Article AR2094 DOI: HTTPS://DOI.ORG/10.23910/1.2020.2094

International Journal of Bio-resource and Stress Management

Crossref

June 2020

Print ISSN 0976-3988
Online ISSN 0976-4038

IJBSM 2020, 11(3):232-239

Research Article *Natural Resource Management*

Mapping and Classification of upland soils Formed from Peninsular Gneiss in Rasipuram Block, Namakkal District of Tamil Nadu

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Citation: Balasubramanian et al., 2020. Mapping and Classification of upland soils Formed from Peninsular Gneiss in Rasipuram Block, Namakkal District of Tamil Nadu. International Journal of Bio-resource and Stress Management 2020, 11(3), 232-239. HTTPS://DOI.ORG/10.23910/1.2020.2094.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

Abstract

A detailed soil survey was carried out in Rasipuram block of Namakkal district, Tamil Nadu, India consists of 24 villages spread over 10614 hectares. Based on variation in physiography and landform, eight soil series and 30 soil mapping units were identified. Eight typifying pedons were analysed for physical and physico-chemical properties and thus used for soil mapping at 1:10000 scale. Soils are shallow to very deep, well drained to somewhat poorly drained, light to dark reddish colour at moist condition, light (sandy loam) to heavy (clay) texture. The pH, EC, organic carbon and cation exchange capacity ranged from 7.4 to 9.4, 0.05 to 0.60 dS m^{-1}, 0.2 to 0.7%, 0.11 to 0.60% and 10 to 45 c mol (p^+) kg^{-1}, respectively. The detailed classification of the soils from study area was *Inceptisols* and *Alfisols* soil order. The land capability classification grouping study in the study area indicates that marginally cultivable soils (IVs) covered 7.05% area was affected with severe limitations of erosion, whereas extent of moderate limitations of slight erosion and calcareousness (IIIc) was 77.34%. The erosion and calcareousness land covering 65.6% (IIIs) of the area were moderately suitable for sustained use under irrigation, provided proper soil and water conservation measures to be adopted.

Keywords: Characterization, classification, upland soils, Rasipuram, Tamil Nadu

1. Introduction

A proper land management is essential to sustainable crop production and maintenance of environment quality. Agricultural intensification and massive infrastructure development enhances the risk of soil erosion and fertility depletion (Singh et al., 2007). As a source for production system, it serves as a store house of water and nutrients and provide environment required for plants and living organisms. For sustainable development and higher production, regional approach in agricultural development planning have not received the due attention in the past and therefore, the location specific needs of various regions remain neglected (Kadrekar, 1993). Soils are considered as the integral part of the landscape and their characteristics are largely governed by landforms on which they are developed (Ram et al., 2010). The modern agriculture requires precise information on various agroclimatic parameters like soil types, rainfall,

Article History

RECEIVED in 16th April 2020 RECEIVED in revised form 29th May 2020 ACCEPTED in final form 30th May 2020

temperature, water resources etc. (Ghosh, 1991; Hallmark et al., 2006). The properties of a soil are basic attributes that influence directly the soil response to any specific use. The usefulness of a soil, however, is not solely due to its inherent qualities but the qualities which affect its capacity to respond to the inputs and management for a specific use or a combination of uses (Ram et al., 2010).

Land resources, particularly soil and water, are limited in extent; the efficient and sustainable utilization is imperative, particularly when the population pressure is increasing alarmingly (Patil et al., 2010). For optimum utilization of available land resources on the sustainable basis, timely and reliable information on soil regarding their nature, extent and spatial distribution along with their potentials and limitations is important (Shalima Devi and Anil Kumar, 2008). To adopt good management practices and remedical measures for various soils, a systematic study of the soils is highly essential. Soil resource inventory through characterization of the resources provides an insight into the potentials and limitations of soils (Manchanda et al., 2002; Vasundhara et al., 2017). The information generated through soil resource inventory is generally interpreted for various grouping of soils for land capability, land irrigability and suitability of soils for different crops through evaluation procedure which helps the administrator managers of agriculture and related developmental activities (Balasubramanian et al., 2019).

