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Soil: Chemical characteristics of Vallanadu series in Tamiraparani river basin of southern Tamil Nadu, India

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Abstract
The soils of Vallanadu were characterized based on morphological, physico-chemical properties for land evaluation and classification. The soils were very shallow to deep, red to yellowish in colour, sandy loam to sandy clay in texture and had sub-angular blocky and angular blocky structures. The sand, silt and clay varied from 46.7 to 82.14%, 2.95 to 33.74% and 8.15 to 44.1% respectively. The soils were moderately acidic to moderately alkaline, non-saline, low to medium in organic carbon. The CEC varied from 4.5 to 16 Cmol $(p^+)kg^{-1}$ and dominated by Ca^{2+} >Mg^{2+}>K^+>Na^+. The soils were low, medium, low to medium in available NPK respectively. Among the micronutrients, Fe and Mn were sufficient, Zn & Cu were deficient. The soils were classified as *Typic Rhodustalf, Typic Haplustalf* and *Typic Haplustepts*. The soils were evaluated as land capability sub-class of IVs, IVes and land irrigability sub-classes of 2s, 3s and 3st.

Keywords: Soil characterization, classification, physico-chemical characteristics, land evaluation

Introduction

Land resource information plays a critical role in the management of natural resources. Soils are considered as an integral part of the landscape and thus their characteristics are largely governed by the landforms on which they have developed (Naitam *et al.*, 2016) [10]. Adequate knowledge on the properties of soils is a key issue for sustainable land management. To increase the soil productivity to meet the food demand of the future, knowledge on soil resources and its suitability to scientific agriculture is very important.

Scientific management and maintenance of soil health based on soil characteristics is the key to accomplish sustained high productivity, food security and environmental safety. The spatial and temporal variation in soil properties even in small area is very high, need to be characterized, classified and interpreted easily for selection of crop and management practice of crop production. Lack of soil characterization becomes obstacle to utilize the soil production potentials and adoption of better management practice to increase the productivity of the soil and crops. Soil resource inventory through characterization of the resources provide an insight potentials and limitations of soils.

Materials and method

The study was initiated in a village hamlet of Vallanadu which lies between the geographical position of 8°42’01”N to 8°42’09”N, 77°52’39”E to 77°51’14”E and 8°43’40”N to 8°41’38”N, 77°52’04”E to 77°51’56”E (Table 1) falls under the potential agriculture block of Srivaikuntam taluk of Tuticorin district, Tamilnadu having approximately 1250 acres with wide range of agricultural ecosystem comprising wetland (nearly 50 acres), garden land (more than 300 acres), and forestry (more than 600 acres) and waterbodies. The area receives annual rainfall of 600-750 mm mostly during North-east monsoon season. The mean annual temperature varies from 28 °C to 30 °C with mean annual summer temperature varying from 30 °C to 32 °C and mean winter temperature ranges from 25 °C to 27 °C. The study area falls under temperature regime of “isomegathermic” and moisture regime of “ustic”. The geological formation of the study area is mainly of granite-gneiss and calcic gneiss.

Detailed soil survey was taken under using the cadastral map with the scale of 1:5000. The various physiographic classes found in the study area are footslope, terrace and basin having the running length of 1, 2 and 2 km respectively covering the total distance of 5 km. The soil pedons were studied for its site features and morphological characteristics. The soil samples were collected from different horizon of all pedons and analysed for different physico-chemical parameters using standard procedures.

The profile depth was measured by using soil survey tape from surface to bedrock or upto 2m whichever comes early and expressed in cm. The soil colour was determined both at dry and moist condition by using Munsell colour chart and expressed in combination of munsell notation such as hue, value and chroma. The soil structure was described in terms of type, class and grade. The consistency was determined under dry, moist, sticky and plastic condition. The presence of roots was noted by naked eye and recorded in size and numbers. The presence of $CaCO_3$ was qualitatively assessed by intensity of effervescence produced by 1:1 HCl solution. Soil reaction (pH) and Electrical conductivity (EC) by Jackson (1973) [4], Organic carbon by Walkley and Black (1934) [18], Texture (Sand, silt and clay) and calcium carbonate ($CaCO_3$) content by Piper (1966), exchangeable cations (Ca, Mg, Na and K) by Jackson (1973) [4], cation exchange capacity by Schollenberger and Dreibelbis (1930), Available nitrogen by Subbiah and Asija (1956) [16], Available phosphorous by Jackson (1973) [4], Available potassium by Stanford and English (1949) [15], Available micronutrients by Lindsay and Norvell (1978) [8]. Soils were classified as per the methods illustrated in "Keys to Soil Taxonomy" (Soil Survey Staff, 2014) [14].

