Application of Remote Sensing Tools for Land Resource Inventory of Kannur Micro Watershed Kollegal Taluk, Chamarajnagar District, Karnataka, India

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Abstract: ***Application Of RS Tools For land resources of the watershed was carried out by using cadastral map (1:10 000 scale) as base. Apart from the cadastral map, remote sensing data products from IRS LISS IV (5.8 m resolution) and Cartosat-1 (2.5 m resolution) were used to identify the landforms and other surface features of Kannur watershed, Chamarajnagar District, Karnataka belonging to Southern Dry Zone. Eight soil profiles representing the study area were selected based on the topography from various physiographic units identified in the area by field survey. Depth of the soils ranged from moderately deep to very deep, colour varied from reddish brown to dark red in uplands and yellowish brown to dark grey in lowland. The texture of the soils was from sandy clay loam to sandy clay. The common structure was weak, fine, sub angular blocky in surface horizons, while moderate medium sub-angular blocky in subsoil. Soil reaction varied from slightly acidic to strongly alkaline (6.2 to 8.7). The organic carbon and CEC of the soil varied from low to medium; 0.2 to 0.65 per cent and 5.0 to 33.9 cmol (p+) kg^{-1} respectively. The upland physiographic units were low in CEC values than midlands and lowlands owing to their low clay content, low organic matter and predominance of 1:1 type of clay minerals, whereas lowlands exhibited moderate CEC values due to higher clay content. The available nitrogen, phosphorus and potassium were low, low to medium and medium respectively.***

Keywords: RS Tools, Land resource inventory, Toposheets, Cadastral Map

1. Introduction

The ability of the land to produce crops is set by soil, climate and landform conditions, which in turn is dependent on intrinsic characteristics, agro-ecological settings, use and management (FAO, 1993). Despite the significant growth in production, the sustainability of some cropping systems has been showing signs of fatigue. Therefore, comprehensive account of our land resources and its potential and problems towards optimizing land use on sustainable basis is necessary. In the recent past, productivity of agricultural soils worldwide in general is on the decline. This prompted the per capita availability of food grain to fall from 510 g per day (1991) to 463 g per day (2004). Keeping these considerations in view, an investigation was carried out for Kannur micro-watershed in Kollegal taluk of Chamarajanagar district to assess the chemical and morphological, physical and physio -chemical characteristics of soils.

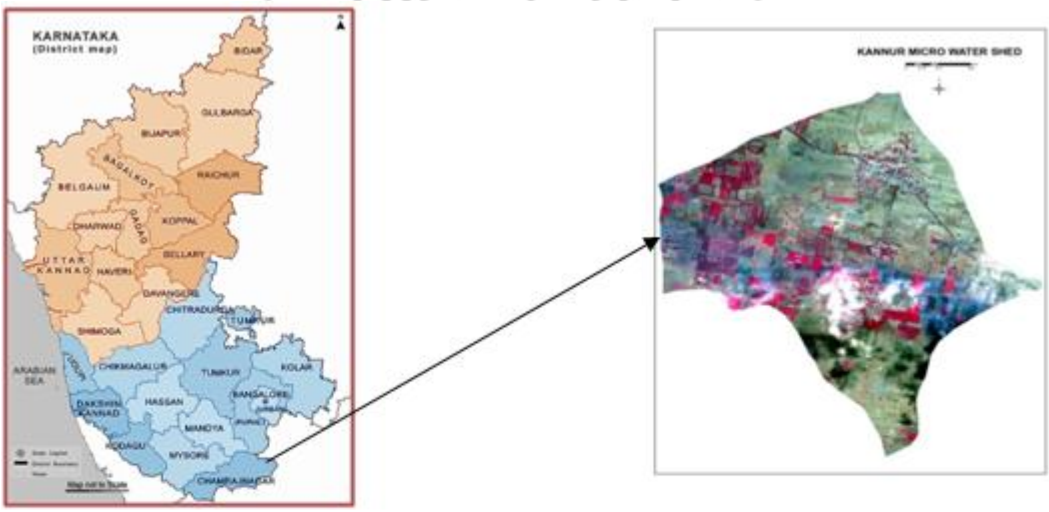

Figure 1: Location of study area in Karnataka

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2. Materials and Methods

The study area, Kannur watershed is located in Kollegal taluk, Chamaraj nagar district, falls under southern dry zone, with semi-arid climate with a dry period of around 6 months in most years. Micro-watershed located between 12° 6' 34.5" and 12° 7' 49.6" N latitudes and 77° 15' 30.9" and 77° 14' 20.2" E longitudes. The yearly annual rainfall varies from 650 to 840 mm. It occupies parts of the four villages *viz.*, Kannur, Anapura, Mangala, and Kamgare.