The concept of using the land for suitable utilization lies within the land use planning process (Bauer, 1973; Vasundhara et al., 2017), which aims at optimizing the use of land while sustaining its potential by avoiding resource degradation. It has been recognized that the land assessment and its reliability for land use decisions depend largely on the quality of soil information (FAO, 1976; Salehi et al., 2003; Meena et al., 2015). Out of 13 mha geographical area in state of Tamil Nadu, nearly 80% of the area soils from Granite gneiss parent material. Hence, to determine the potential of soils for growing field, forage and tree crops in upland soils of Tamil Nadu for sustainable basis. To enhance or at least maintain the present level of productivity, management of land resources on scientific principles, soil resource inventory provides the needed information on their potential and limitations relative to optimum utilization through characterization and evaluation of land resources. Soil resources inventory requires a good understanding of the properties and processes of different soils (Walia and Rao 1996) in a given area of mapping (Prabhavati et al., 2017). In this connection, detailed soil survey at 1:10000 scale, farm level information is very useful tools to soil and crop management and enhance the productivity. Keeping this in view, the present study was attempted in Rasipuram block of Namakkal district, Tamil Nadu.

2. Materials and Methods

2.1. Details of the study area

Rasipuram block lies between 11°23' and 11°32' north latitude and 78°15' and 78°71' east longitude with an area of 10613 ha. The general elevation of the area ranges from 205 to 927 m above mean sea level (MSL) (Figure 1). The block is drained by gullies and small streams into tanks. All the streams and tanks are seasonal and dependent on rainfall. The climate of area is hot moist and semiarid with mean annual rainfall of 804.4 mm. Mean annual temperature of 31.3°c and PET of 181.4 mm. The geology of the study area is archean complex with patches of Dharwars on Granite gneiss rock. Major

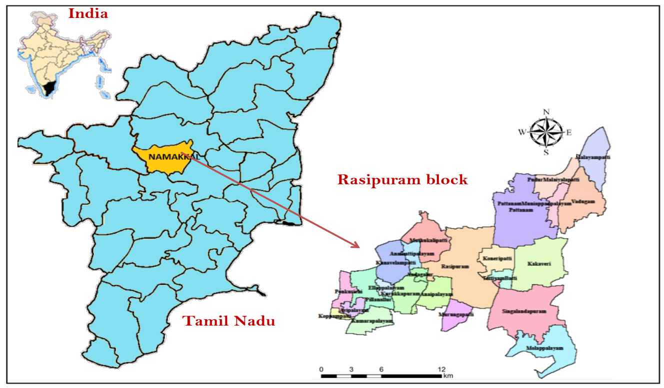

Figure 1: Location map of the study area

land use of the areas are tapioca, maize, paddy, arecanut, turmeric, tomato in irrigated and sorghum and groundnut are in rainfed system.

2.2. Soil Survey and laboratory methods

A detailed soil survey was conducted during 2015-2016 and 8 soil series were established in different landforms using village cadastral maps (1:3000 to 1:8000 scales). Pedon sites were located in transects along the slope from the upper to lower slopes. Soils were characterized for morphological, physical and chemical properties and individual pedons were described as per Soil Survey Division staff (1991) and soil map prepared with eight soil series and 30 soil mapping units (Figure 2). The area qualifies for ustic soil moisture regimes and isohyperthermic soil temperature regimes. Soils were classified upto family level as per guidelines given in USDA soil taxonomy (Soil survey staff, 2014). Horizon wise profile samples and mapping unit wise surface samples were collected, air dried and sieved through 2 mm sieve (0.2) mm sieve for organic carbon, labeled and stored, analysed for particle size distribution following international pipette method and chemical properties like pH, EC, OC, CEC, exchangeable cations, ESP and BS were determined by adopting standard methods (Jackson, 1973).

2.3. Generation of soil and LCC maps

Database on soil and LCC were generated in Microsoft Excel package and theme maps generated by using Arc-GIS software version 10.1.

