Agropedology 2010, 20 (1), 01-06

Land resource data and its evaluation for village level land use planning

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Abstract : Detailed soil survey (1:5000 scale) of Kutturavupatti village (537ha) in Sivagangai district of Tamil Nadu was conducted during 2005-06 to delineate the area for agricultural suitability. Four soil series, namely, Sivagangai, Melapoongudi, Tamarakki and Keelapoongudi were identified. The soils of Sivagangai series had more than 70% gravel content whereas more than 10% free $CaCO_3$ and high pH (8.3) were recorded in soils of Tamarakki. The productivity of majority of soils was good (35.0-56.0) for field crops, average to good (23.2-45.9) for forage crops and extremely poor to average (1.23-24.9) for tree crops based on 0-100 scale. These soils are grouped under class III land capability class, A and B soil irrigability classes and 2 and 3 land irrigability classes.

Additional key words : *Detailed soil survey, soil characteristics, taxonomic classification, land evaluation*

Introduction

Ever increasing population has created pressure on land resources. The concept of using the land for suitable utilization lies within the land use planning process (Bauer 1973), 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; Bogaert and D' Or 2002; Salehi *et al.* 2003). In this connection, detailed soil survey and Geographical Information System (GIS) are very useful tools to get quality information for land evaluation. Keeping this in view, the present study was attempted.

Materials and Methods

The study area (537 ha) lies between $78^0 25'$ and $78^0 30'$ E longitude and $9^0 55'$ and $10^0 00'$ N latitude in Kutturavupatti village of Sivagangai district, Tamil Nadu. The geology of the area comprises mainly of gneiss in the uplands and calcic gneiss in lowlands. The area receives a mean annual rainfall of 1012 mm and the soil moisture regime is ustic. The mean air temperature ranged from 20^0C to 38^0C and the soil temperature regime is isohyperthermic. The base map, (cadastral map) on 1:5000 scale was interpreted for different geomorphic units. Representative pedons for each unit were exposed and studied for morphological properties and mapped at phase level. Horizon-wise soil samples were collected from each pedon, air-dried, ground in wooden plank and roller, passed through a 2 mm sieve and analyzed for various parameters. Particle-size was determined by International Pipette Method. Soil pH and EC were measured in 1:2 soil water suspension using glass electrode pH meter and conductivity bridge. Organic carbon was determined by rapid titration method (Walkely and Black 1934). The free calcium carbonate in soil and cation exchange capacity were determined by standard methods. The soils were classified as per USDA Soil Taxonomy (Soil Survey Staff 1998). The final soil map was prepared under GIS environment. Thematic maps were prepared by exporting digitized soil map from cartalinx to mapinfo software. Data base on soil properties were developed and updated with map unit symbols using Microsoft excel package.

The actual and potential productivity of the soils for field, forage and forest trees was computed based on the method outlined by Riquier *et al.* (1970). Eight selected soil characteristics *viz.*, moisture (H), drainage (D), effective soil depth (P), base saturation (N), texture (T), organic matter content (O) , amount of mineral reserves (M), and cation exchange capacity (A) were considered for determining productivity index. Each of these characteristics pertaining to a particular pedon was rated on a scale of 0 to 100 for agriculture and forestry. The productivity index was worked out as follows:

Productivity index =
(H/100)*(D/100)*(P/100)*(T/100)*(N/100)*(O/100)*(A/100) *(M/100)*100.

Potential productivity (P') was calculated after a careful consideration of all the possible improvement measures. The ratio of potential productivity to actual productivity determined the co-efficient of improvement (CI).

Land capability classification (LCC), soil and land irrigability classification were carried as per guidelines of Klingebiel and Montgomery (1961) and AIS&LUS (1970), respectively.