Climate

The climate of the study area is tropical monsoon type with mean annual air temperature of 24 °C and mean annual rainfall of 801.4 mm (1980-2011), Length of growing period commence from last week of May and continues up to end of October. Soil Moisture Control Section (SMCS) of watershed area falls under Ustic moisture regime with Mean Annual Summer Temperature (MAST) and Mean Annual Winter Temperature (MAWT) differ by less than 6 °C, while analyzing data for about 30 years (IMD, 2012). The availability of moisture is a limiting factor for crop production, which in turn is determined by climate along with physiography and soil type.

Methodology

The detailed survey of the land resources of the watershed was carried out by using cadastral map (1:10 000 scale) as base. Apart from the cadastral map, remote sensing data products from IRS LISS IV (5.8 m resolution) and Cartosat-1 (2.5 m resolution) were used to identify the landforms and other surface features. The imagery has been visually interpreted for identification of different landform units based on image interpretation keys like tone, texture, shape, size and association. Preliminary traverse was carried out by using 1:10,000 cadastral maps. During the traverse, based on surface features different landform units were demarcated and initial legend was prepared by studying soils in few selected places/road cuts. After this, intensive traversing of each landform unit i.e. hills, ridges, uplands and lowlands etc. was carried out. Based on the soil variability observed on the surface, transects were selected along the major slope direction, covering all landform units. In the selected transects, profiles were marked at close intervals to take care of changes in the land features like break in slope, texture etc. In the selected sites, 8 soil profiles were dug (1.5 m x 4 m x 1.5 m) and studied in detail for all their morphological characteristics. The soil and site characteristics were recorded for all profile sites on standard proforma as per the guidelines given in USDA Soil Survey Manual (Soil Survey Staff, 2004). Based on the soil-site characteristics, the soils were grouped into eight different soil series. The area under each series was further divided into phases and their boundaries delineated on the cadastral map based on the variations observed in the texture of the surface soil, slope, erosion, presence of gravels and stones and coverage rocks. The soil samples from each horizon of pedons were collected and analyzed for important physical and chemical characteristics. Particle size distribution was determined by international pipette method (Piper, 1944). Soil reaction, electrical conductivity, exchangeable cations and cation exchange capacity were determined as described by Jackson (1973). Organic carbon was determined by wet oxidation method (Walkley and Black, 1934).The soils were classified as per USDA Soil Taxonomy (Soil Survey Staff, 2003).

3. Results and Discussion

Morphological characteristics

The results of the morphological, physical and chemical characteristics of soils of Kannur micro-watershed, Kollegal taluk, are presented in the tables 1 to 3. Soil depth varied from deep to very deep, Soil colour varied from dark red to dark brown in red soils and very dark grey in black soils. Texture varied from sandy clay loam to clay. The red and black soil pedons exhibited moderate, medium, sub-angular blocky structure. Moist consistency varied from friable to very friable in red soil pedons and from firm to extremely firm in black soil pedons. Consistency was directly related to nature and amount of clay. Friable moist consistency in red soil pedons indicated good soil-water- air relationship. Thin patchy clay skins were visible on the ped surfaces and around sand grains of lower horizons of red soil pedons (P1, P3, P5, P6, P7 and P8). Slickensides were common feature in black soil pedons (P2) because of argillo-pedoturbation. Abundance and intensity of slickensides were more in middle of solum, because of maximum swelling pressure. Similar results were also reported by Dasog and Hadimani (1980).

Physical characteristics

In Upland Pedons, the texture clayey at the surface and sandy clay at sub-surface in Bt horizon, whereas in lowland (P2) and midland (P4) black soil pedons, texture was clay throughout the profile. In the Deccan Plateau of India clay texture in black soil pedons is a common feature (Biswas and Gawande, 1992). Bulk of the particle size distribution in red soil pedons constituted of coarser fractions (more sand and coarse fragment), whereas in black soil pedon, bulk of it was constituted of finer particles due to more chemical weathering in the latter. More total sand in red soil could be attributed to the nature of parent rock, which is granite and granite gneiss complex containing more of quartz (Krishnamurthy, 1993). In red soil pedons bulk density slightly decreased in the Bt horizon, because of better soil aggregation due to increased microbial activity. In black soil pedons (P2, P4) bulk density was influenced by amount of clay and silt. In pedon 7, Bt4 horizon exhibited least value because of low clay and silt content (Goroji, 1994). Particle density is the amount of soil solids per given volume. In red and black soil pedons the amount of sand, silt, clay per given volume shown correlation with the values of particle density in pedon 4, Bw3 horizon shown least particle density values because of very low amount of course sand.