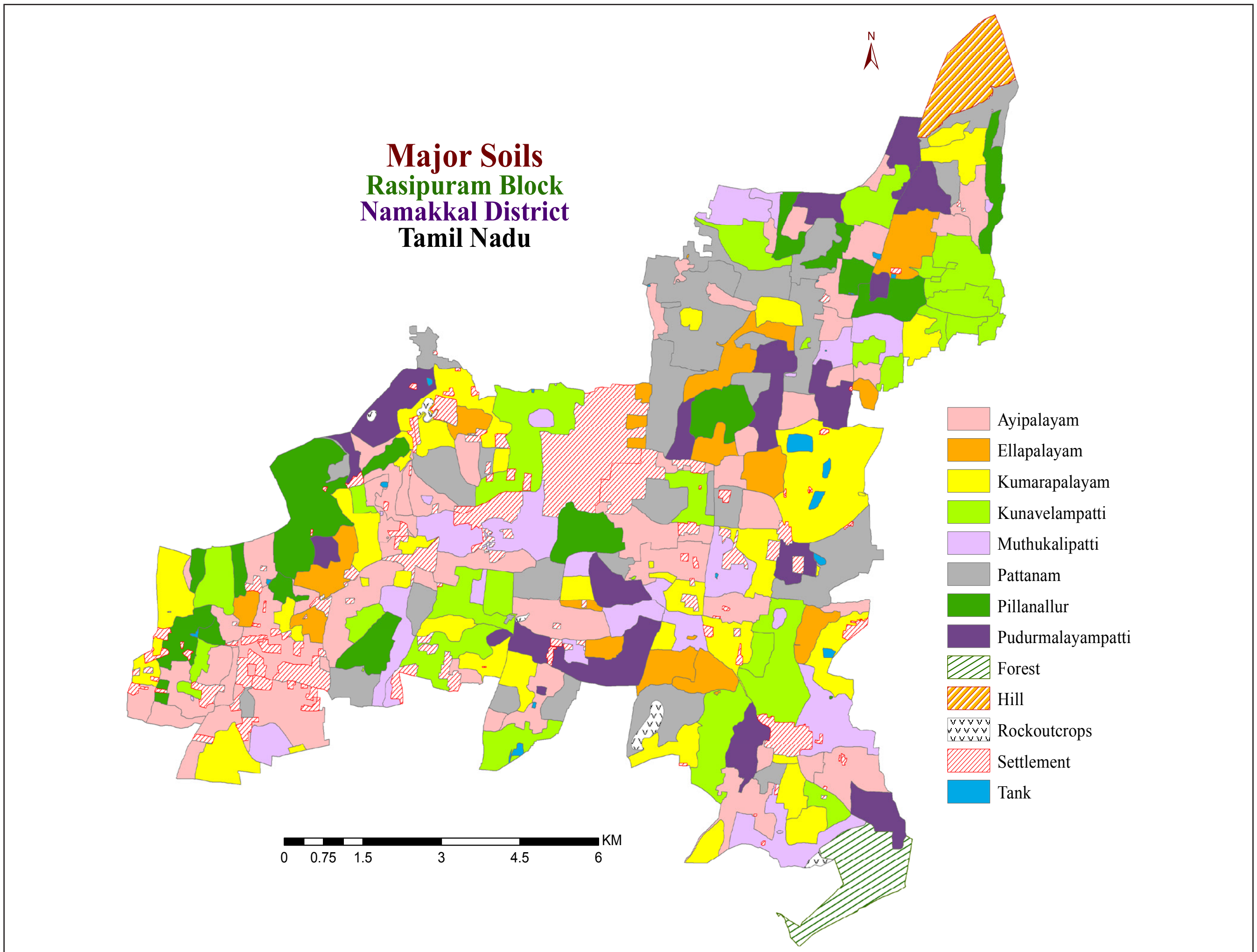

Figure 2: Soil map of the study area

3. Results and Discussion

3.1. Morphological Properties

Site and morphological characteristics of soils are given in Table 1. Soil depths is varied from moderately shallow (<50 cm) (P2 and P5) to deep (>100 cm) (P4, P6 and P7) while others are moderately deep (50-100 cm). The moist colour of surface soil horizons varied from dark yellowish brown (10YR4/4) to dark red (2.5YR3/6) in different pedons, whereas subsurface soils are very dark grayish brown (10YR3/2) to dark yellowish brown (10YR3/2) in P3 and P6. Others are 7.5 YR to 5 YR and 2.5 YR hue, 3 to 4 in value and 2 to 6 in chroma respectively. The variation of soil colours are attributed due to nature and type of soil forming processes, which has also been earlier reported by Mohekar and Chella (2000). This difference in color may be attributed to the organic matter, high clay content, presence of sufficient iron and manganese compounds and their hydration (Diwakar and Singh, 1992). The soil texture varied from sandy loam to clay. In all the pedons soil structure was observed moderate medium sub angular in surface horizons and strong coarse subangular blocky in sub surface horizons. Pedon 2, 3, 6 and 7 gave mild to very strong effervescence due to presence of lime concretions (parent material plagioclase feldspars, calcium and magnesium carbonate). Similar observations have also been reported by Kaushal et al. (1986). The gravel content was found increasing with depth which varied from upland soils. Whereas, in other pedons, irregular distribution of gravel content with depth was observed. In all the pedons, iron concretions were observed in subsurface horizons at varying depths. Presence of clay film observed in pedon 8 is attributed due to the process of illuviation. Similar observations were also made by Ram et al. (2014) and Vasundhara et al. (2017).

