Original Research Article

INFLUENCE OF PARENT MATERIAL AND LAND USE TYPES ON SOIL PROPERTIES OF TAMIL NADU

ABSTRACT

A Study was conducted to study the impact of parent materials and land use on soil physical and chemical properties in soils of Tamil Nadu. The aim of this study is to evaluate the impact of parent materials and land use systems on soil properties. 15 parent materials(Lime, Marl shell, Sandstone with clay interaction, Granite (Gr2), Fuchsite quartzite, Fissile hornblende biotite gneiss, Limestone and Calcareous Shale, Sand/Clay admixture, Teri sand, Sand (Medium), Sand (Grey Brown Medium), Amphibolite, Gabbro, Hornblende biotite gneiss, Chamockite and Sandy Clay) and their respective major land use were selected for the study. In each landuse type per parent material, six composite soil samples were collected from the representative location within the land use types at 0 - 30 cm soil depth and all soil samples were generated for laboratory analysis. Results showed that among the parent materials, Sandy clay had the highest silt + clay fractions, Sandy/Clay admixture had the higher organic carbon content and Fissile hornblende biotite gneiss have higher exchangeable Calcium whereas Granite (Gr2) had the higher exchangeable Magnesium. The Cation exchange capacity (CEC) was significantly highest in Limestone and Calcareous shale whereas the base saturation was significantly higher in Granite (Gr2) in the study area. This shows that land use and parent material highly influence the soil properties. The application of more organic and less inorganic fertilizers will alter the Soil properties of the study area.

Keywords: *Parent material; Land use; Soil physical and chemical properties; Tamil Nadu*

1. INTRODUCION

Soils are considered as the "Earth's Critical Zone" which is defined as the surface layer from treetop to the underlying bedrock enrolled in life-sustaining life ecosystem and services. Globally, a number of poor agricultural management practices have caused decline in soil fertility and detoriated the environment making it vital to secure sustainable agricultural production systems. Despite, it is expected that the world still grapples with food production on a sustainable manner due to rising sea levels, climatic change, soil and land degradation and rapid shrinking of agricultural lands amidst the projected population increase by 2050 and 2100 respectively (Camponi *et al*.,2023).

There are serious doubts about the sustainability of soil formation and the provision of soil ecosystem services due to human pressures such as population growth, land use change, and intensifying human involvement. Therefore, understanding the lifecycle of soil formation to soil degradation is crucial to formulate strategies for restoration, sustainable landuse practices and protection of soil functions (Feiznia *et al*.,2007). Further studies on the influence of parent material and land use change on the soil properties is vital for environmental management to ensure sustainable use of land.

The ability of the soil to perform ecosystem function depends on the integrated actions of different soil properties called soil quality indicators. Simple qualities or properties of the soil that can be assessed to evaluate soil physio – chemical properties in relation to a particular function are known as soil quality indices or indicators (Parsley *et al.,* 2008).

Parent material is one of the important passive factors of soil forming process upon which soil development depends. Parent materials would result in differential weathering products based on different elemental composition which influence the physico – chemical and morphological properties under same agro – ecological conditions (Akpan*et al*., 2018). The number of cations and sesquioxides contained in the parent materials, which have an impact on the soil structure, nutrient status, and soil pH, control the rooting depth. Many researchers have reported that various land use such as agricultural land, crop land, plantation, continuous cultivation, fallow land, grazing, deforestation as well as parent materials can cause depletion or addition of nutrients to the soil and eventually, inflation or reduction in output (Deng *et al*., 2015). It is well known that turning forest into agriculture degrades the soil's physical qualities and makes the area more prone to erosion because macroaggregates are disrupted. Further, climate change, parent material and wide land use types have diverse impacts on the soil attributes. While other land use strategies enrich the soil with nutrients, some frequently cause the loss of soil nutrients.