Physico-chemical properties

The pH values of soils ranged from 6.2 to 8.7, and it was slightly acidic to strongly alkaline in reaction. It might be attributed to intense and uniform leaching of bases throughout the profile (Sitanggang *et al*., 2006). The lower pH indicates the high degree of leaching in the surface soil and its decrease in the subsequent horizons (Das and Roy, 1979) may be due to the predominance of electronegative colloids in the soil. It showed that weathering was not as advanced in these soils. The values of EC (1:2.5 soil water

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ratio) ranged from 0.09 to 0.95 dS m-1.Thus these soils are non-saline in nature. EC of all the pedons was very low due to the leaching caused by land slope and rainfall as observed by Sivasankaran *et al* (1993). The mean Organic carbon content in soil ranged from 0.21 to 0.33 per cent. Its content was low in all the pedons. Surface horizons recorded the high values and its values decreased with depth in all the pedons similar findings were reported by Pal *et al*. (1985).

Cation exchange capacity varied between the pedons and also between the horizons in each pedon. The CEC values of upland pedons were low (5.0 to 14 cmol (p+) kg-1. The low CEC in the surface horizon was due to eluviation of bases, clay and silt to subsurface horizons and illuviation of kaolinite dominated clay to lower layers and accumulation of sesquioxides. Dominance of 1:1 type, kaolinitic clay was the reason for low CEC in these soils (Rajan, 2008). The base saturation was high in all the surface horizons, due to the influence of organic matter and in most of the profiles, showed tendency to increase with the depth and following the distribution pattern of pH. The increase of base saturation with depth is due to the leaching of bases from the upper horizon and their deposition in the lower horizons owing to semi arid climate.

The available nitrogen, phosphorus and potassium content varied very much among the pedons. The available nitrogen varied from 50.3 to 197.0 kg ha^{-1}. The highest available nitrogen content present in pedon 2 where it ranged from 187 to 197 kg ha^{-1}. This was due to higher clay, so that the leaching less pronounced, assisted by continuous addition of fertilizers and increased level of organic matter for cultivation. The available phosphorus varied from 10.5 to 58.1 kg ha^{-1}. The phosphorous content decreased with depth and showed low status of available phosphorous with depth. This may be attributed to its higher removal than replenishment and also high phosphorous fixation capacity (Sathisha and Badrinath, 1994). The available potassium varied from 44.8 to 250 kg ha^{-1}. The highest available potassium content present in pedon 4, where it ranged from 196 to 250 kg ha^{-1}. Lowest available potassium content was in pedon 5, where it ranged from 44.8 to 141.2 kg ha^{-1}. In all pedon soils available potassium content increased with the depth. Coarse textured and gravelly soils are particularly low in available potassium, possibly due to faster and deeper leaching as observed by Badrinath *et al.,* (1986) in Puttur soils. The available sulphur ranged from 6.3 to 33.3 in all the pedons, it shown decreasing trend with increasing soil depth. The low land soil pedon (P2) and mid land soil pedon (P4) shown high values, when compared to all upland soil pedons. This may be due to the fact that amount of clay having net negative charges shown repulsion (Anionic repulsion) property to sulphate anion resulted in higher sulphur availability. The DTPA extractable Fe, Mn and Cu are in optimum range. Similar results were observed by Bhaskar *et al*. (2004) in hill slopes of Narang- Kongripara watershed of Meghalaya.

Concentration of micronutrients decreases with the depth. In all soil pedons, Zn content was below the critical level, which may be due to good drainage condition and better porosity, which played a critical role in zinc availability. Similar results were recorded by Kannan and Mathan (1994) in Tamil Nadu soils.

4. Conclusion

Kannur watershed depth of the soils ranged from moderately deep to very deep, the solum thickness increased from upper to the lower slopes in the study area. The colour of the soils varied from reddish brown to dark red in uplands, this was found to be influenced mainly by the type of parent material, low organic matter content, warmer temperature regime and moderately high rainfall existing in the area. The colour varied from yellowish brown to dark grey in lowlands. This was influenced by the topography and impeded drainage in the sub-surface layers.