3.2. Physical characteristics

Physical and physico-chemical characteristics of the soils are presented in Table 2 and Table 3. The sand content ranged from 33 to 80% with mean value of 53.19%, silt content ranged from 15 to 45% with a mean value of 11.5%. The sand content was higher in surface horizons of P1, P2, P4 and P5, whereas higher clay content was found in the sub-surface horizon because of the illuviation of fine fractions from the

Table 1: Site and morphological characteristics of the soils

Horizon	Depth	Colour	Texture	Structure	Effervescence	Root distribution
Pedon 1. Fine loamy, mixed, calcareous, isohyperthermic, Typic Haplustepts						
Ap	0-23	7.5YR 3/4	Scl	m2sbk	Nil	Mf
Bw1	23-56	2.5 YR 3/6	Scl	m2sbk	Nil	Cf
Bw2	56-80	2.5 YR 3/6	C	m2sbk	Nil	Fvf
Pedon 2. Fine loamy, mixed, calcareous, isohyperthermic, Lithic Haplustepts						
Ap	0-23	7.5 YR 3/2	Scl	m2 sbk	Profuse	Ff
Bw1	23-41	5 YR 4/4	Scl	m2sbk	Profuse	Ff
Pedon 3. Komarapalayam– Fine,mixed,calcareous, isohyperthermic, Typic Haplustepts						
Ap	0-14	10 YR 3/4	Cl	m2sbk	Profuse	Ff
Bw1	14-36	10 YR 3/3	Cl	m2sbk	Profuse	Ff
Bw2	36-53	10YR 3/2	Cl	m2sbk	Profuse	Ff
Pedon 4. Loamy over clayey, mixed, isohyperthermic, Fluventic Haplustepts						
Ap	0-22	10 YR 3/4	Scl	m2 sbk	Nil	Mf
Bw1	23-40	5 YR 3/4	Sc	m2sbk	Nil	Cf
Bw2	40-55	5 YR 4/4	Scl	m2 sbk	Nil	Ff
Bw3	55-67	5 YR 4/4	Cl	m2sbk	Nil	Ff
BC1	67-83	5 YR 4/4	Sl	m1 sbk	Nil	Ff
BC2	83-107	5 YR 4/4	Cl	m2sbk	Nil	Ff
BC3	107-134	5YR 4/4	C	m2 sbk	Nil	Ff
BC4	134-153	5YR 5/3	Sl	m1sbk	Nil	Ff
Pedon 5. Fine loamy, mixed, isohypothermic, Lithic Haplustepts						
Ap	0-24	10 YR 4/4	Sl	M1 sbk	Nil	Ff
Bw1	24-43	5YR 3/4	Scl	m2sbk	Nil	Ff
Pedon 6. Fine loamy mixed, calcareous, isohypothermic, Vertic Haplustepts						
Ap	0-16	10 YR 3/2	Sc	m2 sbk	Profuse	Ff
Bw1	16-30	10 Y R 3/3	Sc	m2sbk	Profuse	Ff
Bw2	30-52	10 YR3/4	Sc	m2sbk	Profuse	Ff
Bw3	52-103	10 YR3/2	C	m2sbk	Profuse	Ff
Pedon 7. Fine mixed, calcareous, isohypothermic, Typic Haplustepts						
Ap	0-28	10 YR 3/4	Sc	m3 sbk	Profuse	Ff
Bw1	28-41	10 YR 3/3	Cl	m2sbk	Profuse	Ff
Bw2	41-54	7.5YR 4/4	Cl	m2sbk	Profuse	Ff
Bw3	54-83	5 YR 4/6	Cl	m2sbk	Profuse	Ff
Bw4	83-117	2.5YR 4/8	GSc	m2sbk	Profuse	Ff
Pedon 8. Fine mixed, isohypothermic, Typic Rhodustalfs						
Ap	0-23	2.5 YR 3/6	Scl	m2 sbk	Nc	Ff
Bt1	23-62	2.5 YR 3/6	Sc	m2sbk	Nc	Ff

surface layers in P8. The increase in clay content in Bt horizons of all the soils could be attributed to vertical migration or translocation of clay (Srinivasan et al., 2013). Sand content in soils of low lands of upper slopes was higher and decreased with increasing depth. The silt content in all the pedons have irregular trend with the depth.

