Plant Archives Vol. 24, No. 2, 2024 pp. 1389-1398 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.194

CHARACTERIZATION AND FERTILITY CAPABILITY CLASSIFICATION OF SOILS UNDER DIFFERENT LANDFORMS OF DHEMAJI DISTRICT, ASSAM, INDIA

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(Date of Receiving-20-03-2024; Date of Acceptance-12-06-2024)

ABSTRACT

The investigation was undertaken in Dhemaji district of Assam in order to characterize and classify the soils under different landforms. Profile samples were collected from three different landforms viz., piedmont plain, alluvial plain and flood plain. The colour of the studied soil sample ranges from grey to brownish yellow with a dominant hue of 10YR. A huge textural variation ranging from sandy loam to loam in surface and loamy sand to clay loam in subsurface was observed. Sand, silt and clay contents varied from 32.35-85.00, 9.00-50.60, 4.40- 34.02 per cent. Organic carbon content in the soil varied from 0.06- 0.98 percent. Soil pH varied from 4.81 to 6.44. The cation exchange capacity varied from 2.01-14.26 cmol (p^+) kg^{-1}. Among the basic cations, Ca^{2+} was the dominant. Percent base saturation ranged from 18.07-62.52. The soils were classified as *Aquic Udorthents* (P1, P7 and P8), *Typic Udorthents* (P5), *Aquic Udifluvents* (P6), *Typic Dystrudepts* (P2 and P3) and *Typic Endoaquepts* (P4). The soils of P1 (piedmont plain), P6 (alluvial plain), P7 and P8 (flood plain) were found to be loamy (L) in type and sandy (S) in sub strata type. Rest of the pedons *viz*., P2 (piedmont plain), P3, P4 and P5 (alluvial plain) were loamy (L) in both type and sub strata type. Finally after considering all the modifiers the fertility capability units were designated as 'LSakm(1-3)', 'LLakm(1-3)', 'LLaek(0-1)', 'LLak(0-1)', 'LLhk(0-1)', 'LSak(0-1)', 'LShkm(0-1)' and 'LSakm(0-1)' for P1, P2, P3, P4, P5,P6, P7 and P8, respectively.

Key words : Characterization, Classification, Fertility, Capability, Landform.

Introduction

In modern agriculture, farmers must be aware of the capabilities and nutrient condition of their soils in order to choose the best options available. The importance of the Land Resource Inventory (LRI), which assesses the capacity of land resources for continuous agricultural output, has increased as a result of this. To lessen the adverse effects on the environment, LRI places a strong emphasis on the optimal use of natural resources. According to Avinash *et al*. (2019), the LRI provides information on land capability, fertility capability, land suitability assessment, and land use planning. While top soil qualities indicate soil fertility, subsoil properties are primarily taken into account in soil classification systems, such as taxonomy. Therefore, the mechanism to close the gap between soil classification and soil fertility is soil fertility capability classification. Investigating the connection between soil characteristics and landform units is crucial through soil-landform studies. By extrapolating the soil qualities on comparable land formations under the same overhead climatic conditions, these studies help to manage soil resources more quickly and with less effort. This is so because the same geomorphic processes that create the soil's underlying material also build a land form unit (Mini *et al.*, 2007).

The Soil Fertility Capability Classification system represents a range of physico-chemical properties for soils, with a focus on restrictions linked to top and subsoil fertility that have a significant impact on plant growth and development. Soil Fertility Capability Classification (FCC) is a technical system, initially proposed by Buol *et al*. (1975) for classifying soils based on the types of constraints or issues (Lalitha *et al*., 2018).

Materials and Methods

General description of the area

The study area comprises of Dhemaji district, a part of north bank plain zone of Assam, located in between the latitudes: 27°16'55"N to 27°52'19"N and longitudes: 94°12'29" E to 95°26'38" E. Total geographical area of the district is 3237 sq km. The study area comprises of both old and new alluvial plains, flood plains, char lands and some highlands. The river Brahmaputra flows from east to west in the southern part of the district and different tributaries originating from Arunachal Pradesh in the north, flow southwest carrying an enormous amount of alluvium through the district before merging with the Brahmaputra. The district is bounded on East by Arunachal Pradesh, on West by Lakhimpur district, on North by Arunachal Pradesh and on South by the Brahmaputra River.