The study reveals that there is a close relationship between physiography and soils. The formation of the diverse group of soils can be attributed to the variation in topography, causing erosion, leaching, sedimentation and other pedogenic processes modified by altered water regime.

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Author Profile

M. Ravindra Naik received the B.Sc(Agri) and M.Sc(Agri) Degrees in Agricultural sciences and specialization in Soil science and Agricultural chemistry as National research scholar from University Of Agricultural Sciences, Bangalore 2012 and 2014, respective degrees. During 2012-2014, he has done research in Application of RS tools and characterization, taxonomical classification of soils with collaboration of [2]ICAR-National Bureau of Soil Science and Land Use Planning, R.C. Bangalore-560 024, Karnataka, India (NBSS &LUP). He is now working with NBSS&LUP.

Table 1: Morphological characteristics of soils of Kannur microwatershed

Pedon No & horizons	Depth (cm)	Colour moist	Texture	Structure			Consistence				Effervescence	Boundary		pores		roots	
				S	G	T	Dry	Moist	Stickyness	Plasticity		D	T	S	Q	S	Q
Pedon 1 Fine, kaolinitic, isohyperthermic, Typic Kandiustalfs.																	
Ap	0-26	5YR 4/4	scl	m	2	sbk	sh	fr	ss	sp	-	c	s	f	c	f	c
Bt1	26-47	2.5YR3/6	c	m	2	sbk	sh	fr	ss	sp	-	c	s	f	c	f	c
Bt2	47-66	2.5YR3/6	c	m	2	sbk	sh	fr	ss	sp	-	a	s	f	c	f	c
Bt3	66-102	2.5YR3/4	vgsc	m	2	sbk	sh	fr	ss	sp	-	g	s	-	-	-	-
Bt4	102-138	2.5YR3/4	vgsc	m	2	sbk	sh	fr	ss	sp	-	g	w	-	-	-	-
Pedon 2 Fine, mixed, isohyperthermic, Typic Haplusterts.																	
Ap	0-19	10YR3/1	c	C	2	sbk	h	fr	vs	vp	-	g	s	c	f	f	c
Bw	19-42	10YR3/1	c	C	2	sbk	h	fr	vs	vp	-	g	s	f	c	f	c
Bss1	42-73	10YR3/1	c	C	2	sbk	h	fr	vs	vp	-	g	s	f	c	f	c
Bss2	73-99	10YR3/1	c	C	2	sbk	h	fr	vs	vp	-	g	w	-	-	-	-
Bss3	99-150	10YR3/1	c	c	2	sbk	h	fr	vs	vp	-	g	w	-	-	-	-
Pedon 3 Fine, kaolinitic isothermic, Kandic Paleustalfs.																	
Ap	0-20	5YR3/4	sc	m	2	sbk	sh	fr	ms	mp	-	c	s	c	f	f	c