Results and Discussion

Soil characterization

Four soil series, namely, Sivagangai (P1), Melapoongudi (P2), Tamarakki (P3) and Keelapoongudi (P4) are tentatively identified in the study area. The morphological characteristics of soils are given in table 1. The moist colour of surface horizons of P2 and P3 varied from yellowish brown (7.5YR4/3) to dark brown (10YR4/2) whereas it was dark reddish (2.5YR3/6) in P1 and P4. The texture of the soils varied from loamy sand to clay. The structure of the soils were moderate medium subangular blocky in surface horizons and strong coarse subangular blocky in sub-surface horizons. The gravel content increased with depth and varied from 3.5% in P3 to 70.2 % in P1 whereas, in other pedons, irregular distribution of gravel content with depth was observed. Gravel content was found in form of quartz fragments and calcretes.

The slope ranged from 0-1% in P2 and P3 and 1-3% in P1and P4. The drainage was somewhat poor (P3), well drained (P1, P4) and moderately well drained (P2). Erosion intensity ranged from very slight (P2, P3), slight (P4) to moderate (P1).

Physical and chemical characteristics of the soils are given in table 2. Clay content ranged from 6.50% in P2 to 46.1% in P4. In P1 and P3, clay content increased with increasing depth due to illuviation of clay and its accumulation in the sub-soil. Silt content ranged from 3.50% in P3 to 18.11 % in P4. The content of sand ranged from 37.8% in P4 to 83.0 % in P2. The silt and sand distribution pattern in all the profiles were found to be irregular. Bulk density of the soils varied from 1.11 Mgm^{-3} in P1 to 1.33Mgm^{-3} in P2. Progressive increase of bulk density with depth was probably related to increase in coarse fraction or coarse fragments of soils (Walia and Rao 1996).

Organic carbon content varied from 0.11% in P2 to 0.60% in P3 and decreased with depth. The pH ranged from 6.5 in P4 to 8.3 in P3. Higher values of pH with increasing depth are attributed to leaching of exchangeable bases from surface horizons. Cation exchange capacity (CEC) was low (8.79 c mol (p+) kg^{-1}) in P2 to high (41.5 c mol (p+) kg^{-1}) in P3. Higher value of CEC may be due to dominance of 2:1 type clay minerals. Base saturation percentage (BSP) was high (>75%) in all the profiles due to presence of Ca and Mg in exchangeable complex.

Table 1. Morphological characteristics of soils

Horizon	Depth (cm)	Colour	Texture	Structure	Gravel (%)
P 1 (Sivagangai series) : Clayey skeletal, mixed, isohyperthermic Rhodic Paleustalfs					
Ap	0-15	2.5 YR3/6	scl	c2sbk	10.2
Bt1	15-46	2.5 YR3/6	sc	c2sbk	15.5
2Bt2	46-72	2.5 YR3/4	sc (g)	c3sbk	35.4
2Bt3	72-97	2.5 YR3/4	sc (g)	c3sbk	50.8
2Bt4	97-130	2.5 YR4/3	sc (g)	c3sbk	60.1
2Bt5	130-150	2.5 YR3/4	sc (g)	c3sbk	70.2
P 2 (Melapoongudi series) : Fine, mixed, isohyperthermic Typic Haplustepts					
Ap	0-20	7.5YR 4/3	sc	c2sbk	4.2
Bw1	20-45	7.5YR 4/6	sc	c2sbk	10.5
Bw2	45-71	7.5YR 4/4	sc	c2sbk	5.5
2Bw3	71-108	7.5YR 4/4	scl	c2sbk	4.8
3Bw4	108-131	7.5YR 4/3	ls	c2sbk	16.2
3Bw5	131-152	7.5YR 4/4	ls	m2sbk	15.2
P 3 (Tamarakki series) : Fine, mixed , isohyperthermic Typic Haplustepts					
Ap	0-15	10YR4/2	sc	m2sbk	3.5
Bw1	15-34	10YR4/2	sc	c2sbk	5.8
Bw2	34-62	10YR4/3	sc	c2sbk	10.8
Bw3	62-81	10YR4/3	sc	c2sbk	11.2
Bw4	81-92	10YR4/4	sc (g)	c2sbk	12.7
Bw5	92-120	10YR4/4	sc (g)	c2sbk	22.1
Bk	120-150	10YR4/4	c	c2sbk	25.2
P 4 (Keelpoongudi series) : Fine, mixed , isohyperthermic Rhodic Paleustalfs					
Ap	0-22	2.5 YR3/6	sc	c2sbk	10.4
Bt1	22-60	2.5 YR3/6	c	c2sbk	7.2
Bt2	60-97	2.5 YR3/4	c	c2sbk	10.4
Bt3	97-133	2.5 YR3/4	sc (g)	c2sbk	14.7
Bt4	133-145	2.5 YR4/4	sc (g)	c2sbk	18.8