Results and Discussion

Morphological characteristics

The data pertaining to soil morphological characteristic are presented in Table 2. The soil depth was decreasing from the higher physiographic elevation of foot slope to basin area. The pedon located at foot slope had comparatively more depth (117-122 cm) indicating the colluvial deposit of soil particles from shoulder than the pedon located at foot plain with the profile depth of 82-100 cm. The profile in plains had less depth (74-84 cm) than all the physiographic position indicating the area is more prone to erosion. However the soil depth of the pedon located in basin had more depth (102-133 cm) as that of foot slope confirm the deposition of elluviated materials at the basin. The variation in the soil depth is related to the slope and degree of soil erosion (Narsaiah *et al.*, 2018) [11-12]. The soils had clear and smooth boundary in surface layers whereas clear and wavy boundaries between the horizon confirm the erosion and deposition process existing in the study area.

With respect to soil colour the pedon located at all elevation (foot slope) were lighter in colour registering the munsell notation of 2.5YR 4/6 to 5YR 3/4 except the soil located in the plain area which registered the munsell notation of 7.5YR 4/3 to 10YR 5/6 in upper and lower horizons respectively. The darker colour registered in the plain area may be due to continuous cultivation of annual crops. However, the change in soil colour might be due to the combined effect of chemical-minerological composition, texture, topographic position, moisture regime, redoximorphic features and organic matter (Choudhury *et al.*, 2019) [3].

The soil structure type in Vallanadu soils varied from sub-angular blocky (footslope and footplain) to angular blocky (basin). The structural size was fine and medium in the foot slope and foot plain whereas it was coarse and medium size under basin area. The soils of footslope and footplain had weak to moderate grade and the soils in the basin had moderate to strong structure due to the deposition of finer fraction from hill slopes. The variation in the soil structure is associated with the presence of higher quantity of clay fraction in the soil (Jena *et al.*, 2016) [6].

The consistence of soils in footslope and plains were slightly hard and friable due to the colluvial deposition whereas the soils in the basin areas was hard and firm consistence as a result of deposition of finer fraction in the basin areas. The stickiness and plasticity increased along the depth of the profile throughout the study area. The surface soils were slightly sticky whereas the soils in the lower horizons were moderately sticky and moderately plastic due to the illuvial movement of clay (Narsaiah *et al.*, 2018) [11-12].

The effervescence was observed in the soils of plain and basin region, which was due to the contribution of the parent material and sedimentation of the carbonates. The remaining soils showed no effervescence because of the red soil characteristics.

Physico-chemical characteristics

The soil texture varied from sandy loam to sandy clay which indicates the presence of more coarse fragments. The sand content varied from 82.14 to 46.7%. The soils near the hill slope had sandy loam texture whereas the cultivated areas of plain and basin had sandy clay loam texture. The higher fraction of sand content in the surface soils could be attributed with loss of finer fraction of soil by erosion and illuvial movement of clay to the deeper horizon (Kumar *et al.*, 2019) [9]. The clay content in the soils ranged from 8.15 to 44.1%. The sand content decreased with the depth whereas the clay content was increased with the depth due to the illuvial movement of clay leading to the development of argillic horizon. The soils near hill slope had low clay content whereas the soils near basin had more clay accumulation as a result of deposition from the higher elevation.

The bulk density varied from 1.18 to 1.54 Mg m^{-3}. The increase in bulk density with depth was associated with low organic matter more compaction and less aggregation(Jena *et al.*, 2016) [6]. The organic carbon decreased with depth in all the pedons ranging from 0.08 to 0.96%. However, surface soil had higher organic carbon than the subsurface layers which may be related to the addition of crop residue and leaf litter in surface soils (Choudhury *et al.*, 2019) [3]. The organic carbon content was low in the barren areas of foothills whereas the cultivated areas near the basin had more organic carbon due to the continuous cultivation by application of organic manures.

The pH ranged from 5.5 to 8.6 and increased with depth. The soils in the footslope and footplains were acidic due to the presence of acidic parent material, appreciable amount of exchangeable Al^{3+} and leaching of bases in sloping landforms (Nayak *et al.*, 2002) [14]. The neutral to alkaline nature of the soil in the plain and basin region may be due to accumulation of bases from the higher elevation (Mahapatra *et al.*, 2019) [9].

The electrical conductivity varied from 0.01 to 1.31 dSm^{-1}. The soils in the footslope and foot plains had lower EC values whereas the soils in the basin region had comparatively more EC because of the accumulation of salts as a result of leaching. The lower EC values were associated with the sloppy landscape and leaching of salts from the surface horizons (Mahapatra *et al.*, 2019) [9].

The soils had cation exchange capacity from 5.6 to 16.9 C mol (p+) kg^{-1} which increased with depth. The soils in the footslope and foot plain had very low CEC due to the coarse texture and governed by the finer clay fractions (Mahapatra *et al*., 2019) [9]. The CEC of the soil was low which may be due to clay containing low CEC minerals like kaolinite, low organic carbon with acidic pH (Choudhury *et al*., 2019) [3]. The soils in basin area had comparatively higher CEC than footslope areas indicating the deposition of the bases transported from higher elevation. Among the cations, exchangeable calcium was dominant in the soils followed by exchangeable magnesium, potassium and sodium. The slow weathering and fixation of released potassium might have resulted low exchangeable potassium (Chandrakala *et al*., 2019) [2]. The base saturation of the soil varied from 70 to 87.68% and increased with depth. The comparatively high values of base saturation percentage of these soils near basin than the footslope and foot plains might be due to lower elevation and deposition of bases from higher elevation (Mahapatra *et al.*, 2019) [9].