Bt1	20-38	2.5YR3/6	c	m	2	sbk	sh	fr	ms	mp	-	g	s	f	c	f	c
Bt2	38-75	2.5YR3/6	c	m	2	sbk	sh	fr	ms	mp	-	g	s	f	c	f	c
Bt3	75-98	2.5YR3/4	c	m	2	sbk	sh	fr	ms	mp	-	g	s	-	-	f	c
Bt4	98-145	2.5YR3/4	c	m	2	sbk	sh	fr	ms	mp	-	g	s	-	-		
Pedon 4 Fine mixed isohyperthermic Oxic Haplustepts.																	
Ap	0-16	10YR4/6	c	m	2	sbk	sh	fr	ms	mp	-	c	s	c	f	f	c
Bw1	16-57	7.5YR4/4	c	m	2	sbk	sh	fr	ms	mp	-	c	s	f	f	f	c
Bw2	57-78	7.5YR4/4	c	m	2	sbk	sh	fr	ms	mp	-	g	s	f	f	f	c
Bw3	78-105	10YR4/3	c	m	2	sbk	sh	fr	ms	mp	-	g	s	f	f	f	c
Bw4	105-140	10YR4/4	c	m	2	sbk	sh	fr	ms	mp	-	g	s	-	-		
Pedon 5 Fine, mixed, isohyperthermic, Kanhaplic Rhodustalfs.																	
Ap	0-19	7.5YR4/4	scl	m	1	sbk	sh	fr	ss	sp	-	a	s	f	c		
Bt1	19-36	2.5YR3/4	c	m	1	sbk	sh	fr	ms	mp	-	c	s	f	c		
Bt2	36-82	2.5YR3/6	c	m	1	sbk	sh	fr	ms	mp	-	g	s	f	m		
Bt3	82-121	2.5YR3/6	c	m	1	sbk	sh	fr	ms	mp	-	g	s	f	m		
Bt4	121-163	2.5YR3/6	c	m	1	sbk	sh	fr	ms	mp	-	g	s	-	-		
Pedon 6 Fine, mixed, iso-hyperthermic, Rhodic Paleustalfs.																	
Ap	0-20	5YR4/4	scl	m	2	sbk	sh	fr	ss	sp	-	a	s	f	c	f	c
Bt1	20-41	2.5YR3/6	c	m	2	sbk	sh	fr	ss	sp	-	c	s	-	-	f	c
Bt2	41-87	2.5YR3/6	c	m	2	sbk	sh	fr	ss	sp	-	g	s	-	-	f	c
Bt3	87-117	2.5YR3/4	c	m	2	sbk	sh	fr	ss	sp	-	g	s	-	-	f	c
Bt4	117-155	2.5YR3/4	c	m	2	sbk	sh	fr	ss	sp	-	g	s	-	-		
Pedon 7 Clayey-skeletal, mixed, iso-hyperthermic, Kandic Paleustalfs.																	
Ap	0-17	7.5YR4/4	gsl	m	1	sbk	sh	fi	so	po	-	a	s	f	c	f	c
Bt1	17-44	5YR3/4	gsc	m	2	sbk	sh	fr	ms	mp	-	c	s	f	f	f	c
Bt2	44-80	2.5YR3/4	gsc	m	2	sbk	sh	fr	ms	mp	-	g	s	-	-	f	c
Bt3	80-109	2.5YR3/4	egsc	m	2	sbk	sh	fr	ms	mp	-	g	s	-	-	f	c
Bt4	109-148	2.5YR3/4	egsc	m	2	sbk	sh	fr	ms	mp	-	g	s	-	-		
Pedon 8 Clayey-skeletal, mixed, iso-hyperthermic, Kanhaplic Rhodustalfs.																	
Ap	0-17	2.5YR3/6	gc	m	2	sbk	sh	fr	ms	mp	-	c	s	f	c	f	c
Bt1	17-45	2.5YR3/6	gc	m	2	sbk	sh	fr	ms	mp	-	g	s	f	m	f	c
Bt2	45-72	2.5YR3/4	vgc	m	2	sbk	sh	fi	ms	mp	ev	a	s	f	m	f	c
Bt3	72-98	2.5YR3/4	egsc	m	1	sbk	sh	fr	ms	mp	ev	c	s	-	-	f	c
Bt4	98-130+	2.5YR3/4	egsc	m	1	sbk	sh	fr	ms	mp	-	c	s	-	-		