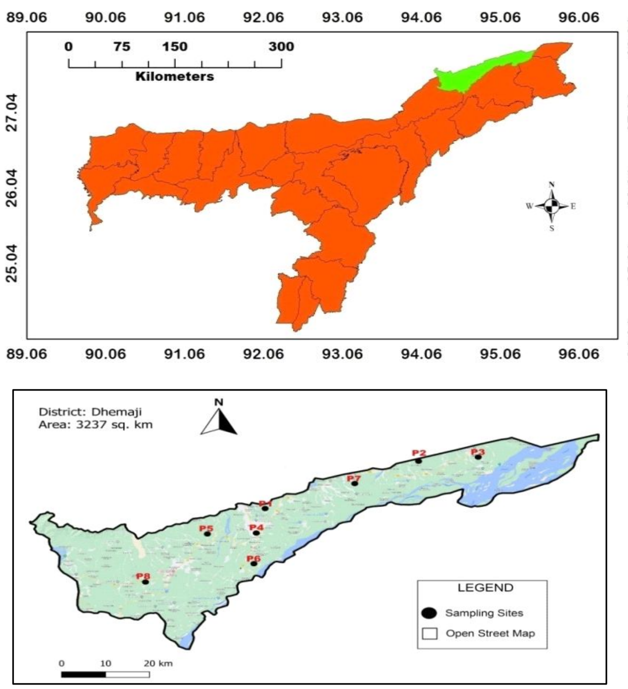

Fig. 1 : Map of the study area.

Table 1 : Site characteristics of the Pedons.

Profile No	Location	Latitude	Longitude	Landform
Pedon 1	Likabali	27.63772 N	94.720696 E	Piedmont plain
Pedon 2	Dekapam	27.79413 N	95.071971 E	Piedmont plain
Pedon 3	Junai	27.79704 N	95.206884 E	Alluvial plain
Pedon 4	Silapathar	27.56439 N	94.699334 E	Alluvial plain
Pedon 5	Shripani	27.56132 N	94.58405 E	Alluvial plain
Pedon 6	Sisiborgaon	27.46806 N	94.69269 E	Alluvial plain
Pedon 7	Simen-Chapori	27.71507 N	94.92286 E	Flood plain
Pedon 8	Bordoloni	27.41412 N	94.439754 E	Flood plain

Selection of sites and collection and preparation of soil samples

The details of the location of the profiles and other site characteristics are described in Table 1. Three different landforms *viz*., piedmont plain, alluvial plain and flood plain were delineated. All together 33 numbers of horizons were demarcated in eight soil pedons from three different landforms. Soil samples were collected from each horizon and kept separately in plastic bags with proper tags. The collected samples were air dried under shade, grinded using wooden pestle and mortar and passed through 2 mm sieve. The morphological characteristics of the soils were studied in the field as per the field guide (Nataranjan and Sarkar, 2009). The particle size analysis

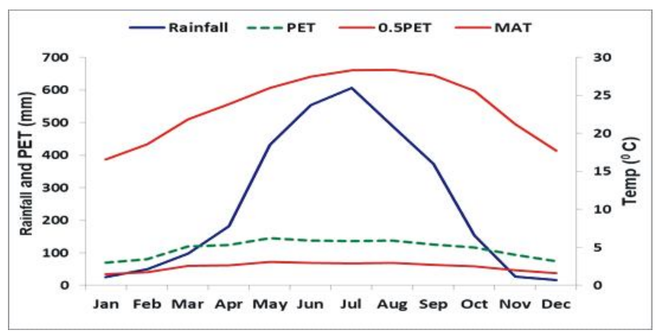

Fig. 2 : Ombrothermic diagram of Dhemaji district based on 25 years (1998-2022) climatic data.

was carried out by the international pipette method (Piper, 1966). Bulk density (BD) and particle density (PD) of the soils were determined by core (Black, 1965) and pycnometer (Black, 1965) methods. Soil porosity was calculated from its relationship with BD and PD. Organic carbon (OC) was estimated by Walkley and Black titration method (1934). The pH (1:2.5), exchangeable cations, cation exchange capacity (CEC), available potassium, exchangeable calcium and magnesium were determined following standard procedures (Jackson, 1973). Free oxides of Fe and Al was done by sodium citrate bicarbonate dithionite method (Mehra and Jackson, 1958). The soils were classified as per Keys to Soil Taxonomy (Soil Survey Staff, 2014). Simple correlation analysis was done for selected parameters using the procedures of Snedecor and Cochran (1967). Fertility capability classification was done as per the method outlined by Boul *et al.* (1975) and

Sanchez *et al.* (2003) by consisting both surface and sub-surface soils physicochemical properties.