The exchangeable sodium percentage (ESP) was less than 15% in all the pedons. The calcium carbonate content increased with depth varying from 0.45 to 15.5%. The soils in plains and basin region had more calcium carbonate content than the other region which was due to the influence of the parent material and sedimentation of carbonates (Sankar and Dadhwal 2009) [13].

Nutrient status

The available nitrogen ranged from 39.2 to 232.4 kg ha^{-1} and decreased with depth. The low availability of nitrogen in footslope soil was due to less accumulation of organic matter and coarse texture whereas the soils in lower regions had lower nitrogen due to leaching of NO_3^- N in soils (Supriya *et al.*, 2019) [17]. The soils had the available phosphorous decreased with depth. The lower phosphorous in sub soil may be due to fixation with clay minerals and oxides of Fe and Al (Srinivasan *et al.*, 2016) [17]. The available potassium varied from 70 to 370 kg ha^{-1} and exhibited decreasing trend along the depth. The potassium content was low in the hill slopes and foot plains whereas the soils in plains had more available potassium content due to the continuous application of fertilizers for crop cultivation. The amount and type of clay, organic carbon, soil pH and CEC significantly affects the K-availability in the soil (Narsaiah *et al.*, 2018) [11-12].

The available micronutrients was decreasing with increasing depth. The content of DTPA-Fe varied from 3.14 to 23.25 mg kg^{-1}, DTPA-Zn ranged from 0.06 to 1.4 mg kg^{-1}, DTPA-Cu ranged from 0.18 to 2.83 mg kg^{-1} and DTPA-Mn varied 2.79 to 8.16 mg kg^{-1}. The higher availability of iron was attributed to the coarse texture and non-calcareous to slightly calcareous nature of the soil. The higher manganese content in the surface soil was related to the acidic nature of the soil. The lower amount of zinc and copper might be attributed to the acidic pH, texture and fixation with the clay (Jegadeeswari *et al.*, 2017) [5].

Soil classification

The soils of the study area falls under "isomegathermic" temperature regime and "ustic" moisture regime. As a result of illuviation, argillic horizon was formed in the soil profile. The presence of argillic horizon with more than 35% base saturation and hue value of 2.5YR made the pedons in the footslope and foot plain soils *Typic Rhodustalf*. The pedons in plain were classified under the sub-group of *Typic Haplustepts* due to the presence of the cambic horizon. The pedons in the basin were classified under *Typic Haplustalf* due to presence of argillic horizon with base saturation more than 35%.

The pedons in footslope having both clay content and gravel content above 35% were categorized as *clayey- skeletal* whereas pedons in footplain with less than 35% clay and gravel content more than 35% were grouped as *loamy-skeletal*. The pedons in plain and basin had clay fraction between 35-60% was categorized as *fine*. The pedons in footslope, foot plain and basin with pH between 5 and 7 falls under *non-acid* category. The pedons in the plain came under *calcareous* due to the presence of $CaCO_3$ content and produces strong effervescence with 1:1 HCl.

The pedons in footslope with Clay/CEC ratio of 0.24 to 0.4 falls under *semiactive* category. The pedon in plains with ratio of more than 0.6 falls under *superactive* category. The remaining pedons with the clay/CEC ratio between 0.4 and 0.6 were classified as *active*. The occurrence of the low CEC indicates the presence of the lower cation exchange bearing mineral like *kaolinite*.

Interpretative groupings

Land capability classification

The soils were grouped under land capability sub-classes of IVs and IVes. The soils of foot plains, plains and basin were classified under IVs sub-class had the limitations of texture, depth of the soil, sub-surface fragments percentage, Cation exchange capacity. These land areas can be put into cultivation with proper soil management practices. The soils of footslopes comes under IVes sub-class had limitation such as slope, severe erosion, shallow depth and low cation exchange capacity.

Land irrigability classification

Generally, the soils of the study area were grouped under the land irrigability subclass of 2s, 3s and 3st. However, the soils of foot plains and basin region were classified under 2s with moderate limitation. These soils had the gently sloping lands with the limitations of the coarse texture and had slight erosion. The soils on the plain classified as 3s sub-class with limitation of depth and sub-surface coarse fragments. The soils of footslope was classified under 3st sub-class, with the limitation of erosion, slope and presence of more sub-surface coarse materials.

Crop suitability

The soils were evaluated for its suitability for rice, sugarcane, sorghum, banana and coconut. The pedons in foot plain, plain and basin was marginally suitable for cultivation of rice. The pedons in footslope were not suitable due to severe limitation on the topographical features of slope, severe erosion, rainfall requirement and soil texture. The pedons in plain and basin were moderately suitable for cultivation of sugarcane. The pedons in foot slope and foot plain were not suitable for sugarcane cultivation due to limitation on irrigation requirement, slope, soil depth, more stoniness and low CEC.