2. MATERIALS AND METHODS

2.1. STUDY AREA

The study was conducted in Tamil Nadu state which extends from8°4'N to 13°35'N latitudes and from 76°18'E to 80°20'E longitudes (Fig 1.). The most common parent materials in Tamil Nadu are clay, hornblende, quartzite, limestonerespectively. Tamil Nadu gets an average annual rainfall of 96 cm.The most common land uses followed in the state are Agricultural and horticultural crop land, agricultural and horticultural plantation, Fallow lands, water bodies. In addition, the crop lands are diversified with variety of crops like food crops, cash crops, plantation crops etc.

Fifteen Parent materials and land use types were selected for the study. In each land use type per parent material, composite soil samples were collected from the representative location in 0-30cm soil depth. Undisturbed soil samples were selectively collected for saturated hydraulic conductivity and bulk density determinations.

2.3. LABORATORY ANALYSIS

The soil samples were air-dried, sieved through a 2 mm size-sieve, and the following analyses were performed in accordance with the necessary standard protocols. Soil pH was determined using pH meter in a ratio of 1:2.5 soils and water. Soil Electrical Conductivity (EC) was determined using EC meter. The measurement of organic carbon followed Nelson and Sommer’s recommendations. As explained by Udo *et al*., the Bray-1 method was used to assess the amount of available phosphorus. Exchangeablecations were extracted using 1 M NH4 OAC (pH 7.0), and Ca and Mg concentrations were assessed using the EDTA titration method and K and Na concentrations using a flame photometer. Base saturation was estimated as the portion of the total ECEC that Ca, Mg, K, and Na occupied and Exchangeable Sodium Percentage (ESP) was derived using standard formula. The cation exchange capacity (CEC) was obtained by the summation of exchangeable bases (Ca^{2+},Mg^{2+},K^{+},Na^{+}).

3. RESULTS AND DISCUSSION

The major parent material occupied larger area and the major land use followed in the soil formed from the particular parent material was enlisted in the Table 1 and Fig 2 (both the table and Fig are below). The series under which the soil formed from the respective parent material was also given. According to the table, it was evident that Lime, Marl Shell occupied larger area followed by Sandstone with clay interaction, Granite, Fuchsite quartzite, Schistose quartzite, Sillimani, Fissile hornblende biotite gneiss, Limestone and calcareous shale, Sand/Clay admixture, Teri sand, Sand (Medium), Sand (Grey Brown Medium), Amphibolite, Gabbro, Hornblende biotite gneiss whereas least area occupied by Chamockite and Sandy Clay.

The influence of parent material and land use on soil physical properties is presented in Table 2. There were textural variations among all parent materials taken under consideration. The mean sand fraction was significantly higher in Fuchsite quartzite, Schistose quartzite, Sillimani (87.8%) followed by chamocklite (79.7%) which was in on par with Teri Sand (79.7%) and Sand (Grey Brown Medium) (79.7%) followed by Amphibolite (76.5%) and Lime Marl Shell (68.7%) which was on par with Fissile Hornblende Biotite gneiss (68.7%) and Limestone and Calcareous Shale (68.7%) respectively (Huot*et al*.,2015). The mean Silt fraction was significantly higher in Sandstone with Clay intercalation (25%) which was on par with Sand/ Clay admixture followed by Sandy Clay (16.5%).The mean Clay fraction was significantly higher in Gabbro(38.3%) which was on par with Sandy clay(38.3%).The higher clay and silt fractions in Sandy Clay parent material could be attributed to more binding effect due to higher organic matter content.

The influence of parent material and land use on soil chemical properties is presented in Table 3. The pH of the soil was acidic in Sandstone with clay interaction, Fuchsite quartzite, Schistose quartzite, Sillimani and Sand/Clay admixture and neutral in Granite (Gr2), Amphibolite and Gabbro and basic pH is prominent in Sand (Grey Brown Medium), Limestone and Calcareous Shale, Teri sand, Fissile hornblende and Lime, Marl Shell. The EC of all combinations lies in the range between 0 – 0.3. The organic carbon content was higher in Sandy/Clay admixture and Sandstone with clay interaction. The available phosphorous content was significantly higher in Sandy clay followed by Amphibolite.