Taxonomic classification

Based on the morphological, physical and chemical properties, these soils were grouped into two orders *viz.,* Alfisols and Inceptisols (table 1). P1 and P4 were classified as Alfisols due to presence of argillic horizon with the base saturation >35%. These pedons were classified as Ustalf suborder due to the ustic moisture regime. These profiles were classified under Rhodic Paleustalf subgroup due to argillic horizons, hue of 2.5YR and value of 3 at moist condition. P2 and P3 were classified as Inceptisols owing to presence of cambic sub-surface horizon and suborder Ustepts. Pedons P2 and P3 were classified under Haplustepts greatgroup due to absence of duripan, presence of free $CaCO_3$ within 200 cm of the mineral soil surface and base saturation of more than 60% in all horizons. Alfisols and Inceptisols occupied 89% and 11% of the study area, respectively.

Land Evaluation

Actual productivity (P) and potential productivity

Table 2. Physical and chemical properties of soils

Depth (cm)	Sand	Silt	Clay	BD Mgm^{-3}	OC (%)	pH (1:2 water)	Free $CaCO_3$ (%)	CEC c mol (p+) kg^{-1}	Base saturation (%)
	------------- (%) -------------								
P 1 (Sivagangai series) : Rhodic Paleustalfs									
0-15	63.9	11.0	25.05	1.25	0.59	7.7	3.57	12.9	84.6
15-46	60.2	4.61	35.02	1.25	0.25	7.8	3.77	13.9	85.2
46-72	52.0	8.04	39.50	1.17	0.19	7.8	3.72	20.7	94.2
72-97	51.7	7.30	40.50	1.25	0.19	7.8	4.01	20.9	90.8
97-130	52.8	6.01	41.08	1.14	0.16	7.9	3.86	21.0	83.2
130-150	49.7	6.02	44.04	1.33	0.14	7.9	3.96	21.0	85.5
P 2 (Melapoongudi series) : Typic Haplustepts									
0-20	55.0	9.90	35.0	1.21	0.56	7.2	3.81	13.4	93.1
20-45	59.8	4.0	36.10	1.21	0.33	7.8	3.77	13.6	90.9
45-71	56.2	5.20	38.05	1.25	0.22	8.0	3.67	14.0	94.9
71-108	59.1	12.01	28.50	1.25	0.19	8.0	3.72	9.4	88.3
108-131	83.0	10.10	6.50	1.27	0.16	8.0	3.09	8.8	88.2
131-152	79.0	11.50	8.50	1.33	0.11	8.1	3.47	8.9	86.7
P 3 (Tamarakki series) : Typic Haplustepts									
0-15	56.3	8.21	35.01	1.25	0.60	8.1	4.10	18.6	98.9
15-34	59.1	4.80	36.05	1.25	0.33	8.1	4.01	19.9	99.4
34-62	57.4	3.50	39.01	1.17	0.25	8.1	3.67	21.0	98.4
62-81	50.2	9.11	40.01	1.14	0.22	8.2	4.40	27.3	96.4
81-92	48.1	11.15	40.05	1.25	0.19	8.2	4.30	27.9	96.3
92-120	49.9	8.50	41.10	1.25	0.16	8.3	9.34	35.9	96.6
120-150	38.2	16.10	45.50	1.25	0.14	8.3	10.80	41.5	97.5
P 4 (Keelpoongudi series) : Rhodic Paleustalfs									
0-22	56.0	8.41	35.10	1.25	0.33	6.9	3.43	13.8	95.5
22-60	39.6	18.11	42.05	1.14	0.22	7.3	3.09	14.9	82.6
60-97	37.8	16.01	46.10	1.17	0.16	6.7	3.72	19.8	87.7
97-133	48.3	7.05	44.50	1.11	0.16	6.5	3.28	18.1	78.5
133-145	47.4	9.02	43.14	1.25	0.14	6.5	3.33	18.0	83.3