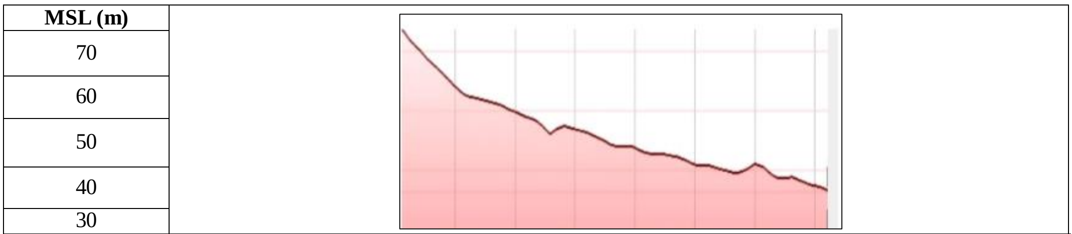
For the production of the banana, pedons in plain and basin were marginally suitable and the pedons located at foot slope, foot plain were not suitable for banana due to drawbacks such as surface coarse fragments and shallow soil depth. The pedons under footslope and foot plain were not suitable for coconut cultivation and the remaining pedons of plains and basin was marginally suitable having limitation on shallow soil depth and more than 35 percent coarse fragments.

The pedons in plain and basin areas were moderately suitable (S_2) for sorghum production and pedons of foot slope were marginally suitable and the pedons in foot plains were not suitable for sorghum due to limitation on soil fertility parameters such as low CEC, low organic carbon, shallow depth, more stoniness and coarse fragments.

Conclusion

The soils of Vallanadu were acidic to moderately alkaline, non-saline, low to medium in organic carbon, low CEC, low, medium, low to medium in available NPK respectively, deficient in DTPA-Zn and Cu, sufficient in DTPA-Mn and Fe and classified as *Typic Rhodustalf, Typic Haplustalf* and *Typic Haplustepts*. The soils of the footslopes (P1 and P2) were not suitable for cultivation of rice, sugarcane, banana, coconut and marginally suitable for sorghum cultivation with IVes, 3st sub-classes of suitability and irrigability. The soils of foot plains (P3 and P4) were classified as IVs, 2s sub-class are marginally suitable for cultivation of rice, sorghum, sugarcane, banana and coconut. The soils of plains (P5 and P6) were not suitable for cultivation with IVs and 3s sub-class of suitability and irrigability whereas pedons (P7 and P8) were moderately suitable for sugarcane, sorghum and marginally suitable for rice, banana and coconut with IVs suitability and 2s irrigability sub-class. The soils of basin (P9 and P10) were classified under IVs and 2s sub-class of land suitability and land irrigability are moderately suitable for sugarcane, sorghum and marginally suitable for rice, coconut and banana.

The soils near the foot slopes require proper soil and water conservation measures for the crop cultivation. The soils in the footplain region had low fertility and must reclaimed with nutrient supplement on regular basis. The cultivated soils of the plain and basin regions should be cultivated with appropriate agronomic and soil conservation practices to improve the soil productivity.



Depth (cm)	P1	P2	P3	P4	P6	P5	P7	P8	P9	P10
0–20	A_p	A_p	A_p	A_p	A_p	A_p	A_p	A_p	A_p	A_p
40–60	B_{t1}	B_{t1}	B_{t1}	B_{t1}	B_{t1}	B_{t1}	B_{w1}	B_{w1}	B_{t1}	B_{t1}
80	B_{t2}	B_{t2}	B_{t2}	B_{t2}	B_{t2}	B_{t2}	B_{w2}	B_{w2}	B_{t2}	B_{t2}
100							B_{w3}	B_{w3}	B_{t3}	B_{t3}
120–140	C_r	C_r	C_r	C_r	C_r	C_r	C_r	C_r	C_r	C_r