The available potassium was significantly higher in Sandy clay and gabbro and further exchangeable bases like exchangeable Ca was higher in Fissile hornblende biotite gneiss and Limestone calcareous shale and exchangeable Mg was higher in Granite (Gr2) and exchangeable potassium was in higher concentrations in Amphibolite whereas Lime, Marl Shell, Fissile hornblende biotite gneiss and Limestone and calcareous shale had higher concentrations of exchangeable Sodium. The cation exchange capacity of the soil was eventually higher in parent materials such as Lime, Marl Shell, Fissile hornblende biotite gneiss and limestone and calcareous shale respectively. The total exchangeable sites occupied by basic cations were significantly higher in Granite (Gr2) followed by Sandy clay.

CONCLUSION

The study revealed that among the parent materials and land use combinations, Sandy clay parent material had the highest silt + clay fractions and most of the soil had the textural variations within sandy clay, Sandy loam and Sandyclayloam respectively. Sandy/Clay admixture had the highest organic carbon content followed by Sandstone. The available phosphorous and potassium was significantly higher in Sandy clay followed amphibolites and gabbro (Wilson *et al*., 2019). The combination of parent material and land use types indicated that the major parent material under the given major land use had the highest water and nutrient holding capacity, high rooting volume, good aeration status, higher exchange sites, more available nutrients for plant uptake, less erosion threats, more biological activity, etc., followed by other parent materials in the study area. The results also revealed that the soil physical and chemical properties were influenced by appropriate land use types and parent materials respectively in the study area.