Table 2: Physical and physico-chemical characteristics of the soils

Horizons	Depth (cm)	Sand (%)	Clay (%)	Silt (%)	pH (1:2.5) H_2O	EC dS m^{-1}	OC (%)	Exchangeable CEC	Ca	Mg	Na	K	ESP (%)	BS (%)
								cmpol (p+) kg^{-1}						
Pedon 1. Fine loamy, mixed, calcareous, isohyperthermic, Typic Haplustepts														
Ap	0-23	60	32	8	8.3	0.1	0.4	18	10.0	3.0	2.0	0.5	11.1	86.1
Bw1	23-56	58	35	7	8.4	0.1	0.3	20	12.0	4.0	1.8	0.3	9.1	90.5
Bw2	56-80	42	45	15	8.1	0.1	0.3	28	20.0	3.0	3.4	0.2	12.1	95.0
Pedon 2. Fine loamy, mixed, calcareous, isohyperthermic, Lithic Haplustepts														
Ap	0-23	60	28	8	8.5	0.10	0.7	16	10.0	1.8	1.4	0.1	8.8	83.1
Bw1	23-41	58	35	10	8.5	0.20	0.3	18	10.0	4.0	1.9	0.1	10.6	88.9
Pedon 3. Fine mixed, calcareous, isohyperthermic, Typic Haplustepts														
Ap	0-14	47	38	15	8.7	0.05	0.3	38	22.0	6.0	6.6	0.5	17.4	92.4
Bw1	14-36	50	35	15	8.7	0.07	0.2	40	21.0	7.0	7.1	0.3	17.8	88.5
Bw2	36-53	47	40	13	8.6	0.05	0.2	37	21.0	6.0	6.9	0.2	18.6	92.2
Pedon 4. Loamy over clayey, mixed, isohyperthermic, Fluventic Haplustepts														
Ap	0-22	65	27	8	8.4	0.1	0.5	15	9.0	2.0	1.5	0.3	10.0	85.3
Bw1	23-40	58	40	12	8.4	0.1	0.4	22	12.6	4.0	2.5	0.2	11.4	87.8
Bw2	40-55	62	30	8	8.1	0.6	0.5	18	10.0	3.0	1.5	0.2	8.4	81.7
Bw3	55-67	45	40	15	8.4	0.1	0.4	23	15.0	3.0	3.0	0.1	13.1	91.7
BC1	67-83	80	15	5	8.5	0.1	0.3	12	7.0	1.0	1.0	0.1	8.3	75.8
BC2	83-107	45	40	15	8.2	0.1	0.2	22	13.0	3.5	3.1	0.1	14.1	89.5
BC3	107-134	40	45	15	8.3	0.1	0.2	28	19.0	2.8	4.0	0.1	10.0	92.5
BC4	134-153	80	15	5	8.5	0.1	0.3	10	5.8	1.2	0.8	0.2	8.0	80.0
Pedon 5. Fine, loamy mixed, isohypothermic Lithic Haplustepts														
Ap	0-24	75	20	5	8.6	0.1	0.57	15	8.5	1.8	1.6	0.5	10.2	79.4
Bw1	24-43	59	33	8	8.6	0.1	0.35	25	15.0	4.0	3.1	0.2	12.1	87.1
Pedon 6. Fine loamy, mixed, isohypothermic, Typic Haplustepts														
Ap	0-16	45	40	15	8.4	0.1	0.70	25	15.0	4.0	3.9	0.1	15.6	92.0
Bw1	16-30	49	38	13	9.0	0.1	0.60	35	18.0	7.0	6.9	0.2	19.7	91.7
Bw2	30-52	33	42	15	9.2	0.1	0.40	40	23.0	6.0	7.4	0.2	18.5	91.5
Bw3	52-103	47	43	10	9.4	0.1	0.40	45	27.0	4.0	9.5	0.2	21.1	90.5
Pedon 7. Fine mixed, calcareous, isohypothermic, Typic Haplustepts														
Ap	0-28	40	45	15	8.5	0.1	0.3	25	14	4.0	4.5	0.1	18.0	90.4
Bw1	28-41	47	38	15	8.9	0.1	0.3	29	17	4.0	5.2	0.2	17.9	91.4
Bw2	41-54	45	40	15	8.2	0.4	0.2	23	14	3.0	3.3	0.2	14.3	89.1
Bw3	54-83	45	40	15	9.0	0.1	0.3	35	20	5.0	6.2	0.1	17.7	89.4
Bw4	83-117	50	38	12	8.9	0.1	0.2	32	17	6.0	4.5	0.1	14.1	86.3
Pedon 8. Fine mixed, isohypothermic, Typic Rhodustalfs														
Ap	0-23	62	28	10	7.4	0.3	0.3	15	9.0	3.0	1.1	0.2	7.0	84.2
Bt1	23-62	42	43	15	7.5	0.1	0.2	23	14.0	2.6	3.2	0.2	13.9	86.9

