 3/4	gs	m	2	sbk	11.2	39.4	49.4	c
P5- Loamy, mixed, isohyperthermic Typic Haplustalfs										
Ap	0-22	10YR 4/4	as	f	1	sbk	79	12.8	8.2	ls
Bt1	22-49	5YR 4/6	gs	m	1	sbk	72.2	13.9	13.9	sl
Bt2	49-78	5YR 4/6	gs	m	1	sbk	70.1	15.3	14.6	sl
Bt3	78-105	5YR 4/6	gs	m	1	sbk	65.8	15.5	18.7	sl
Bt4	105-140	5YR 4/6	-	m	2	sbk	59.7	19.2	21.1	scl
P6- Loamy-skeletal, mixed, isohyperthermic Aridic Rhodustalfs										
Ap	0-10	5YR 4/3	cs	m	1	sbk	70.4	14.9	14.7	sl
Bt1	10-29	5YR 4/3	gs	m	2	sbk	67.7	15.9	16.4	sl
Bt2	29-59	2.5YR 3/4	gs	m	2	sbk	63.3	13.8	22.9	scl
Bt3	59-95	2.5YR 3/4	gs	m	2	sbk	63.4	13.7	22.9	scl
Bt4	95-123	2.5YR 3/4	-	m	2	sbk	68.4	9.9	21.7	scl
P7- Loamy-skeletal, mixed, calcareous isohyperthermic Aridic Lithic Ustorthents										
Ap	0-22	7.5YR 3/4	as	m	1	sbk	77.5	9.6	12.9	sl
P8- Loamy, mixed, calcareous isohyperthermic Typic Haplustepts										
Ap	0-13	10YR 3/3	cs	m	1	sbk	79.8	9.7	10.5	sl
Bw	13-40	10YR 3/4	as	m	2	sbk	64.2	13.3	22.5	scl

1	2	3	4	5	6	7	8	9	10	11
P9- Loamy-skeletal, mixed, calcareous isohyperthermic Typic Haplustepts										
Ap	0-12	10YR 4/4	cs	m	1	sbk	62.6	18.5	18.9	sl
Bw1	12-40	10YR 3/4	cs	m	2	sbk	67.0	14.8	18.2	g sl
Bw2	40-63	10YR 3/4	as	m	2	sbk	76.2	6.8	17	sl
P10- Loamy-skeletal, mixed, isohyperthermic Aridic Haplustepts										
Ap	0-13	10YR 3/3	ca		0	gr	86.9	6.7	6.4	ls
Bw1	13-26	5YR 4/4	as	f	1	sbk	75.5	9.9	14.6	sl
Bw2	26-43	5YR 3/3	-	f	1	sbk	82.7	9.2	8.1	ls
P11- Coarse, loamy, mixed, calcareous isohyperthermic Typic Haplustepts										
Ap	0-12	10YR 3/2	ca	f	1	sbk	75.4	11.7	12.9	sl
AB	12-46	10YR 3/2	as	f	1	sbk	77.8	9.4	12.8	sl
Bw1	46-66	7.5YR 3/4	cs	m	1	sbk	75.6	9.9	14.5	sl
Bw2	66-85	7.5YR 4/4	cs	m	1	gr	75	10.4	14.6	sl
Bw3	85-98	7.5YR 4/6	cs	m	1	gr	82	8.2	9.8	ls
Bw4	98-106	7.5YR 4/6	cs	m	1	gr	75.4	11.7	12.9	sl
Ck	106+	10YR 6/3	-	m	1	gr	76.4	18.3	5.3	ls
P12- Coarse, loamy, mixed, calcareous isohyperthermic Fluventic Haplustepts										
Ap	0-10	10YR 3/1	as	f	1	sbk	76.0	12.9	11.1	sl
A2	10-26	10YR 3/1	as	f	2	sbk	75.8	11.9	12.3	sl
Bw1	26-48	5YR4/4	cs	m	1	sbk	76.9	10.9	12.2	sl
Bw2	48-67	5YR 4/4	cw	m	1	sbk	75.5	12.2	12.3	sl
Bw3	67-83	5YR 4/6	cw	m	1	gr	82.8	9.1	8.1	ls
BC	83-110	7.5YR 5/6	cs		massive		86.1	11.6	2.3	ls
C	110-118	10YR 6/8	-		massive		83.3	10.9	5.8	ls