Fig 1: Landform with soil pedon in Vallanadu village

Table 1: Morphological Characteristics of the Vallanadu soils

Horizon	Depth (cm)	Boundary		Soil colour		Structure			Consistence				Roots			Pores		Effervescence
		D	T	Moist	Dry	G	S	T	Dry	Moist	Stk	Pls	Q	S	L	Q	Sz	
Pedon 1 - Clayey skeletal, kaolinitic, nonacid, semiactive, isomegathermic, Typic Rhodustalf (Foot slope)																		
A_p	0-26	C	s	5YR 5/8	5YR 5/4	2	m	sbk	sh	fr	ss	sp	c	f	t	c	f	-
B_{t1}	26-78	C	s	2.5YR 5/6	2.5YR 4/6	1	f	sbk	sh	fr	ms	mp	f	f	p	f	f	-
B_{t2}	78-117	C	w	2.5YR 5/6	2.5YR 4/6	1	f	sbk	sh	fr	ms	mp	f	f	p	f	f	-
C_r	>117	Weathered granitic gneiss																
Pedon 2 - Clayey skeletal, kaolinitic, nonacid, semiactive, isomegathermic, Typic Rhodustalf (Foot slope)																		
A_p	0-13	c	s	2.5YR 7/6	2.5YR 6/6	2	f	sbk	sh	fr	ss	sp	m	f	t	m	f	-
B_{t1}	13-75	c	w	2.5YR 5/8	2.5YR 4/8	1	f	sbk	sh	fr	ms	mp	f	f	p	f	f	-
B_{t2}	75-122	c	w	2.5YR 5/8	2.5YR 4/8	1	f	sbk	sh	fr	ms	mp	f	f	p	f	f	-
C_r	>122	Weathered granitic gneiss																
Pedon 3 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Foot plains)																		
A_p	0–3	c	s	2.5 YR 4/6	2.5YR 4/4	1	m	sbk	sh	fr	ss	sp	m	f	t	c	f	-
B_{t1}	3–11	c	s	2.5YR 4/6	2.5YR 4/4	1	m	sbk	sh	fr	ss	sp	m	f	t	f	f	-
B_{t2}	11-59	c	w	2.5YR 5/8	2.5YR 3/4	2	f	sbk	h	fi	ms	sp	f	f	p	f	f	-
C_r	>59	Weathered granitic gneiss																
Pedon 4 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Foot plains)																		
A_p	0–6	c	s	5YR 5/6	5YR 3/4	1	f	sbk	sh	fr	ss	sp	m	f	t	m	vf	-
Bt_1	6–20	c	s	5YR 5/8	5YR 4/6	2	f	sbk	sh	fr	ss	sp	c	f	t	f	vf	-
Bt_2	20–82	c	w	2.5YR 4/8	2.5YR 3/6	2	m	sbk	h	fi	ms	mp	f	f	p	f	vf	-
C_r	>82	Weathered granitic gneiss																
Pedon 5 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Plains)																		
A_p	0-10	c	s	2.5YR 5/6	2.5YR 4/4	1	m	sbk	sh	fri	ss	sp	c	f	t	c	f	-
Bt_1	10-57	c	w	2.5YR 5/6	2.5YR 3/4	2	f	sbk	h	fi	ms	mp	c	m	t	c	f	-
Bt_2	57-81	c	w	2.5YR 5/6	2.5YR 4/6	2	f	sbk	sh	fr	ms	mp	f	f	p	c	vf	-
C_r	>81	Weathered granitic gneiss																

Pedon 6 - Loamy skeletal, kaolinitic, nonacid, superactive, isomegathermic, Typic Rhodustalf (Plains)																	
Ap	0-26	c	s	5YR 5/8	5YR 4/4	1	f	sbk	s	vfr	ss	sp	m	f	t	f	f	-
Bt1	26-71	c	w	2.5YR 5/6	2.5YR4/6	2	f	sbk	sh	fr	ss	sp	c	f	p	f	vf	-
Bt2	71-84	c	w	2.5YR 5/6	2.5YR4/6	2	f	sbk	sh	fi	ms	mp	c	f	p	c	f	-
Cr	>84	Weathered granitic gneiss																
Pedon 7 - Fine, kaolinitic, calcareous, active, isomegathermic, Typic Haplustept (Plains)																	
Ap	0-27	c	s	7.5YR 5/4	7.5YR 4/3	3	m	sbk	h	vfi	ms	mp	f	f	t	m	m	Slight
Bw1	27-33	c	w	5YR 6/6	5YR 6/4	2	m	sbk	sh	fi	ss	sp	f	vf	p	f	f	Slight
Bw2	33-56	c	w	2.5YR 4/4	2.5YR 4/6	2	f	sbk	sh	fi	ms	mp	f	vf	p	f	m	Strong
Bw3	56-78	c	w	7.5YR 7/4	7.5YR 6/4	1	f	sbk	sh	fi	ms	mp	-			f	f	violent
Cr	>78	Weathered calcic gneiss																
Pedon 8 - Fine, kaolinitic, calcareous, active, isomegathermic, Typic Haplustept (Plains)																	
Ap	0-16	c	s	7.5YR 4/3	7.5YR 3/3	3	m	sbk	h	vfi	ms	mp	m	f	t	m	m	Strong
Bw1	16-31	c	s	7.5YR 5/6	7.5YR 4/6	3	m	sbk	h	vfi	ms	mp	c	f	p	m	m	Strong
Bw2	31-49	c	s	5YR 6/8	5YR 5/8	2	f	sbk	sh	fr	ms	mp	f	f	p	c	f	-
Bw3	49-74	c	w	10YR 7/6	10YR 5/6	1	f	sbk	sh	fr	ms	mp	f	f	p	c	f	-
Cr	>74	Weathered calcic gneiss																
Pedon 9 - Fine, kaolinitic, nonacid, active, isomegathermic, Typic Haplustalf (Basin)																	
Ap	0-22	c	s	5YR 5/8	5YR 4/6	3	c	sbk	sh	fr	ss	sp	m	m	t	m	m	-
Bt1	22-38	c	s	2.5YR 5/6	2.5YR 5/4	2	f	abk	h	fi	ms	mp	m	m	p	m	m	-
Bt2	38-63	c	s	2.5YR 4/6	2.5YR 3/6	2	f	abk	h	fi	ms	mp	f	f	p	f	f	Slight
Bt3	63-102	c	w	2.5YR 4/6	2.5YR 3/6	1	f	abk	h	fi	ms	mp	-			f	f	Slight
Cr	>102	Weathered granitic gneiss																
Pedon 10 - Fine, kaolinitic, nonacid, active, isomegathermic, Typic Haplustalf (Basin)																	
Ap	0-28	c	s	5YR 5/8	5YR 4/6	3	c	sbk	sh	fr	ss	sp	m	m	t	m	c	-
Bt1	28-76	c	s	2.5YR 5/6	2.5YR 5/4	2	f	abk	h	fi	ms	mp	c	m	p	c	f	-
Bt2	76-97	c	w	2.5YR 4/6	2.5YR 4/4	2	f	abk	h	fi	ms	mp	f	f	p	f	f	-
Bt3	97-133	c	w	2.5YR 4/6	2.5YR 4/4	1	vf	abk	h	fi	ms	mp	f	f	p	f	f	slight
Cr	>133	Weathered granitic gneiss																