Results and Discussion

Morphological characteristics

The morphological properties of the soils are presented in Table 2 .The soil colour (moist) ranged from very dark gray to strong brown with dominant hue of 10YR in all the pedons. Value ranged from 3-6 and a wide variation of chroma from 1-6 was observed. 10YR hue was common which might be due to hydrated oxides of iron formed under humid condition (Dutta *et al*., 2017). The hue of 7.5YR in C1 horizon of P1 (piedmont plain) might be due to more oxidative condition and presence of more amount of free iron oxides (Karmakar and Rao, 1999a). The lower chroma (1-2) in the soils of P6 (alluvial plain) under rice ecosystem may be due to aquic characteristics associated with seasonal reduction condition of soils. Hues of mottles ranged from 5 YR to 7.5YR, value ranged from 4-8 and chroma ranged from 6-8 in the studied profiles. Higher chroma of mottles is supposed to be normally associated with rice cultivation (Kanno, 1956). Also, higher chroma 6-8 indicates the alternate oxidation and reduction in the subsurface soils (Choudhury *et al*., 2016). A wide textural variation ranging from sandy loam to loam in surface and loamy sand to clay loam in the subsurface horizons was observed in the studied soils. The heavier texture observed in sub surface horizons of P3 and P4 compared to the surface horizon may be due to higher rate of weathering and translocation of clay to lower horizon (Dutta *et al*., 1999). The structural development of the studied soils were medium, weak, sub angular blocky in the surface horizon and medium to coarse, structure less to moderate, sub angular blocky to single grain in subsurface horizons. Soils were predominantly sub-angular blocky in all the pedons especially in surface layer which may be attributed to the presence of higher quantities of clay fraction (Gogoi *et al*., 2022). Single grain structure was found in of P1, P5, P6, P7 and P8. The consistency of the soils varied from slightly hard to soft when dry, loose to friable when moist and slightly sticky to non-sticky when wet in piedmont plain (P1 and P2). In case of alluvial plain soils (P3, P4, P5 and P6) consistency were found hard to soft when dry, loose to firm when moist and sticky to non-sticky when wet. Again the soils of flood plain (P7 and P8) were found slightly hard to soft when dry, loose to friable when moist and slightly sticky to non-sticky. These results corroborates with the findings of Sarmah *et al.* (2019).

Physical properties

A decreasing trend or irregular distribution was observed for sand with depth which, indicates transformation of sand. Correlation analysis showed that sand was negatively and significantly correlated with silt (r = -0.891**) and clay (r = -0.857**), which suggests *in situ* weathering of sand to form silt and clay (Dutta *et al*., 1999). Sand content increases with depth in most of the profile, which may be due to preferential deposition of coarser fraction of sediments brought by the Brahmaputra River and its tributaries (Karmakar and Rao, 1999a). The silt content showed irregular trend with depth which might be due to variations in weathering of parent material or *in situ* formation (Gogoi *et al*., 2022). The clay content decreased with depth in P1, P6, P7 and P8 suggests recent origin and least development of these soils. In P2 and P4 clay content first showed an increasing trend and then decreased with depth. In P5 depth distribution of clay was irregular. Such type of clay distribution is indicative of moderately well developed soils (Barshad, 1964). A wide difference (> 0.15 in Silt / (Silt + Clay) in between two adjacent horizons were observed in C1 and 2C2 horizon and also 2C2 and 3C3 horizon of P5, Ap and 2C1 horizon of P7, which indicated the presence of lithological discontinuity.

The bulk density value ranged from 1.32 to 1.60 Mg m^{-3} in piedmont plain, 1.33 to 1.70 Mg m^{-3} in alluvial plain and 1.45 to 1.73 Mg m^{-3} in flood plain. The value of bulk density increased with depth which might be due to decrease in organic matter content and increase in compaction in deeper layer caused by over-head weight of the over-lying soil (Walia and Rao, 1997). The value of particle density ranged from 2.21 to 2.45 Mg m^{-3} in piedmont plain, 2.31 to 2.48 Mg m^{-3} in alluvial plain and 2.15 to 2.33 Mg m^{-3} in flood plain. Particle density increased with depth in P1, P3, P5 and P7 which might be due to higher amount of heavy minerals in sub surface soils (Gupta *et al*., 2001).

Chemical properties

The important soil chemical properties are presented in Table 4. Results showed that organic carbon content was found to be higher in the surface horizon (0.36 to 0.98 per cent) than in sub surface (0.06 to 0.96 per cent). Amount of organic carbon decreased with depth in all the pedons except in P6 (alluvial plain) where the distribution of organic carbon was irregular which might be due to the accumulation of organic matter in sub surface horizon due to fluvial activity (Joshi and Kadrekar, 1987). The studied soils indicated a pH ranging from 4.96 to 5.77 in piedmont plain, 5.00 to 6.44 in alluvial plain and 4.81 to 6.38 in flood plain. The pH showed an increasing

Table 2 : Morphological characteristics of piedmont plain, alluvial plain and flood plain soils of Dhemaji district.