Note: c-clear, a-abrupt, s-smooth, w-wavy, g-gradual, f-fine, m-medium,0-structureless, 1-weak, 2-moderate, sbk-subangular blocky, gr-granular, c-clay, cl-clay loam, ls-loamy sand, s- sand, sl-sandy loam, scl-sandy clay loam.

Chemical characteristics

Soil reaction was found to be slightly acid to strongly alkaline and varied from 6.21 to 8.91 and it was irregularly distributed with the depth, which might be due to the presence of calcium carbonate in soil solum (Pulakeshi *et al.* 2014). Electrical conductivity was very low and varied from 0.03 to 0.85 dS m^{-1}. Soil organic carbon content varied from 0.09 to 0.86 per cent with a mean value of 0.33 per cent. The dry semiarid climate coupled with poor vegetative cover might be the reason for low SOC. In most of the pedons (P1, P3, P4, P6, P7 and P11), organic carbon was decreasing with depth and the high content at the surface might be due to the addition of crop residues (Shalima Devi and Anil Kumar 2010). Calcium carbonate equivalent varied from nil to 38.5 per cent and it was distributed irregularly with depth except in P11 pedon where it increased with depth. Thus, calcium carbonate accumulated at the lower soil horizon, due to the downward movement of calcium ions and their precipitation in sub-surface layers (Chaudhary 1992; Gill *et al.* 2012). Cation exchange capacity varied from 2.49 to 38.83 cmol (p+) kg^{-1} and the variation was following clay content. Available phosphorus, potassium, and sulphur ranged from 1.78 to 31.48 kg ha^{-1}, 34.1 to 443.2 kg ha^{-1} and 0.81 to 55.64 mg kg^{-1}, respectively. The available nutrients are either decreasing with depth or irregularly distributed, because of fixation or removal of sub-soil nutrients by deep-rooted crops and pasture and subsequent addition of these nutrients to the surface soils after decomposition.

Most of the soil in the study area have calcium carbonate layers in the sub-surface (within 100 cm). The formation of calcium carbonate may be due to the result of the movement of Ca $(HCO_3)_2$ from the wetter lows to the relatively drier highs as a consequence of the capillary pull of evaporation. Because of the low groundwater table (>200m), low rainfall (<550 mm), and high potential evapotranspiration (>1500mm), the rainwater infiltration depth is lesser than evaporation depth. As a result, the calcium carbonate is precipitated in the near sub-surface where the free water is lost. In such cases, the formation of calcium carbonate nodules is aided by the presence of the argillic horizon, which favoured rainwater storage (solvent) and upward movement of calcium (high capillary pores).