Table 2: Particle Size distribution and nutrient content of the soils

Horizon	Depth (cm)	Gravel content (%)	Particle Size Distribution			Texture	B.D (Mg/m^3)	Moisture content (%)	OC (%)	Available nutrients (kg ha^{-1})			Available micronutrients (ppm)			
			Sand	Silt	Clay					N	P	K	Fe	Zn	Cu	Mn
Pedon 1 - Clayey skeletal, kaolinitic, nonacid, semiactive, isomegathermic, Typic Rhodustalf (Foot slope)																
Ap	0-26	55.6	63.47	6.9	29.63	scl	1.33	0.67	0.43	204.4	26.44	140	8.49	0.12	1.27	8.15
Bt1	26-78	55.8	56.81	7.82	35.33	sc	1.43	0.81	0.35	145.6	20	110	6.12	0.09	0.93	6.94
Bt2	78-117	60.9	51.67	11.05	37.28	sc	1.43	0.95	0.24	78.4	18.62	70	5.74	0.06	0.7	6.28
Pedon 2 - Clayey skeletal, kaolinitic, nonacid, semiactive, isomegathermic, Typic Rhodustalf (Foot slope)																
Ap	0-13	46.3	60.25	7.28	32.47	scl	1.43	0.76	0.43	162.4	24.6	250	6.21	0.15	0.83	7.7
Bt1	13-75	55.1	53.63	9.84	36.53	sc	1.43	0.92	0.32	128.8	20.92	120	4.97	0.09	0.58	6.27
Bt2	75-122	67.4	49.92	11.21	38.37	sc	1.54	1.14	0.26	92.4	19.54	100	3.28	0.06	0.39	5.84
Pedon 3 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Foot plains)																
Ap	0–3	23.5	64.16	24.96	10.88	sl	1.33	0.68	0.61	232.4	31.96	180	23.25	0.26	1.1	6.98
Bt1	3–11	28.4	53.84	17.60	28.56	scl	1.33	0.98	0.38	114.8	24.14	150	12.64	0.15	0.71	6.12
Bt2	11-59	42.6	52.70	10.90	36.40	sc	1.43	0.98	0.26	98	20.46	110	8.97	0.12	0.58	4.91
Pedon 4 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Foot plains)																
Ap	0–6	24.8	70.54	16.29	13.17	sl	1.33	0.83	0.56	128.8	33.34	210	21.72	0.33	1.3	7.38
Bt1	6–20	27.4	58.81	20.14	21.05	scl	1.54	0.92	0.32	89.6	25.06	160	8.56	0.24	0.66	6.54
Bt2	20–82	41.7	53.89	15.07	31.04	scl	1.54	1.48	0.29	70	20.92	130	6.79	0.18	0.6	4.47
Pedon 5 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Plains)																
Ap	0-10	29.8	67.30	22.77	9.93	sl	1.33	0.89	0.59	142.8	14.32	270	9.41	0.22	1.24	5.57
Bt1	10-57	32.1	66.06	15.99	17.95	sl	1.43	0.91	0.4	47.6	14.16	120	6.32	0.18	0.87	4.65
Bt2	57-81	47.5	60.85	17.20	21.95	scl	1.43	2.16	0.29	28	12.46	80	5.77	0.13	0.69	4.12
Pedon 6 - Loamy skeletal, kaolinitic, nonacid, superactive, isomegathermic, Typic Rhodustalf (Plains)																
Ap	0-26	20.8	61.75	9.14	29.11	scl	1.33	3.2	0.43	165.2	29.04	220	26.87	1.08	2.31	6.65
Bt1	26-71	16.1	54.32	10.63	35.05	sc	1.43	3.86	0.4	123.2	22.84	170	14.95	0.76	1.74	5.83
Bt2	71-84	24.5	48.69	13.74	37.57	sc	1.43	3.97	0.32	92.4	21.29	110	11.24	0.55	1.1	4.98
Pedon 7 - Fine, kaolinitic, calcareous, active, isomegathermic, Typic Haplustept (Plains)																
Ap	0-27	29.4	62.15	16.22	21.63	scl	1.25	3.86	0.61	184.8	31.06	320	18.53	0.82	1.97	6.38
Bw1	27-33	32.1	58.89	14.38	26.73	sc	1.43	4.01	0.53	117.6	29.04	210	8.32	0.65	0.92	5.87
Bw2	33-56	53.5	51.68	11.88	36.44	sc	1.54	4.32	0.19	72.8	24.7	180	8.05	0.49	0.41	5.25
Bw3	56-78	58.2	48.93	11.39	39.68	sc	1.54	4.85	0.08	39.2	20.36	120	4.07	0.37	0.21	4.76
Pedon 8 - Fine, kaolinitic, calcareous, active, isomegathermic, Typic Haplustept (Plains)																
Ap	0-16	18.2	65.7	14.1	20.2	scl	1.33	2.91	0.72	182	28.73	370	19.96	1.4	2.46	5.39
Bw1	16-31	20.5	61.8	13.8	24.4	scl	1.43	3.06	0.56	148.4	22.32	150	8.13	0.83	1.28	4.46
Bw2	31-49	27.4	50.6	13.5	35.9	sc	1.54	3.24	0.4	98	19.43	130	3.64	0.61	0.37	3.95
Bw3	49-74	61.1	46.7	12.2	41.1	sc	1.54	3.87	0.16	42	18.19	110	3.14	0.47	0.18	3.27
Pedon 9 - Fine, kaolinitic, nonacid, active, isomegathermic, Typic Haplustalf (Basin)																
Ap	0-22	22.5	66.53	12.59	20.88	scl	1.25	1.18	0.77	148.4	20.98	140	12.92	0.82	2.83	4.67
Bt1	22-38	18.47	59.47	15.31	25.22	scl	1.33	1.64	0.7	89.6	18.19	110	7.84	0.71	1.64	3.8