Horizon	Depth (cm)	Matrix (colour)	Mottle (colour)	Texture	Structure			Consistency		
					S	G	T	Dry	Moist	Wet
(P1 – Piedmont Plain : Likabali) ***Oxyaquic Udorthents***										
Ap	0-15	10YR 4/2		sl	m	1	sbk	s	fr	so
C1	15-35	7.5YR 5/6		ls	c	0	sg	s	l	so
C2	35-90	10YR 4/4		ls	c	0	sg	s	l	so
(P2 – Piedmont Plain : Dekapam) ***Typic Dystrudepts***										
Ap	0-18	10YR 3/3		scl	m	1	sbk	sh	fr	ss
Bw	18-65	10YR 5/4	f1d, 7.5YR 4/6	scl	m	1	sbk	sh	r	ss
2CB	65-115	10YR 5/6	f1d,7.5YR 4/6	sl	m	1	sbk	s	fr	so
2C	115- 135	10YR 5/3	f1d,7.5YR 4/8	sl	m	1	sbk	s	fr	so
(P3 – Alluvial Plain : Junai) ***Typic Dystrudepts***										
Ap	0-15	10YR 4/3		l	m	1	sbk	sh	fr	ss
Bw	15-60	10YR 5/2	f1d,7.5YR 5/6	l	m	1	sbk	sh	fr	ss
2Bw1	60-100	10YR 6/4	f1d, 5YR 6/8	cl	m	2	sbk	sh	fi	s
2Bw2	100-120	10YR 5/4	f1d,5YR 5/8	cl	m	2	sbk	h	fi	s
(P4 – Alluvial Plain : Silapathar) ***Typic Endoaquepts***										
Ap	0-15	10YR 3/2		sl	m	1	sbk	s	fr	so
BA	15-35	10YR 4/1	f1d, 7.5YR 7/8	scl	m	1	sbk	sh	fr	ss
Bw1	35-75	10YR 5/6	f1d,7.5 YR 6/6	scl	m	1	sbk	sh	fr	ss
2BC	75-95	10YR 4/3	f1d, 7.5YR 5/8	sl	m	1	sbk	s	fr	so
2C	95-120	10YR 5/6	f1d, 7.5YR 6/6	sl	m	1	sbk	s	fr	so
(P5 – Alluvial Plain : Shripani) ***Typic Udorthents***										
Ap	0-15	10YR 4/3		sl	m	1	sbk	sh	fr	ss
C1	15-35	10YR 5/4		ls	c	0	sg	s	l	so
2C2	35-75	10YR 4/4		sil	m	1	sbk	s	fr	ss
3C3	75-100	10YR 4/3		sl	m	1	sbk	s	fr	ss
(P6 – Alluvial Plain : Sisiborgaon) ***Aquic Udifluvents***										
Ap	0-15	10YR 4/2		Sl	m	1	sbk	sh	fr	ss
AC	15-30	10YR 4/1		sl	m	1	sbk	sh	fr	ss
C1	30-60	10YR 3/1		sl	m	1	sbk	sh	fr	ss
C2	60-75	10YR 4/1		ls	c	0	sg	s	fr	so
C3	75-125	10YR 3/2		ls	c	0	sg	s	fr	so
(P7 – Food Plain : Simen Chapori) ***Aquic Udorthents***										
Ap	0-8	10YR 3/2		sl	m	1	sbk	sh	fr	so
2C1	8-25	10YR 3/3		ls	c	0	sg	s	l	so
2C2	25-75	10YR 3/3		ls	c	0	sg	s	l	so
(P8 – Flood Plain : Bordoloni) ***Aquic Udorthents***										
Ap	0-12	10YR 5/3		sl	m	1	sbk	sh	fr	ss
AC	12-30	10YR 4/2		sl	m	1	sbk	sh	fr	so
C1	30-65	10YR 3/3		ls	c	0	sg	s	l	so
C2	65-90	10YR 3/3		ls	c	0	sg	s	l	so
C3	90-120	10YR 3/2		ls	c	0	sg	s	l	so

trend with depth in all the pedons. The lower value of pH in surface soil might be due to the higher organic carbon content in surface horizon and leaching loss of exchangeable bases from upper horizon to lower horizon under high rainfall condition. This is evident from the significant negative correlation (r = -510*) of pH with organic carbon. The soils of flood plain and alluvial plain showed higher pH values, which increased with soil depth. This may be due to shallow ground water leading aquic characteristics (Russell and Rhoades, 1956). The EC of

Table 3 : Physical properties of piedmont plain, alluvial plain and flood plain soils of Dhemaji district.

Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Silt / (Silt+Clay)	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (%)
(P1 – Piedmont Plain : Likabali)								
Ap	0-15	62.70	25.10	12.20	0.67	1.52	2.34	35.04
C1	15-35	77.64	13.28	9.08	0.59	1.55	2.38	34.87
C2	35-90	78.78	12.97	8.25	0.61	1.60	2.45	34.69
(P2 – Piedmont Plain : Dekapam)								
Ap	0-18	56.80	22.15	21.05	0.51	1.36	2.38	42.86
Bw	18-65	58.46	18.04	23.50	0.43	1.32	2.27	41.85
2CB	65-115	64.47	20.21	15.32	0.57	1.48	2.22	33.33
2C	115-135	70.10	19.40	10.50	0.65	1.50	2.21	32.13
(P3 – Alluvial Plain : Junai)								
Ap	0-15	44.20	33.65	22.15	0.60	1.33	2.28	41.67
Bw	15-60	32.80	42.65	24.55	0.63	1.45	2.35	38.30
2Bw1	60-100	35.08	32.77	32.15	0.50	1.40	2.39	41.42
2Bw2	100-120	32.35	33.63	34.02	0.50	1.38	2.47	44.13
(P4 – Alluvial Plain : Silapathar)								
Ap	0-15	62.90	17.10	20.00	0.46	1.35	2.37	43.04
BA	15-35	58.43	19.25	22.32	0.46	1.40	2.33	39.91
Bw1	35-75	56.01	20.65	23.34	0.47	1.44	2.42	40.50
2BC	75-95	62.55	22.45	15.00	0.60	1.56	2.44	36.07
2C	95-120	72.15	17.08	10.77	0.61	1.61	2.48	35.08
(P5 – Alluvial Plain : Shripani)								
Ap	0-15	58.54	26.04	15.42	0.63	1.49	2.24	33.48
C1	15-35	78.00	15.46	6.54	0.70	1.68	2.33	27.90
2C2	35-75	42.25	50.60	7.15	0.88	1.70	2.40	29.17
3C3	75-100	61.70	25.10	13.20	0.66	1.67	2.40	30.42
(P6 – Alluvial Plain : Sisiborgaon)								
Ap	0-15	54.70	25.30	20.00	0.56	1.49	2.23	33.18
AC	15-30	67.80	20.10	12.10	0.62	1.55	2.21	29.86
C1	30-60	72.60	18.60	8.90	0.68	1.45	2.40	39.58
C2	60-75	77.20	16.30	6.50	0.71	1.64	2.35	30.21
C3	75-125	85.00	9.76	5.24	0.65	1.70	2.21	23.08
(P7 – Flood Plain : Simen Chapori)								
Ap	0-8	60.23	23.44	16.33	0.59	1.48	2.20	32.73
2C1	8-25	74.25	18.95	6.80	0.74	1.61	2.28	29.39
2C2	25-75	85.00	10.60	4.40	0.71	1.73	2.33	25.75
(P8 – Flood Plain : Bordoloni)								
Ap	0-12	60.70	24.10	15.20	0.61	1.45	2.23	34.98
AC	12-30	69.05	19.75	11.20	0.64	1.48	2.30	35.65
C1	30-65	79.87	12.58	7.55	0.62	1.60	2.22	27.93
C2	65-90	80.00	13.75	6.25	0.69	1.68	2.20	23.64
C3	90-120	85.00	9.00	6.00	0.60	1.70	2.15	20.93

the studied profile was generally low varying from 0.02 to 0.08 dSm^{-1} in piedmont plain, 0.02 to 0.07 dSm^{-1} in alluvial plain and 0.01 to 0.06 dSm^{-1} in flood plain. It indicated that studied soils contains very low amount of soluble salts.

Data on exchangeable cation (Table 4) revealed that exchangeable Ca^{2+} was dominant cation followed by exchangeable Mg^{2+}, Na^{+} and K^{+}. These low amount of exchangeable Na^{+} and K^{+} might be due to the preferential leaching loss of monovalent cations over divalent cations

Table 4 : Chemical properties of piedmont plain, alluvial plain and flood plain soils of Dhemaji district.