Table 3: Range and mean value of Soil properties

Ranges	Sand (%)	Clay (%)	Silt (%)	pH	EC (dsm^{-1})	OC (%)	CEC	Exch-cations (cmol (p+) kg^{-1})				ESP (%)	BS (%)
								Ca	Mg	Na	K		
Min	33	15	5	7.4	0.05	0.2	10	5.8	1	0.8	0.1	7	75
Max	80	45	15	9.4	0.60	0.7	45	27	7	9.5	0.5	21.1	95
Mean	53.19	35.09	11.5	8.4	0.14	0.36	25.3	14.8	3.7	3.8	0.21	13.4	87

3.3. Physico-chemical characteristics

The pH of soils ranged from 7.4 to 9.4 with a mean of 8.4 and electrical conductivity ranged 0.05 to 0.6 with mean average of 0.14 dSm^{-1}. Organic carbon content varied from 0.2 to 0.7% with a mean value of 0.36%. The enrichment of OC content in surface (0-25 cm) soils are high could be plant dry matter and root biomass accumulation. Low OC content indicated poor nutrient management and high removal of crops (Srinivasan et al., 2017). Cation exchange capacity of typifying pedons ranged from 10 to 45cmol (p^+) kg^{-1} with an average value of 25.3 cmol (p^+) kg^{-1}. The CEC increased with increase in clay content of the pedons. Higher values of CEC in sub surface horizons commensurate with the amount of clay. The CEC increased with depth in the pedons of P1, P2, P6, and P7 due to increase in clay content of lower horizons. The CEC decreased with depth in the pedons of P4, and P8 due to variation in clay and organic matter content (Mishra and Ghosh, 1995). The exchangeable bases had distinct pattern regarding their sequential dominance. In all the pedons, the order followed was Ca> Na > Mg >K. Among the cations $Ca^{2+}$was dominant. The variation observed in base saturation (BS) indicates the degree of leaching which was used as diagnostic character for classifying the soil orders. High base saturation was due to high Ca^{2+} followed by Mg^{2+}, Na^{2+}, K^+ (Patil and Dasog, 1997). Exchangeable sodium percentage (ESP) varied from 7 to 21.1%, maximum from P3, P6 and P7 soils, values are above 15%. Similar result was also reported by Balasubramanian et al. (2019).

3.4. Soil classification

The detailed classification of the soils from study area was presented in Table 4. Based on morphological, physical, physico-chemical and mineralogical meteorological data, the soils in the study area of were classified as *Inceptisols* and *Alfisols*. Whereas Pedon 2 and 5 have any mixed cambic diagnostic horizion and presence of lithic contact within 50 cm of the mineral soil surface horizon were classified as *Lithic Haplustepts*. Presence of argillic horizon and base saturation of more than 50% in all the sub-surface layers, Hue of 2.5 YR or redder and value, moist, of 3 or less and dry value no more than 1 unit higher than the moist value were classified as *Typic Rhodustalfs* (P8). Other soils series also falling under *Inceptisols* which presence of cambic (Bw) diagnostic horizon.

3.5. Land Capability classification

The land capability classification grouping study in the study area indicates that moderately good cultivated soils (IIIc) covered 77.34% area was affected with moderate limitations of erosion, where as extent of marginally limitations (IVs) by severe soil erosion and calcareousness was 7.05%. Steep land and fairly good land occupied 0.5% in the block. The land capability classes and LCC sub classes are shown in Table 5 and Figure 3.