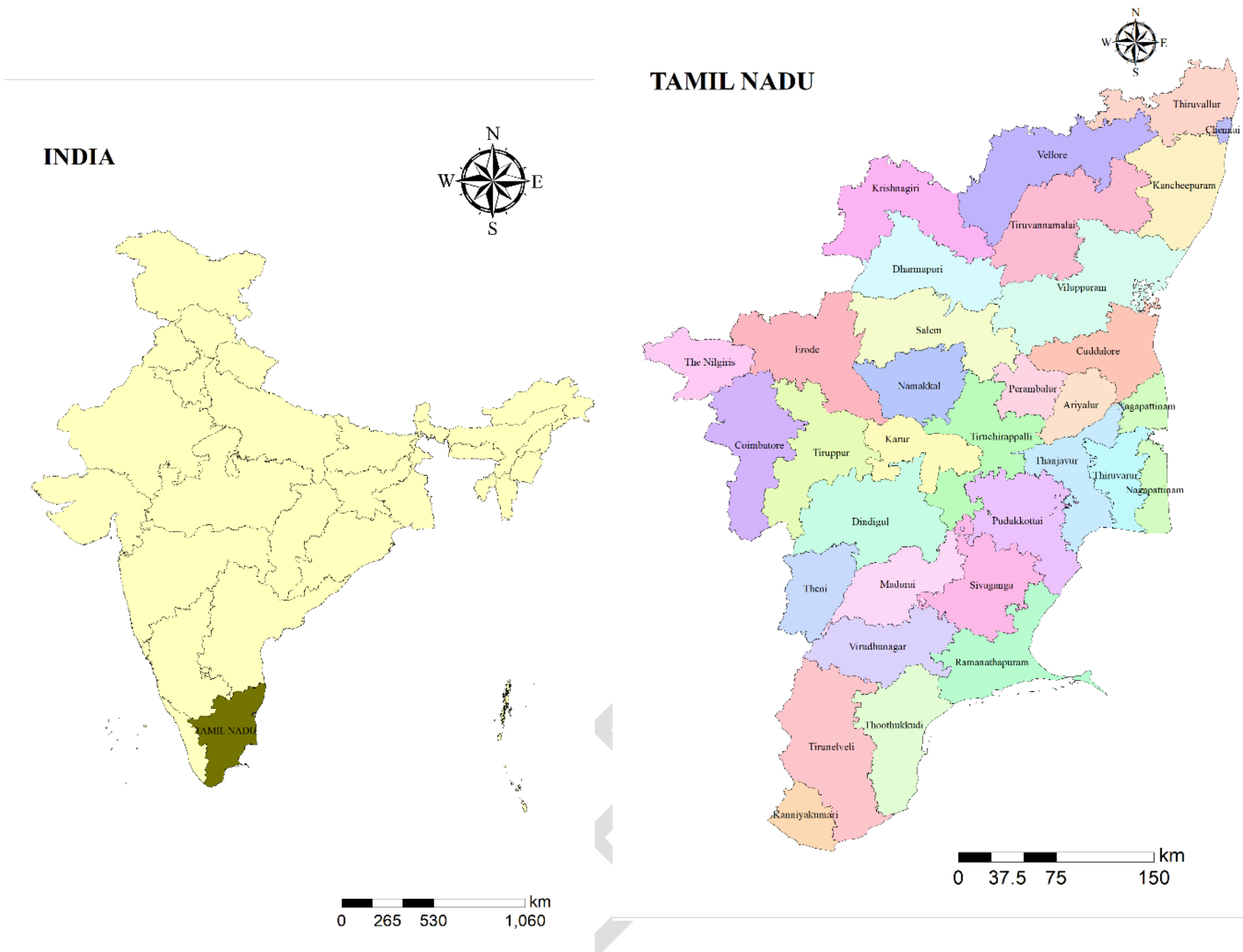

Figure1. Study Area for Parent material and land use influence on soil properties