Horizon	Depth (cm)	O.C. (%)	pH (1:2.5)	EC (1:2.5)dsm^{-1}	Exchangeable Bases				CEC	BS (%)	Fe_d (%)	Al_d (%)
					Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}				
					cmol (p^+) kg^{-1}							
(P1 – Piedmont Plain : Likabali)												
Ap	0-15	0.51	4.96	0.08	1.10	0.30	0.13	0.14	9.25	18.07	0.72	0.71
C1	15-35	0.30	5.56	0.05	1.60	1.10	0.06	0.10	5.12	55.71	0.46	0.55
C2	35-90	0.12	5.97	0.02	1.00	0.50	0.05	0.04	3.85	41.33	0.54	0.45
(P2 – Piedmont Plain : Dekapam)												
Ap	0-18	0.42	5.52	0.07	2.00	0.80	0.08	0.11	12.62	23.73	0.81	0.89
Bw	18-65	0.33	5.52	0.05	2.40	1.80	0.19	0.13	10.55	42.86	0.86	0.74
2CB	65-115	0.18	5.77	0.03	2.19	2.00	0.11	0.12	10.40	42.48	0.69	0.71
2C	115-135	0.06	5.70	0.03	1.80	0.80	0.13	0.09	6.42	44.00	0.72	0.75
(P3 – Alluvial Plain : Junai)												
Ap	0-15	0.81	5.00	0.05	0.60	0.50	0.10	0.13	6.17	21.54	0.34	0.82
Bw	15-60	0.78	5.02	0.05	1.00	0.70	0.18	0.08	5.58	35.12	0.45	0.92
2Bw1	60-100	0.18	5.13	0.03	1.20	1.00	0.18	0.07	4.55	53.80	0.51	1.30
2Bw2	100-120	0.15	5.31	0.05	1.40	0.90	0.12	0.07	3.99	62.52	0.62	0.94
(P4 – Alluvial Plain : Silapathar)												
Ap	0-15	0.87	5.38	0.06	1.40	0.80	0.10	0.18	11.32	21.93	0.42	0.96
BA	15-35	0.78	5.43	0.06	1.40	0.60	0.08	0.15	6.73	33.11	0.48	0.92
Bw1	35-75	0.69	5.44	0.03	1.00	0.60	0.08	0.13	6.62	27.41	0.33	0.96
2BC	75-95	0.18	5.62	0.04	0.80	0.75	0.06	0.07	8.27	20.31	0.41	0.82
2C	95-120	0.09	5.97	0.02	0.60	0.80	0.06	0.05	5.27	28.79	0.42	0.50
(P5 – Alluvial Plain : Shripani)												
Ap	0-15	0.66	5.10	0.05	1.10	0.40	0.08	0.11	9.12	18.59	0.47	0.86
C1	15-35	0.24	6.27	0.04	1.40	1.00	0.05	0.05	4.15	60.22	0.46	1.14
2C2	35-75	0.24	6.36	0.02	1.60	0.80	0.09	0.10	5.02	51.52	0.44	1.02
3C3	75-100	0.09	6.44	0.03	1.80	0.90	0.06	0.03	7.58	36.83	0.39	0.88
(P6 – Alluvial Plain : Sisiborgaon)												
Ap	0-15	0.98	5.45	0.07	2.00	0.40	0.05	0.17	14.26	18.35	0.69	0.86
AC	15-30	0.84	5.93	0.06	2.20	1.00	0.04	0.15	11.73	28.89	0.84	1.14
C1	30-60	0.96	5.95	0.07	1.80	0.60	0.03	0.09	7.12	35.44	0.71	1.02
C2	60-75	0.40	6.27	0.05	1.50	0.40	0.04	0.04	4.29	45.99	0.49	0.98
C3	75-125	0.24	6.35	0.02	1.00	0.40	0.04	0.03	3.15	46.51	0.49	0.88
(P7 – Flood Plain : SimenChapori)												
Ap	0-8	0.36	4.81	0.03	1.00	0.80	0.04	0.13	10.68	18.39	0.48	1.18
2C1	8-25	0.15	6.24	0.04	1.30	1.10	0.03	0.09	6.73	37.48	0.62	0.84
2C2	25-75	0.09	6.38	0.01	0.80	0.50	0.04	0.03	2.51	54.55	0.47	1.32
(P8 – Flood Plain : Bordoloni)												
Ap	0-12	0.39	5.34	0.06	2.00	0.40	0.04	0.18	8.73	30.00	0.75	0.99
AC	12-30	0.42	5.66	0.05	2.20	1.30	0.04	0.15	8.54	43.26	0.54	1.09
C1	30-65	0.21	6.20	0.04	1.30	0.75	0.03	0.13	5.29	41.69	0.47	0.69
C2	65-90	0.15	6.31	0.05	0.85	0.60	0.04	0.07	2.83	55.00	0.76	0.79
C3	90-120	0.06	6.30	0.01	0.65	0.40	0.03	0.05	2.01	56.31	0.44	0.46

under high rainfall condition (Gogoi *et al.*, 2022). The cation exchange capacity (CEC) of the studied soils varied from 3.85 to 12.62 cmol (p^+) kg^{-1} in piedmont plain, 3.15 to 14.26 cmol (P+) kg^{-1} in alluvial plain and 2.01 to 10.68 cmol (p+) kg^{-1} in flood plain. Low CEC might be due to dominance of low activity kaolinatic clay minerals (Karmakar and Rao, 1999). The CEC of the soils was mainly contributed by the clay fractions and organic carbon as evident from significant positive correlation of CEC with clay (r = 0.395*) and organic carbon (r =

Table 5 : Correlation coefficient (r) between different soil properties.

	Sand	Silt	Clay	BD	OC	pH	CEC	BS
Sand	1							
Silt	-0.891**							
Clay	-0.850**	0.520**						
BD	0.634**	-0.322	-0.822**					
OC	-0.327	0.240	0.339*	-0.538**				
pH	0.656**	-0.432*	-0.735**	0.805**	-0.481**			
CEC	-0.277	0.159	0.337*	-0.555**	0.532**	-0.475**		
BS	0.220	-0.159	-0.230	0.429*	-0.590**	0.546**	-0.728**	

** Correlation is significant at the 0.01 level (2-tailed) *Correlation is significant at the 0.05 level (2-tailed).

Table 6 : Type, substrata type, condition modifiers and final FCC of piedmont plain, alluvial plain and flood plain soils of Dhemaji district.