Table 3. Chemical characteristics of soil pedons

Depth (cm)	pH	EC (dSm^{-1})	Org. C	$CaCO_3$	CEC [cmol (p+) kg^{-1}]	Ratio CEC/Clay	Available nutrients		
			------------%---------				P (kg ha^{-1})	K (kg ha^{-1})	S (ppm)
1	2	3	4	5	6	7	8	9	10
P1- Loamy-skeletal, mixed, isohyperthermic Typic Rhodustalfs									
0-14	6.21	0.08	0.40	2.9	7.35	1.28	1.78	89.8	20.97
14-39	8.63	0.17	0.39	12	11.3	0.6	7.36	182.6	10.48
P2- Loamy-skeletal, mixed, isohyperthermic Typic Rhodustalfs									
0-11	7.48	0.04	0.26	12.9	2.49	0.54	9.39	71.2	16.93
11-19	7.41	0.03	0.15	0.2	7.82	1.04	3.3	40.2	25.81
19-33	6.44	0.05	0.28	4.5	6.04	0.36	3.3	46.4	11.29
33-42	6.64	0.03	0.23	0.2	7.74	0.43	3.05	58.8	5.64
42-56	7.05	0.04	0.26	0	5.24	0.38	3.05	34.1	13.71
P3-Loamy-skeletal, mixed, calcareous isohyperthermic Calcic Haplustalfs									
0-15	8.67	0.22	0.62	6.8	27.96	1.64	9.9	71.2	16.13
15-47	8.73	0.21	0.35	16.8	15.29	0.65	4.06	40.2	23.39
47-52	8.57	0.17	0.15	8.6	13.35	0.95	4.32	40.2	5.64
P4-Loamy-skeletal, mixed, calcareous isohyperthermic Typic Haplustalfs									
0-13	8.51	0.20	0.82	11.3	20.77	0.75	14.47	89.8	11.29
13-32	8.57	0.20	0.49	10.7	21.82	0.72	2.28	176.4	20.97
32-67	8.71	0.16	0.47	10.9	38.83	1.31	5.33	120.7	0.81
67-90	8.69	0.31	0.47	10.2	38.52	0.78	5.58	96	13.71
P5-Loamy, mixed, isohyperthermic Typic Haplustalfs									
0-22	8.52	0.19	0.39	1.8	10.07	1.24	8.38	108.3	17.74
22-49	8.58	0.19	0.09	0	10.97	0.79	5.84	77.4	27.42
49-78	8.55	0.19	0.15	0.6	12.18	0.83	4.57	40.2	4.84
78-105	8.57	0.20	0.11	1.4	12.56	0.67	5.84	52.6	25
105-140	8.59	0.17	0.25	3.2	13.38	0.63	5.08	46.4	2.42

1	2	3	4	5	6	7	8	9	10
			P6-Loamy-skeletal, mixed, isohyperthermic Aridic Rhodustalfs						
0-10	7.88	0.31	0.50	2.5	11.17	0.76	18.78	306.5	9.68
10-29	8.72	0.27	0.19	3.2	11.19	0.68	7.87	374.6	20.16
29-59	8.56	0.34	0.28	1.6	15.37	0.67	3.3	108.3	6.45
59-95	8.79	0.61	0.22	2	29.74	1.3	2.54	58.8	46.77
95-123	8.68	0.85	0.17	1.8	13.8	0.64	3.55	58.8	8.87
			P7-Loamy-skeletal, mixed, calcareous isohyperthermic Aridic Lithic Ustorthents						
0-22	8.55	0.16	0.16	1.8	11.38	0.88	10.15	89.8	55.64
			P8-Loamy, mixed, calcareous isohyperthermic Typic Haplustepts						
0-13	8.7	0.20	0.45	6.1	7.75	0.74	5.84	164.1	2.42
13-40	8.77	0.22	0.49	10.2	18.95	0.84	2.03	139.3	12.1
			P9-Loamy-skeletal, mixed, calcareous isohyperthermic Typic Haplustepts						
0-12	8.4	0.42	0.54	11.6	13.47	0.71	31.48	443.2	6.45
12-40	8.62	0.22	0.60	13.1	11.21	0.61	8.63	275.5	19.35
40-63	7.77	0.25	0.26	3.4	19.29	1.13	2.28	58.8	5.64
			P10-Loamy-skeletal, mixed, isohyperthermic Aridic Haplustepts						
0-13	8.28	0.14	0.25	0.7	8.59	1.35	8.38	96	12.9
13-26	7.41	0.09	0.23	0.7	10.45	0.72	3.55	77.4	6.45
26-43	8.27	0.13	0.86	2.9	8.04	0.99	4.06	40.2	15.32
			P11-Coarse, loamy, mixed, calcareous isohyperthermic Typic Haplustepts						
0-12	8.68	0.28	0.77	5.2	9.46	0.73	15.23	120.7	14.52
12-46	8.69	0.42	0.34	5.2	20.29	1.58	3.81	65	32.26
46-66	8.71	0.38	0.24	7.9	7.55	0.52	3.81	102.2	23.39
66-85	8.74	0.26	0.13	11.6	9.77	0.67	3.81	145.5	16.13
85-98	8.83	0.22	0.15	11.8	7.35	0.75	4.32	40.2	26.61
98-106	8.85	0.24	0.09	16.5	18.98	1.47	5.33	102.2	6.45
106+	8.92	0.22	0.15	38.5	11.4	2.16	4.06	52.6	23.39
			P12-Coarse, loamy, mixed, calcareous isohyperthermic Fluventic Haplustepts						
0-10	7.61	0.29	0.69	1.4	20.92	1.88	25.38	120.7	23.39
10-26	7.78	0.24	0.71	1.8	8.88	0.72	27.41	102.2	15.32
26-48	8.28	0.14	0.10	0.2	16.67	1.36	23.35	77.4	7.26
48-67	8.38	0.15	0.13	1.1	8.54	0.7	8.38	96	6.45
67-83	8.39	0.11	0.11	2.8	5.97	0.74	4.82	65	4.03
83-110	8.53	0.08	0.13	0.5	3.53	1.53	3.81	46.4	13.71
110-118	8.61	0.09	0.09	0.5	8.57	1.49	3.3	40.2	8.87