(P') of the soils along with the co-efficient of improvement (CI) in respect of field, forage and tree crops are given in table 3. For actual productivity to field crops, P3 was grouped under 'average' class with the productivity rating of 28.7. Other pedons (P1, P2 and P4) were grouped under 'good' class, with the ratings varying from 35.0 in P1 to 35.3 in P2 and P4. The soils in the study area were grouped under the class 'good' with the potential productivity rating ranging from 47.2 in P3 to 56.09 in P2. Co-efficient of improvement was 1.41 to 1.58 only in all soils, indicating the limited possibility of increasing productivity of field crops in these soils.

For actual productivity to forage crops all the soil profiles were grouped under 'average' class of productivity with the ratings ranging from 23.2 in P1 to 24.7 in P3. These soils were grouped under 'good' class of potential productivity with the ratings ranging

Table 3. Productivity rating of soils for field, forages and tree crops

Soil	Field crops			Forage crops			Tree crops		
	P	P'	CI	P	P'	CI	P	P'	CI
P1	35.0	49.0	1.41	23.2	36.9	1.59	11.6	24.6	2.12
P 2	35.3	56.0	1.58	23.5	43.6	1.85	5.2	20.7	3.98
P 3	29.7	47.2	1.58	24.7	45.9	1.85	1.23	8.2	6.66
P 4	35.3	49.8	1.41	23.5	37.3	1.58	11.7	24.9	2.12

Rating: Excellent (65-100); Good (35-64); Average (20-34); Poor (8-19); Extremely poor (0-7)

from 46.9 in P1 to 45.9 in P3. Co-efficient of improvement was 1.58 to 1.85 in all soils indicating the little scope of increasing productivity of forage crops in these soils.

For actual productivity to tree crops, P1 and P4 were grouped under 'poor' class of productivity with the rating ranging from 11.6 to 11.7, respectively. The other two soils (P2 and P3) were grouped under 'extremely poor' class with the rating of 1.23 and 5.2, respectively. P3 was grouped under the class 'poor' with the potential productivity rating of 8.20. P1, P2 and P4 were grouped under the class 'average' with the potential productivity rating ranging from 20.7 in P2 to 24.9 in P4. Co-efficient of improvement was 2.12. to 6.6 in all soil profiles. The calcareousness, drainage and fine texture are major factors which is limiting the productivity of the soil.

All the soil profiles showed the highest values of co-efficient of improvement for tree crops compared to field and forage crops because of fine texture (sandy clay and clay) suggesting that the soils could have more scope for improvement for cultivating tree crops. Similar observations have also been reported by Rajeswari *et al.* (2004) in Sengathurai village soils of Coimbatore district, Tamil Nadu.

The soils were grouped under land capability class III. These soils had severe limitations that reduce the choice of plants or require special conservation practices. Limitations are moderately steep slopes, gravelliness and erosion for P1 and P4, drainage and semi arid climate for P2 and P3. These pedons were grouped under two soil irrigability classes i.e. A and B. Limitations like moderately rapid permeability, coarse fragments and gravelliness erosion were noticed in P1, P2 and P3 had soil limitations such as fine texture and moderately rapid permeability with additional limitations of coarse fragments and erosion in P4. As per Land irrigability classification, the area has been grouped under class 2 and 3.

Acknowledgements

The first author gratefully acknowledges the help received from Dr. S. Vadivelu and Dr. A. Natarajan, NBSS & LUP, Banglore and Sh. V. Janakiraman, SS & LUO, Coimbatore for providing technical guidance during field work.

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Received : January 2009 *Accepted : June 2010*