B_{t2}	38-63	9.7	52.69	11.16	36.15	sc	1.33	1.93	0.53	81.2	16.64	90	7.25	0.58	0.9	3.12
B_{t3}	63-102	62.4	47.35	13.22	39.43	sc	1.43	2.15	0.46	53.2	12.3	80	5.73	0.36	0.69	2.79
Pedon 10 - Fine, kaolinitic, nonacid, active, isomegathermic, Typic Haplustalf (Basin)																
Ap	0-28	17.5	66.2	12.85	20.95	scl	1.25	1.32	0.96	159.6	27.34	180	11.5	1.03	1.65	4.42
B_{t1}	28-76	19.8	62.63	12.61	24.76	scl	1.33	1.59	0.88	100.8	26.1	150	5.59	0.78	0.58	3.89
B_{t2}	76-97	24.1	56.49	8.39	35.12	sc	1.43	1.88	0.64	86.8	22.22	120	4.66	0.52	0.42	3.36
B_{t3}	97-133	63.4	50.6	9.72	39.67	sc	1.43	2.04	0.43	64.4	20.98	100	3.9	0.49	0.24	2.95

Table 3: Exchange properties of Vallanadu soils

Horizon	Depth (cm)	CEC (C mol p^+ kg^{-1})	Exchangeable cations (C mol p^+ kg^{-1})				BSP	ESP	$CaCO_3$ (%)	pH	EC (dSm^{-1})
			Ca^{++}	Mg^{++}	Na^+	K^+					
Pedon 1 - Clayey skeletal, kaolinitic, nonacid, semiactive, isomegathermic, Typic Rhodustalf (Foot slope)											
A_p	0-26	5.8	3.44	1.18	0.04	0.05	81.21	0.85	0.5	5.85	0.01
B_{t1}	26-78	6.5	3.92	1.3	0.09	0.08	82.92	1.67	0.65	6.42	0.01
B_{t2}	78-117	6.8	4.14	1.44	0.09	0.08	84.56	1.57	0.7	6.49	0.01
Pedon 2 - Clayey skeletal, kaolinitic, nonacid, semiactive, isomegathermic, Typic Rhodustalf (Foot slope)											
A_p	0-13	5.9	2.98	1.48	0.04	0.18	79.32	0.85	0.55	6.4	0.07
B_{t1}	13-75	7.4	3.92	2.02	0.09	0.21	84.32	1.44	0.7	5.8	0.03
B_{t2}	75-122	8.9	4.86	2.54	0.13	0.21	86.97	1.68	1	5.5	0.03
Pedon 3 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Foot plains)											
A_p	0–3	4.5	2.46	0.94	0.04	0.1	78.67	1.13	0.8	5.4	0.06
B_{t1}	3–11	5.7	3.22	1.36	0.09	0.13	84.21	1.88	0.95	5.6	0.03
B_{t2}	11-59	6.8	3.74	1.85	0.13	0.18	86.76	2.20	1.05	6.3	0.02
Pedon 4 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Foot plains)											
A_p	0–6	4.8	2.32	1.38	0.04	0.08	79.58	1.05	0.95	6.1	0.03
B_{t1}	6–20	6.5	3.36	1.94	0.09	0.1	84.46	1.64	1.05	6.1	0.03
B_{t2}	20–82	7.3	3.72	2.12	0.13	0.13	83.56	2.13	1.1	6.1	0.02
Pedon 5 - Loamy skeletal, kaolinitic, nonacid, active, isomegathermic, Typic Rhodustalf (Plains)											
A_p	0-10	7.9	4.68	1.56	0.04	0.07	80.38	0.63	7.6	6.5	0.12
B_{t1}	10-57	8.2	4.9	1.66	0.09	0.07	81.95	1.34	12.5	6.8	0.19