Soil- Landform relationships

The landform soil relationship showed that conical hills, ridges and local rises are having rock outcrops and bare rock exposures associated with extremely shallow, excessively drained, coarse loamy soils. The soils developed on upper sectors of pediplains are shallow, well-drained, gravelly loamy associated with shallow, well-drained, calcareous gravelly loams. The soils formed from the middle and the lower sectors of pediplains are moderately shallow, moderately well-drained, calcareous gravelly loams associated with moderately shallow, somewhat excessively drained, gravelly loams. Soils of Noyyal and Amravati valley/floors are deep, moderately well-drained, calcareous loams associated with deep, moderately well-drained calcareous clays (Fig. 3). Seasonal water logging is the main problem in valley soils.

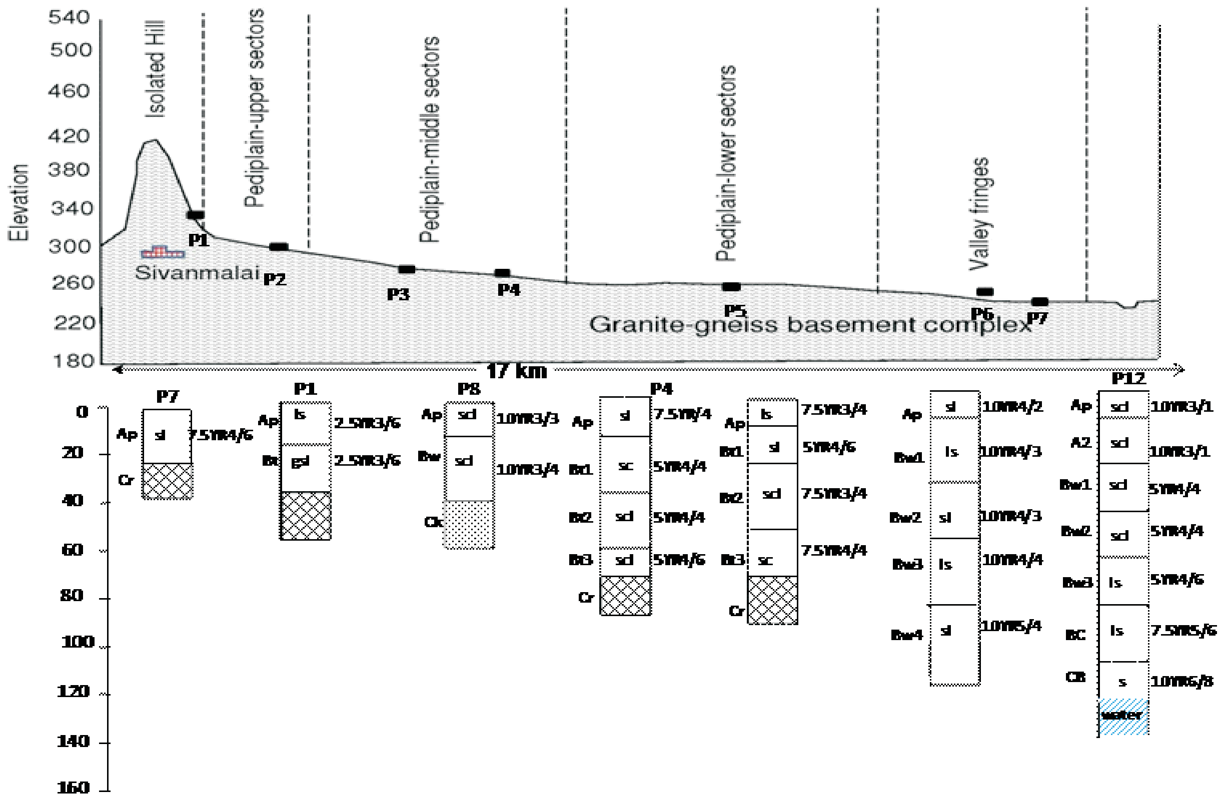

Fig. 3. Landform cross-section and its relationships with soil in Kangayam block.

Soil classification

Based on the soil morphological, physical, and chemical properties, the typifying pedons were classified into Inceptisols, Alfisols, and Entisols soil orders according to USDA Soil Taxonomy (Soil Survey Staff 2014). Pedons P8, P9, P10, P11, and P12 were classified under Haplustepts because of the presence of cambic sub-surface diagnostic horizon, ustic soil moisture regime, and they did not satisfy the characteristics of other Great groups under Inceptisols. Further, pedons P8, P9, and P11 were classified under the sub-group Typic Haplustepts as they possessed the soil characteristics representing the central concept of Haplustepts. However, soil P12 was classified under Fluventic Haplustepts due to irregular distribution of organic carbon with depth. The P10 soil was classified under Aridic Haplustepts because six tenths or more of the cumulative days per year are dry. Considering the percentage of particle size fractions in the soil control section, P8 was classified as loamy class, P9 and P10 as loamy-skeletal and P11 and P12 under coarse-loamy. All the pedons, except the P10 pedon, were calcareous. The pedon P7 was classified under Entisols due to the absence of any diagnostic horizons. As the bedrock was present within 50 cm below the soil surface and the control section remains moist less than 90 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8° C, the soil was grouped under Aridic Lithic subgroup and classified as Aridic Lithic Ustorthents.