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Table 2: Physico-chemical properties of the soils

Pedon no & horizons	Depth in (cm)	Texture			Gravel (%)	B.D (Mg m-3)	P.D (Mg m-3)	pH (1:2.5)	E.C (1:2.5) (dS m^{-1})	O.C (%)
		Sand %	Silt %	Clay %						
Pedon 1, Fine, kaolinitic, iso-hyperthermic, Typic Kandiustalfs.										
Ap	0-26	52.34	20.86	26.80	1-5	1.53	2.78	7.08	0.36	0.39
Bt1	26-47	47.00	11.60	44.20	1-5	1.65	2.95	6.83	0.27	0.34
Bt2	47-66	44.44	7.86	47.70	5-10	1.60	2.96	6.62	0.29	0.35
Bt3	66-102	45.61	7.89	46.50	60	1.52	2.89	6.36	0.28	0.29
Bt4	102-138	50.40	7.10	42.50	60	1.42	2.85	6.22	0.20	0.28
Pedon 2, Fine, mixed, iso-hyperthermic, Typic Haplusterts.										
Ap	0-19	25.70	19.60	54.70	1-5	1.47	2.89	8.72	0.45	0.45
Bw	19-42	19.00	22.30	58.70	1-5	1.48	2.99	8.60	0.58	0.36
Bss1	42-73	22.90	22.30	54.80	1-5	1.43	2.97	8.06	0.53	0.32
Bss2	73-99	25.70	22.20	52.10	1-5	1.42	2.80	8.12	0.44	0.28
Bss3	99-150	27.10	20.60	52.30	1-5	1.42	2.90	7.76	0.38	0.26
Pedon 3, Fine, kaolinitic, iso-hyperthermic, Kandic Paleustalfs.										
Ap	0-20	45.60	16.90	37.50	1-5	1.56	2.73	7.15	0.29	0.48
Bt1	20-38	44.90	14.30	40.80	1-5	1.66	2.90	7.12	0.24	0.34
Bt2	38-75	43.70	13.85	42.45	1-5	1.67	2.92	7.10	0.19	0.25
Bt3	75-98	42.30	13.60	44.10	1-5	1.53	2.85	7.03	0.14	0.22
Bt4	98-145	41.60	12.65	45.75	1-5	1.41	2.64	6.53	0.10	0.18
Pedon 4, Fine, mixed, iso-hyperthermic, Oxic Haplustepts.										
Ap	0-16	27.0	27.4	45.5	1-5	1.46	2.51	8.04	0.40	0.65
Bw1	16-57	23.2	28.2	48.6	1-5	1.40	2.64	8.42	0.38	0.69
Bw2	57-78	15.9	34.2	49.9	1-5	1.41	2.64	8.47	0.33	0.55
Bw3	78-105	11.4	36.0	52.6	1-5	1.39	1.99	8.36	0.24	0.41
Bw4	105-140	10.1	33.3	56.6	1-5	1.34	2.08	8.38	0.18	0.46
Pedon 5, Fine, mixed, iso-hyperthermic, Kanhaplic Rhodustalfs.										
Ap	0-19	50.80	20.70	28.50	1-5	1.36	2.64	6.71	0.29	0.32
Bt1	19-36	39.30	12.80	47.90	1-5	1.43	2.79	6.86	0.24	0.30
Bt2	36-82	42.20	12.00	45.80	1-5	1.20	2.48	6.75	0.20	0.27
Bt3	82-121	44.00	10.70	45.30	1-5	1.39	2.62	6.84	0.15	0.16
Bt4	121-163	50.50	9.00	40.50	1-5	1.51	2.90	6.25	0.09	0.11
Pedon 6, Fine, mixed, iso-hyperthermic, Rhodic Paleustalfs.										
Ap	0-20	53.70	11.50	34.80	1-5	1.71	2.71	7.6	0.95	0.43
Bt1	20-41	45.00	12.20	42.80	1-5	1.61	2.7	7.8	0.86	0.32
Bt2	41-87	47.50	10.00	42.50	1-5	1.55	2.58	7.7	0.46	0.31
Bt3	87-117	48.10	8.30	43.60	1-5	1.44	2.53	7.5	0.42	0.27
Bt4	117-155	53.20	7.10	39.70	1-5	1.40	2.03	6.9	0.31	0.21
Pedon 7, Clayey-skeletal, mixed, iso-hyperthermic, Kandic Paleustalfs.										
Ap	0-17	55.9	21.6	22.5	15-35	1.28	2.56	6.69	0.22	0.39
Bt1	17-44	51.00	10.0	39.0	15-35	1.30	2.62	6.80	0.38	0.28
Bt2	44-80	50.71	9.19	40.10	15-35	1.31	2.65	7.01	0.34	0.19
Bt3	80-109	49.90	9.00	40.10	>60	1.21	2.37	6.75	0.28	0.11
Bt4	109-148	55.10	9.10	35.80	>60	1.19	2.37	6.75	0.19	0.08
Pedon 8, Clayey-skeletal, mixed, iso-hyperthermic, Kanhaplic Rhodustalfs.										
Ap	0-17	38.05	13.50	48.40	15-35	1.51	2.75	6.35	0.87	0.45
Bt1	17-45	39.41	12.30	49.20	15-35	1.66	2.80	6.45	0.86	0.31
Bt2	45-72	38.48	11.90	49.20	60	1.71	2.90	7.00	0.81	0.26
Bt3	72-98	38.28	11.70	49.40	>60	1.40	2.70	7.40	0.78	0.19
Bt4	98-130	46.68	10.82	45.40	>60	1.32	2.65	7.79	0.65	0.14

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Table 3. Available nutrient status of the soils.