Landform	Pedon	Soil classification	Type	sub strata type	Check list					Modifiers Slope	(%)	FCC unit
					a	h	E	k	m			
Piedmont plain	P1 (Likabali)	*OxyquicUdorthents*	L	S	*			*	*	akm	1-3	LSakm(1-3)
	P2 (Dekapam)	*Typic Dystrudepts*	L	L	*			*	*	akm	1-3	LLakm(1-3)
Alluvial plain	P3 (Junai)	*Typic Dystrudepts*	L	L	*		*	*		aek	0-1	LLaek(0-1)
	P4 (Silapathar)	*Typic Endoaquepts*	L	L	*			*		ak	0-1	LLak(0-1)
	P5 (Shripani)	*Typic Udorthents*	L	L		*		*		hk	0-1	LLhk(0-1)
	P6 (Sisiborgaon)	*Aquic Udifluvents*	L	S	*			*		ak	0-1	LSak(0-1)
Flood plain	P7 (Simen-Chapori)	*Aquic Udorthents*	L	S		*		*	*	hkm	0-1	LShkm(0-1)
	P8 (Bordoloni)	*Aquic Udorthents*	L	S	*			*	*	akm	0-1	LSakm(0-1)

0.565**). The CEC value in flood plain soils was found to be low. Similar findings were also reported by Deka *et al*. (2009) in old flood plain and the lower alluvial plain soils of Brahmaputra valley of Assam. The per cent base saturation of the studied soils varied from 18.07 to 55.71 per cent in piedmont plain, 18.35 to 62.52 per cent in alluvial plain and 18.39 to 56.31 per cent in flood plain. The highest value of base saturation was observed in 2Bw2 horizon of P3, which might be due to illuviation of cations. A wide variation was observed in per cent base saturation which indicated the degree of leaching of bases (Das *et al.*, 2019).

Results on Table 4 indicated that both the oxides of Al and Fe were low in surface horizon in most of the studied soils and showed irregular trend with depth. The CBD extractable Al (Ald) varied from 0.45 to 0.89 per cent in piedmont plain, 0.50 to 1.30 per cent in alluvial plain and 0.46 to 1.18 per cent in flood plain. Fe (Fed) varied from 0.54 to 0.86 per cent in piedmont plain, 0.33 to 0.84 per cent in alluvial plain and 0.44 to 0.76 in flood plain. The increasing trend of Fed in P3 might be due to the fluctuating ground water table which cause seasonal reduction of Fe and enhance its downward movement with receding ground water (Blume and Schwertmann, 1969).

Soil classification

Based on the field morphology and physicochemical properties, the soils of the eight profiles were classified up to the subgroup level following the criteria outlined in Keys to Soil Taxonomy (Soil Survey Staff, 2014). The P1, P5, P6, P7 and P8 soils did not show presence of B Horizon and hence classified under the order Entisols. The soils of P1, P7 and P8 did not have any diagnostic subsurface horizon and amount of organic matter decreased regularly with soil depth, so these soils are qualified for order Entisols and sub order Orthents. As the moisture regime is Udic, the soils were classified as Udorthents at great group level. In P1 soils were saturated with water in one or more layer within 150 cm for 30 or more cumulative days so P1 was classified as *Oxyaquic Udorthents* at sub group level. In P7 and P8 within 100 there were horizons having redox depletion with chroma of 2 or less, so this two soils were classified as *Aquic Udorthents* at sub group level. P5 soils did not qualify for any sub group other than 'Typic' and hence classified as *Typic Udorthents*. P6 was further classified as Fluvents at suborder level due to the irregular decrease

Table 7 : Taxonomic classification of the studied soils.

Pedon No	Location	Order	Sub order	Great group	Subgroup
P1	Likabali,	Entisol	Orthents	Udorthents	*Oxyaquic Udorthents*
P2	Dekapam	Inceptisol	Udept	Dystrudepts	*Typic Dystrudepts*
P3	Junai,	Inceptisol	Udept	Dystrudepts	*Typic Dystrudepts*
P4	Silapathar	Inceptisol	Aquepts	Endoaquepts	*Typic Endoaquepts*
P5	Shripani	Entisol	Orthents	Udorthents	*Typic Udorthents*
P6	Sisiborgaon	Entisol	Fluvents	Udifluvents	*Aquic Udifluvents*
P7	Simen-Chapori	Entisol	Orthents	Udorthents	*Aquic Udorthents*
P8	Bordoloni	Entisol	Orthents	Udorthents	*Aquic Udorthents*

Table 8 : Relevant average value for Fertility capability classification in piedmont plain, alluvial plain and flood plain soils of Dhemaji District.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	pH (1:1)	EC (dSm^{-1})	OC g kg^{-1}	CEC	Ex. Na	Ex. K
							cmol (p+) kg^{-1}		
(P1 – Piedmont Plain : Likabali)									
0-20	66.44	22.15	11.42	3.87	0.07	4.58	8.22	0.11	0.13
20-50	78.21	13.13	8.67	4.49	0.04	2.10	4.49	0.05	0.07
(P2 – Piedmont Plain : Dekapam)									
0-20	56.97	21.74	21.30	4.14	0.07	4.11	12.41	0.09	0.11
20-50	58.46	18.04	23.50	4.28	0.05	3.30	10.55	0.19	0.13
(P3 – Alluvial Plain : Junai)									
0-20	41.35	35.90	22.75	4.38	0.05	8.03	6.02	0.12	0.12
20-50	32.80	42.65	24.55	4.42	0.05	7.80	5.58	0.18	0.08
(P4 – Alluvial Plain : Silapathar)									
0-20	61.78	17.64	20.58	4.98	0.06	8.48	10.17	0.09	0.18
20-50	57.22	19.95	22.83	5.00	0.05	7.35	6.67	0.08	0.14
(P5 – Alluvial Plain : Shripani)									
0-20	63.41	23.40	13.20	5.19	0.05	5.55	7.88	0.08	0.10
20-50	60.13	33.03	6.85	5.68	0.03	2.40	4.59	0.07	0.07
(P6 – Alluvial Plain : Sisiborgaon)									
0-20	57.98	24.00	18.03	4.65	0.07	9.45	13.63	0.05	0.16
20-50	71.00	19.10	9.97	4.89	0.07	9.20	8.66	0.03	0.11
(P7 – Flood Plain : Simen-Chapori)									
0-20	68.64	20.75	10.61	5.05	0.04	2.34	8.31	0.03	0.11
20-50	83.21	11.99	4.80	5.29	0.02	1.00	3.22	0.04	0.04
(P8 – Flood Plain : Bordoloni)									
0-20	64.04	22.36	13.60	4.32	0.06	4.02	8.65	0.04	0.17
20-50	76.26	14.97	8.77	5.17	0.04	2.80	6.38	0.03	0.14