Pedons P1, P2, P3, P4, P5, and P6 were classified under the soil order Alfisols, because of the presence of argillic sub-surface diagnostic horizon. The pedon P1, P2, and P6 were classified under Rhodustalfs at Great group due to the redder hue value of 2.5 YR in sub-surface horizons. The pedon P3 was classified under the calcic subgroup as it has the calcic horizon with its upper boundary within 100 cm of the mineral surfaces. The pedon P4 and P5 were classified under Typic Haplustalfs. The P6 pedon was classified under the aridic subgroup because of the cumulative dry spell of six months in a year. At the family level of classification, the soils under Alfisols were classified under two textural class *viz*., loamy-skeletal for pedon P1, P2, P3, P4 and P6; loamy for P5 based on the particle size fractions in their control section. The CEC to clay ratio suggested the mixed mineralogy for all the pedons and the P3 and P4 pedons were calcareous (Soil Survey Staff 2014).

Conclusion

Soils of Kangayam block were shallow to moderately deep, well to moderately well-drained, slightly acid to strongly alkaline and non-saline soils. The organic carbon content of the soils was low, calcium carbonate was appreciable in sub-soils, cation exchange capacity was low to medium. Available phosphorus, potassium, and sulphur were low, and medium, respectively. The soils were classified as Typic Rhodustalfs, Calcic Haplustalfs, Typic Haplustalfs, Aridic Rhodustalfs, Aridic Lithic Ustorthents, Typic Haplustepts, Aridic Haplustepts, and Fluventic Haplustepts. Proper management of silvipastoral systems by adopting drought-resistant grass and tree species in combination with soil and water conservation measures will provide a better groundcover, which in turn increases the fertility status of the soil and the productivity of the ecosystem as well.

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