Depth (cm)	Horizon	Exchangeable bases (cmol (p+) kg-1)				Sum of Bases	CEC (NH4OAC) (cmol (p+) kg-1)	ESP (%)	BS (%)	CEC/Clay	Available Macronutrients (Kg ha-1)			Secondary Nutrient (mg kg-1)	Available micronutrients (mg kg-1)			
		Ca	Mg	K	Na						N	P2O5	K2O	S	Cu	Fe	Mn	Zn
Pedon 1 Fine, kaolinitic, iso-hyperthermic, Typic Kandiustalfs.																		
Ap	0-26	3.12	1.99	1.87	0.01	3.13	8.01	0.12	39.07	0.30	139	18.60	146.23	18.05	2.64	5.68	16.52	0.08
Bt1	26-47	2.64	1.88	1.81	0.23	2.87	8.31	2.76	34.53	0.19	105	14.58	141.54	17.05	1.62	3.38	11.52	0.22
Bt2	47-66	2.44	1.81	1.66	0.22	2.66	6.78	3.24	39.23	0.14	110	11.51	129.81	14.58	1.34	3.58	10.62	0.08
Bt3	66-102	2.17	0.72	1.53	0.21	2.38	5.31	3.95	44.82	0.12	98	11.00	119.64	11.88	0.96	2.72	9.84	1.52
Bt4	102-138	2.00	0.66	1.15	0.19	2.19	5.04	5.04	3.76	0.11	94	10.50	89.93	9.59	0.85	2.08	9.00	0.60
Pedon 2 Fine, mixed, iso-hyperthermic, Typic Haplusterts.																		
Ap	0-19	12.7	8.50	1.73	1.05	23.99	33.99	3.09	70.58	0.60	197	58.1	135.98	31.94	2.18	7.28	4.79	0.12
Bw	19-42	11.1	6.40	1.62	0.95	20.07	30.07	3.15	66.75	0.53	192	41.6	131.92	27.08	1.80	4.74	3.87	0.42
Bss1	42-73	10.5	6.30	1.68	0.94	19.42	29.42	3.20	66.01	0.50	188	23.24	127.23	22.22	1.60	5.36	4.42	0.48
Bss2	73-99	8.60	5.20	1.42	0.89	16.11	26.11	3.42	61.71	0.48	187	22.60	111.27	21.52	1.54	4.84	4.46	0.36
Bss3	99-150	8.10	5.20	1.36	0.86	15.53	25.53	3.38	60.83		187	22.02	107.05	14.58	1.12	4.71	4.43	0.30
Pedon 3, Fine, kaolinitic, iso-hyperthermic, Kandic Paleustalfs.																		
Ap	0-20	2.92	0.92	1.23	0.45	5.52	7.02	6.41	78.63	0.19	175	28.2	96.18	21.52	0.84	9.16	8.82	0.28
Bt1	20-38	4.98	3.63	1.01	0.51	10.13	11.63	4.38	87.10	0.28	168	27.5	78.98	14.58	0.82	7.20	11.52	0.31
Bt2	38-75	4.79	1.97	0.89	0.53	8.18	9.68	5.47	84.50	0.22	164	20.3	69.59	13.19	0.74	6.66	10.62	0.32
Bt3	75-98	1.96	1.56	0.8	0.25	4.57	6.07	4.11	75.28	0.14	142	18.9	62.56	10.41	0.68	5.94	9.58	0.28
Bt4	98-145	1.94	0.54	0.74	0.1	3.32	4.82	2.07	68.87	0.11	105	18.4	57.86	6.25	0.6	4.02	8.74	0.24
Pedon 4 Fine, mixed, iso-hyperthermic, Oxic Haplustepts.																		
Ap	0-16	3.2	1.7	0.17	1.3	6.37	11.14	11.66	57.14	0.24	125.4	41.5	250	33.33	3.24	13.8	16.10	0.22
Bw1	16-57	4.2	2	0.51	1.8	8.51	13.61	13.21	62.50	0.28	87.7	30.5	252	32.63	1.78	12.6	18.00	0.18
Bw2	57-78	3.3	1.5	0.4	1.4	6.60	9.90	14.14	66.66	0.20	59.6	22.5	205	27.77	1.60	9.20	14.00	0.17
Bw3	78-105	2.1	1	0.34	0.7	4.14	6.21	11.27	66.66	0.12	53.3	22.0	200	20.13	1.44	7.60	13.80	0.18