of organic carbon with soil depth. The soils were classified as Udifluvents at greatgroup level. Due to the presence of horizons within 50 cm of the mineral soil surface having redox depletions with chroma of 2 or l, the P6 soils were further classified as *Aquic Udifluvents*. The soils of P2, P3 and P4 (Alluvial plain) were classified as Inceptisols due to the presence of cambic (Bw) horizon. The soils of P2 and P3 had ochric epipedon, cambic sub surface horizon and soil moisture regime udic. So these three soils were classified as Inceptisols order and udept suborders. These two pedons had base saturation of less than 60 per cent in all the horizons at a depth between 25 and 75 cm. Hence, at the greatgroup level these two pedons were classified as Dystrudepts. P2 and P3 soils did not show properties for any subgroup other than 'Typic'. So these soils were classified as *Typic Dystrudepts*. Pedon P4 (alluvial plain) have Aquic characteristics satisfying the conditions of endosaturation.

Chroma of 2 and less, redoximorphic features were found in these soils. So, these were classified as Endoaquept at greatgroup level and further classified as *Typic Endoaquepts*.

Fertility capability classification

Based on the criteria suggested by Boul *et al*. (1975) and Sanchez *et al*. (2003), the soils of Dhemaji district were placed under FCC classes as 'LSakm(1-3)', 'LLakm(1-3)' for piedmont plain (P1 and P2), 'LLaek(0-1)', 'LLak(0-1)', 'LLhk(0-1)', 'LSak(0-1)' for alluvial plain (P3, P4, P5 and P6), 'LShkm(0-1)', 'LSakm(0-1)' for flood plain (P7 and P8).

The fertility capability classification showed that the slope of the piedmont plain was (1–3%), while slope of alluvial and flood plain were nearly levelled (0-1%). The slope of the land can be managed in piedmont plain with graded bunding and plowing and cultivating across the slope (Chandrakala *et al*., 2021). Loamy texture in both type and substrata type were existed in P2, P3, P4 and P5 FCC units which was congenial for crop production as the water holding capacity is good. Problem of aluminium toxicity (a) was existed in P1, P2, P3, P4 and P8. Whereas, problem of acid soil (h) were found in P5 and P7, which may be due to leaching out of basic cation during high rainfall condition. Acidity of the soil has to be managed by application of lime. Modifier k was existed in all the studied soil, as major portion of the soil K exists as a part of mineral structure and in a fixed or non-exchangeable form with small fraction as water-soluble and exchangeable K in soil (Sharma *et al*., 2006). Hence, application of potassic fertilizer is needed in those FCC units. All the soils were under fallow at the time of sample collection and all were found to be deficient in potassium (K) reserves. The pedon P3 rated with modifier e (low nutrient retaining ability) hence leaching potential were more. This could be as a result of prevalent granulated clayey soils with low activity clay minerals (Babalola, 2019). Biological condition modifier (m) and low cation exchange capacity (e) have to be managed by the addition of FYM, Compost and organic manures in the FCC units with those modifiers. Variation of the modifiers were observed in the FCC, units which may be due to the variability in parent materials, land use, landform and management practices which influences soil properties. Adhikary *et al*. (2010) and Lalitha *et al*. (2018) also reported similar findings.

Conclusion

The morphological and physico-chemical characteristics of the soils in the Dhemaji District varied considerably under various landforms. As the foundation for classifying the soils according to their fertility status, the land resource data that is produced can be used to detect various fertility-related restrictions of both surface and subsoil. The predominant soil types in the region were loamy, which is ideal for growing crops. Still, soils produced on different landforms in the research area have a number of condition modifiers, including poor CEC, low K reserve, low organic carbon, acid soil, and Al saturation. The identification of these obstacles has made it easier to comprehend the appropriate conservation measures for water and soil, as well as the soil amendments that need be done to increase the potential for effective land use.

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