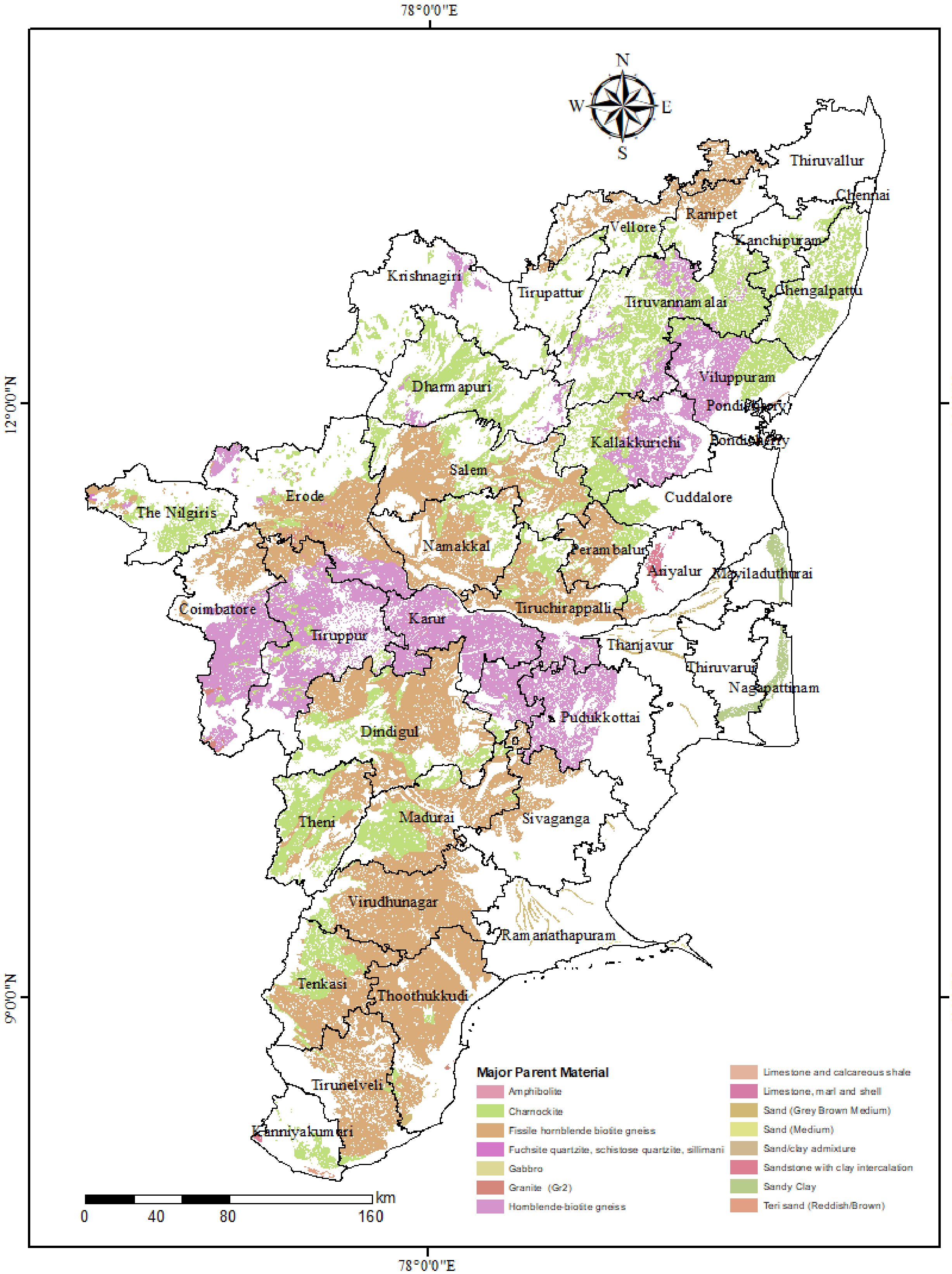

Figure 2. Distribution of major parent material in Tamil Nadu

Table 1. Major Parent material and Land use Combinations

S. No.	Parent Material	Land Use	Area (in Ha.)	Series
1	Sand/Clay admixture	Agricultural Plantation	1447306297.40	Kombuthuki
2	Sandstone with Clay intercalation	Agricultural Plantation	1447306297.00	Kombuthuki
3	Teri Sand	Agricultural Plantation	696086309.32	Peravurani
4	Sand -Grey Brown Medium	Agricultural Land -2 Crop Area	696086309.32	Peravurani
5	Chamockite	Agricultural Land-More than 2 Crop Area	696086309.32	Peravurani
6	Granite -Gr2	Agricultural Land-Current Fallow	487839594.79	Thengampudur
7	Gabbro	Agricultural Land-Zaid Crop	269947918.14	Ambasamudram
8	Lime, Marl Shell	Agricultural Plantation	266041423.34	Kallivalasu
9	Fissile Hornblende Biotite gneiss	Agricultural Land-Current Fallow	266041423.34	Kallivalasu
10	Limestone and Calcareous Shale	Agricultural Plantation	266041423.34	Kallivalasu
11	Sand - Medium	Agricultural Plantation	185166835.04	Habitation
12	Hornblende Biotite gneiss	Agricultural Land-More than 2 Crop Area	185166835.04	Habitation
13	Fuchsite quartzite, Schistose quartzite, Sillimani	Agricultural Plantation	106429175.82	Puvattihalli
14	Amphibolite	Agricultural Land-2 Crop Area	93824480.47	Chokkanpatti
15	Sandy clay	Agricultural Land-Rabi Crop	36451945.73	Nalladevanpatti