B_{t2}	57-81	8.8	5.36	1.72	0.13	0.1	83.07	1.78	15.5	7.7	0.38
Pedon 6 - Loamy skeletal, kaolinitic, nonacid, superactive, isomegathermic, Typic Rhodustalf (Plains)											
A_p	0-26	8.7	3.88	1.78	0.09	0.26	69.08	1.50	0.7	5.8	0.03
B_{t1}	26-71	9	4.34	2.06	0.09	0.26	75.00	1.33	0.8	6	0.04
B_{t2}	71-84	9.8	4.7	2.32	0.13	0.31	76.12	1.74	1.05	6.5	0.04
Pedon 7 - Fine, kaolinitic, calcareous, active, isomegathermic, Typic Haplustept (Plains)											
A_p	0-27	12.8	7.68	2.72	0.13	0.1	83.05	1.22	1.6	7.57	0.15
B_{w1}	27-33	14.1	8.74	2.86	0.13	0.1	83.90	1.10	2.1	8.14	0.17
B_{w2}	33-56	15.2	9.24	3.3	0.17	0.13	84.47	1.32	3.7	8.25	0.17
B_{w3}	56-78	16	9.8	3.64	0.17	0.13	85.88	1.24	5.5	8.6	0.11
Pedon 8 - Fine, kaolinitic, calcareous, active, isomegathermic, Typic Haplustept (Plains)											
A_p	0-16	10.9	6.64	2.4	0.09	0.03	84.04	0.98	2.4	8	0.11
B_{w1}	16-31	11.3	6.98	2.64	0.13	0.03	86.55	1.33	3.6	7.94	0.17
B_{w2}	31-49	11.9	7.3	2.86	0.13	0.05	86.89	1.26	1.05	7.89	0.2
B_{w3}	49-74	12.5	7.62	3.12	0.17	0.05	87.68	1.55	1.15	7.63	0.21
Pedon 9 - Fine, kaolinitic, nonacid, active, isomegathermic, Typic Haplustalf (Basin)											
A_p	0-22	10.4	5.68	2.02	0.35	0.08	78.17	4.31	0.65	5.79	0.11
B_{t1}	22-38	11.7	6.78	2.46	0.35	0.1	82.82	3.61	0.9	6.61	0.19
B_{t2}	38-63	12.4	7.32	2.74	0.43	0.13	85.65	4.05	1.4	6.92	1.27
B_{t3}	63-102	12.8	7.64	2.9	0.52	0.13	87.42	4.65	2	7.3	0.4
Pedon 10 - Fine, kaolinitic, nonacid, active, isomegathermic, Typic Haplustalf (Basin)											
A_p	0-28	9.8	5.34	2.24	0.35	0.1	81.94	4.36	0.5	7.31	0.38
B_{t1}	28-76	10.9	6.06	2.6	0.43	0.1	84.31	4.68	0.7	7.34	0.77
B_{t2}	76-97	12	6.72	2.95	0.48	0.13	85.67	4.67	0.85	7.35	1.31
B_{t3}	97-133	12.7	7.2	3.28	0.52	0.13	87.64	4.67	1.2	7.39	0.63

Table 4: Interpretative groupings of the Vallanadu soils

Pedon	LCC	LIC	Crop Suitability				
			Rice	Sugarcane	Banana	Coconut	Sorghum
P1	IV_{es}	3st	N	N	N	N	S 3
P2	IV_{es}	3st	S 3	S 3	N	S 3	S 3
P3	IV_s	2s	S 3	N	N	N	N
P4	IV_s	2s	S 3	S 3	S 3	S 3	S 3
P5	IV_s	3s	N	N	N	N	N
P6	IV_s	3s	N	N	N	N	N
P7	IV_s	2s	S 3	S 2	S 3	S 3	S 2
P8	IV_s	2s	S 3	S 3	S 3	S 3	S 2
P9	IV_s	2s	S 3	S 2	S 3	S 3	S 2
P10	IV_s	2s	S 3	S 3	S 3	S 3	S 3

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