Table 4: Classification of the major soils in the study area

Pedon	Soil Series	Taxonomic Classification	ha	TGA %
P1	Ayipalayam	Fine loamy, mixed, calcareous, isohyperthermic, Typic Haplustepts	562.2	5.29
P2	Ellapalayam	Fine loamy, mixed, calcareous, isohyperthermic, Lithic Haplustepts	1210.7	11.41
P3	Komarapalayam	Fine, mixed, calcareous, isohyperthermic, Typic Haplustepts	2329.4	21.95
P4	Kunavelampatti	Loamy over clayey, mixed, isohyperthermic, Fluventic Haplustepts	1255.1	11.82
P5	Muthukalipatti	Fine, loamy mixed, isohypothermic Lithic Haplustepts	747.5	7.04
P6	Pattanam	Fine loamy, mixed, isohypothermic, Typic Haplustepts	586.5	5.52
P7	Pillanallur	Fine mixed, calcareous, isohypothermic, Typic Haplustepts	1061.5	10.01
P8	Pudurmalayampatti	Fine mixed, isohypothermic, Typic Rhodustalfs	1204.0	11.35
		Total	8956.9	84.39

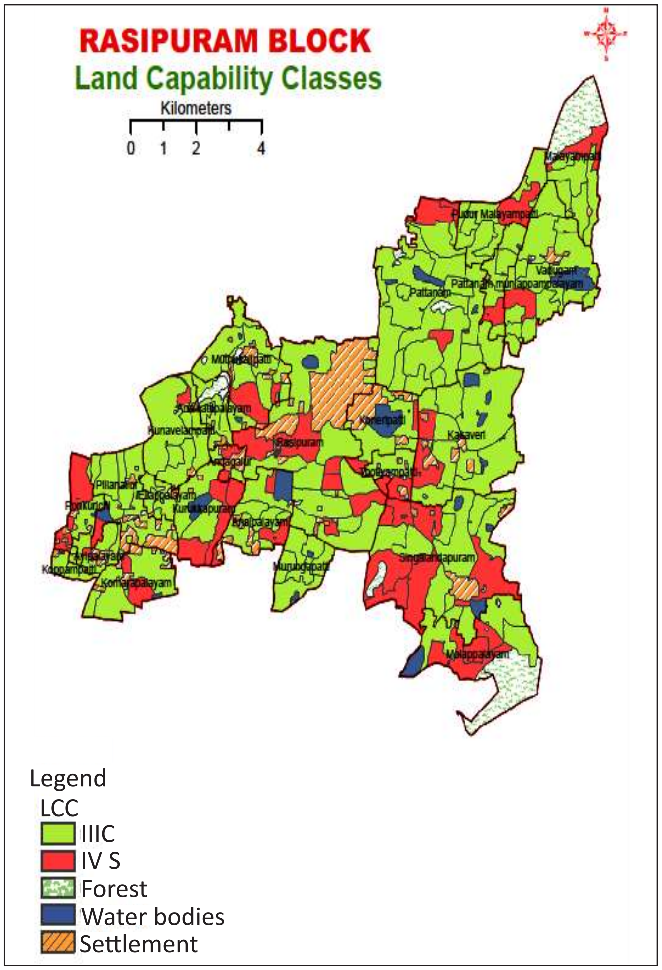

Figure 3: Land Capability classification map of study area

Table 5: Land Capability sub Classes in study area

Land capability subclass	Mapping Unit	Area	
		ha	%
IIIc	AysclA1, AyscA1, AyclA1, AygscA1,EpslA1, EpsclA1, EpcA1, EpscA1, KoslA1, KosclA1, KoclA1, KoscA1, KogscA1 KocA1 KvsclA1, KvscA1, KvcA1, PislA1, PisclA1, PiscA1, PrsclA1, PrscA1, PrcA1, PtscA1, PtcA1.	8209.4	77.34
IVs	MkslA1, MksclA1, MkscA1.	747.5	7.05
	Total	8956.9	84.39

4. Conclusion

Based on morphological, physical and physico-chemical properties of study area were neutral to moderately alkaline, non-saline, low to medium in OC and CEC. The exchangeable bases in all the pedons in the order of Ca^{2+}>Na^{+}>Mg^{2+}> K^{+} on the exchange complex. The soils were classified as *Typic Haplustepts, Lithic Haplustepts, Fluventic Haplustepts, Vertic Haplustepts* and *Typic Rhodustalfs* at sub group level. Based on the variable soil properties land capability and irrigability classes were prepared which are key for sustainable soil and crop management in upland of Tamil Nadu.

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