Table 2. Influence of parent material and land use on physical properties

S. No.	Parent Material	Land Use	Sand (%)	Silt (%)	Clay (%)	Texture	Bulk Density
1	Sand/Clay admixture	Agricultural Plantation	54.50	25.00	20.50	Loam	1.43
2	Sandstone with Clay intercalation	Agricultural Plantation	54.50	25.00	20.50	Loam	1.43
3	Teri Sand	Agricultural Plantation	79.72	9.78	10.50	Sandyloam	1.58
4	SAND -Grey Brown Medium	Agricultural Land-2 Crop Area	79.72	9.78	10.50	Sandyloam	1.58
5	Chamockite	Agricultural Land-More than 2 Crop Area	79.72	9.78	10.50	Sandyloam	1.58
6	Granite - Gr2	Agricultural Land-Current Fallow	65.66	7.45	26.89	Sandyclayloam	1.41
7	Gabbro	Agricultural Land-Zaid Crop	52.90	8.80	38.30	Sandyclay	1.34
8	Lime, Marl Shell	Agricultural Plantation	68.78	11.53	19.69	Sandyclayloam	1.46
9	Fissile Hornblende Biotite gneiss	Agricultural Land-Current Fallow	68.78	11.53	19.69	Sandyclayloam	1.46
10	Limestone and Calcareous Shale	Agricultural Plantation	68.78	11.53	19.69	Sandyclayloam	1.46
11	Sand –Medium	Agricultural Plantation	0.00	0.00	0.00	-	0.00
12	Hornblende Biotite gneiss	Agricultural Land-More than 2 Crop Area	0.00	0.00	0.00	-	0.00
13	Fuchsite quartzite, Schistose quartzite, Sillimani	Agricultural Plantation	87.75	2.05	10.20	Loamysand	1.60
14	Amphibolite	Agricultural Land-2 Crop Area	76.54	13.24	10.22	Loamysand	1.58
15	Sandy clay	Agricultural Land-Rabi Crop	45.26	16.48	38.26	Sandyclay	1.32

Table 3. Influence of parent material and land use on Soil chemical properties

S. No.	Parent Material	Land Use	pH	EC	OC (%)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Ex.Ca (cmol/ kg)	Ex. Mg (cmol/ kg)	Ex.Na (cmol/ kg)	Ex.K (cmol/ kg)	CEC (meq/ 100g)	Base Saturation(%)	ESP(%)
1	Sandy clay	Agricultural Plantation	7.00	0.14	0.34	10.20	342.00	4.00	5.50	0.48	0.10	10.40	96.92	4.62
2	Amphibolite	Agricultural Plantation	7.10	0.06	0.23	10.00	86.00	2.49	2.18	0.22	0.84	9.80	58.47	2.24
3	Fuchsite quartzite, Schistose quartzite, Sillimani	Agricultural Plantation	6.30	0.02	0.26	7.24	92.40	2.24	1.80	0.05	0.11	5.25	80.00	0.95
4	Sand – Medium	Agricultural Land-2 Crop Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Hornblende Biotite gneiss	Agricultural Land-More than 2 Crop Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Lime, Marl Shell	Agricultural Land- Current Fallow	8.20	0.30	0.48	0.80	242.00	17.85	9.69	0.66	0.30	29.70	95.96	2.22
7	Fissile Hornblende Biotite gneiss	Agricultural Land-Zaid Crop	8.20	0.30	0.48	0.80	242.00	17.85	9.69	0.66	0.30	29.70	95.96	2.22
8	Limestone and Calcareous Shale	Agricultural Plantation	8.20	0.30	0.48	0.80	242.00	17.85	9.69	0.66	0.30	29.70	95.96	2.22
9	Gabbro	Agricultural Land- Current Fallow	6.90	0.10	0.42	4.80	308.00	7.50	6.00	0.25	0.25	15.50	90.32	1.61
10	Granite - Gr2	Agricultural Plantation	7.10	0.20	0.33	5.12	105.70	6.60	17.00	0.12	0.41	11.60	208.02	1.03
11	Teri Sand	Agricultural	8.10	0.30	0.67	6.22	82.70	1.62	0.52	0.26	0.15	4.22	60.45	6.18

		Plantation											
12	SAND - Grey Brown Medium	Agricultural Land-More than 2 Crop Area	8.10	0.30	0.67	6.22	82.70	1.62	0.52	0.26	0.15	4.22	60.45	6.18
13	Chamockite	Agricultural Plantation	8.10	0.30	0.67	6.22	82.70	1.62	0.52	0.26	0.15	4.22	60.45	6.18
14	Sandstone with Clay intercalation	Agricultural Land-2 Crop Area	6.00	0.01	0.79	4.00	40.00	6.40	1.20	0.34	0.06	19.20	41.67	1.77
15	Sand/Clay admixture	Agricultural Land-Rabi Crop	6.00	0.01	0.79	4.00	40.00	6.40	1.20	0.34	0.06	19.20	41.67	1.77

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