Bw4	105-140	2.5	0.8	0.37	0.8	4.47	6.70	11.93	66.66	0.12	34.5	20.5	196	18.05	1.12	7.10	13.20	0.12
Pedon 5 Fine, mixed, iso-hyperthermic, Kanhaplic Rhodustalfs.																		
Ap	0-19	3.92	1.17	1.92	0.68	7.69	8.06	8.43	95.40	0.28	116.0	25.2	141.2	18.05	0.6	5.7	7.04	0.16
Bt1	19-36	7.86	2.88	1.89	0.81	13.44	14.58	5.55	92.18	0.30	109.8	27.8	99.87	17.77	0.56	4.9	8.92	0.24
Bt2	36-82	5.98	2.22	1.01	0.70	9.91	10.31	9.79	96.12	0.25	69.0	21.2	75.24	15.41	2.08	3.3	5.8	0.1
Bt3	82-121	1.96	0.81	1.00	0.40	4.17	4.21	9.50	99.04	0.10	50.3	15.9	55.24	9.52	2.96	5.28	7	0.08
Bt4	121-163	1.92	0.75	0.8	0.28	3.75	4.20	6.46	6.46	0.10	54.2	14.6	44.8	7.91	2.42	4.72	8.6	0.06
Pedon 6 Fine, mixed, iso-hyperthermic, Rhodic Paleustalfs.																		
Ap	0-20	4.32	1.33	1.64	0.54	7.83	9.23	5.85	84.83	0.27	142.5	33.00	128.24	15.13	0.96	4.52	9.5	0.23
Bt1	20-41	5.62	1.59	1.45	0.7	9.36	10.76	6.50	86.98	0.25	120.4	23.86	113.39	11.5	0.74	5.2	8.2	0.28
Bt2	41-87	6.9	2.2	1.08	0.68	10.86	12.26	5.54	88.58	0.29	96.50	21.60	84.45	10.13	0.62	5.9	7.8	0.28
Bt3	87-117	3.21	1.9	0.93	0.42	6.46	7.86	5.34	82.18	0.19	89.90	20.40	72.72	8.74	0.85	4.42	6.4	0.22
Bt4	117-155	2.05	0.5	0.79	0.22	3.56	4.96	4.35	71.77	0.12	85.00	19.78	61.77	7.36	0.74	3.46	5.6	0.12
Pedon 7 Clayey-skeletal, mixed, iso-hyperthermic, Kandic Paleustalfs.																		
Ap	0-17	3.63	1.91	1.43	0.65	7.62	8.26	7.86	92.19	0.37	192.5	42.21	111.82	12.88	2.66	4.58	8.3	0.34
Bt1	17-44	3.33	1.41	1.38	0.53	6.65	7.45	7.11	93.53	0.19	170.3	39.15	107.91	12.3	2.98	4.66	7.1	0.45
Bt2	44-80	3.88	1.40	1.21	0.44	6.93	8.34	5.27	83.09	0.21	99.70	32.46	94.62	9.22	2.04	3.94	6.8	0.45
Bt3	80-109	3.33	0.88	0.93	0.38	5.52	6.04	6.29	91.39	0.15	89.09	28.72	72.72	7.49	1.94	3.86	5.6	0.39
Bt4	109-148	3.33	0.53	0.82	0.29	4.97	5.92	4.89	83.95	0.17	75.00	19.04	64.12	6.61	1.76	2.64	4.6	0.29
Pedon 8 Clayey-skeletal, mixed, iso-hyperthermic, Kanhaplic Rhodustalfs.																		
Ap	0-17	5.27	5.90	0.16	1.07	11.4	12.24	8.74	93.13	0.25	127.8	39.15	122.30	14.91	1.82	5.92	7.79	0.16
Bt1	17-45	5.14	4.20	0.14	1.15	9.63	10.47	10.98	91.97	0.22	99.40	28.75	113.00	13.02	2.08	7.08	10.26	0.26
Bt2	45-72	4.05	3.09	0.13	1.08	6.37	8.21	13.15	77.58	0.17	92.40	18.77	104.83	10.04	1.72	8.86	9.90	0.18
Bt3	72-98	4.05	2.90	0.13	0.55	6.09	6.93	7.93	87.87	0.14	75.40	17.34	94.60	10.94	1.64	2.75	7.77	0.17
Bt4	98-130	2.40	1.50	0.12	0.31	3.83	4.67	6.63	82.01	0.10	72.70	13.6	87.00	9.44	1.47	2.40	6.64	0.15

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