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Morphological, physical and hydrological properties of the soils of North-West Gir Madhuvanti Toposequence of south Saurashtra region of Gujarat

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Abstract
Six representative pedons were characterize of morphological, mechanical, physical and hydrological properties of the soils of different land slope of north-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat. Soils of the study area were shallow to deep, somewhat excessive to imperfectly drained, dark gray (10YR 4/1 M) to very dark brown (10YR 2/2 M), near level to moderately gently sloping, slightly to severely eroded, loam to clay in texture and moderate to strong sub angular blocky structure. The parent material (trap basaltic, lime stone and alluvium) and topography were observed dominant factor for the soils formation in this region. The weighted mean of total sand, silt and clay content were 22.83, 38.90 and 38.26 per cent, respectively. B.D. was 1.31 Mg m^{-3}. The saturated hydraulic conductivity, MWHC and AWC were 0.06 cm hr^{-1}, 45.99 percent and 0.20 m^3 m^{-3}, respectively. The total PAWC and WSC increased with decreasing elevation.

Keywords: Morphological, physical, hydrological, mechanical, land slopes, North-West Gir Madhuvanti Toposequence

Introduction
Soil is vital natural resource on whose proper use depends the life supporting system of a country and the socio-economic development of its people. To meet the requirements of food, fiber, fuel and fruits for the increasing population, farm land development is often extended even to the areas unsuitable to agriculture and when the land for agriculture is shrinking; the existing cultivated area is subjected to greater burden in many cases. Success in agriculture depends on the land quality and soil characteristics. For the better utilization of land resource and to tackle soil problem, a systemic study of land slope is necessary. Information of soil and related properties obtained from the soil survey and soil classification can help in better delineation of soil and land suitability for irrigation and efficient irrigation water management. The morphology of soil profile and the basic interactions, which lead to the development of the particular soil, have been evaluated within the limitation of present techniques and methodology. Soil survey provides useful information for planning proper soil management practices, which are play important role in augmenting crop production. For the sustainable use of the natural resources, a detailed charter of land resources giving its potential and constraints becomes pre-requisite for planning.

Material and method
The study area (north-west Gir Madhuvanti toposequence) was located between $21^0$13' to $21^0$25' N latitudes and $69^0$57' to $70^0$32' E longitudes encompassing parts of the Mendarda, Vanthli, and Keshod tehsils of Junagadh district and Porbandar tehsil of Porbandar district of south Saurashtra at an elevation ranged from 5 to 190 above mean sea level. IRS IA LISS II FCC imagery on 1:50,000 scale in conjunction with Survey of India topographical (SOI) map referred above on 1:50,000 scale were used to select various land slopes of north-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat namely: hill slope (LS-1), upper piedmont (LS-2), lower piedmont (LS-3), plain area (LS-4), depression area (LS-5) and upper coast (LS-6) (Fig.-1).

The mean annual rainfall is 1120 mm and the climate of the area is semi-arid characterized by extremes of temperature and low wind velocity. Two to three kilograms of soil samples were collected in cotton bags from each horizon of the pedons under study and labeled properly in month of May. In all soil samples (1 to 5 samples from each pedon depending upon the horizon differentiation) were collected from the different profiles. Soil samples collected were air dried. Some of the clods were use for bulk density determination and remaining soils were gently crushed (ground) with a wooden mortar with pestle and passed through the 2 mm sieve for physical and chemical analysis. Particle size distribution by International pipette method (Piper, 1950) [7], Bulk density by Page *et al*. (1986) [4], Particle density and Total porosity by Richards (1954) [10], Maximum water holding capacity (MWHC) and Expansion of soil by Piper, (1950) [7], Moisture retention characteristics and Available water content (AWC) by Richards (1965) [11], Saturated hydraulic conductivity (cm hr -1) by Klute, (1965) [3].

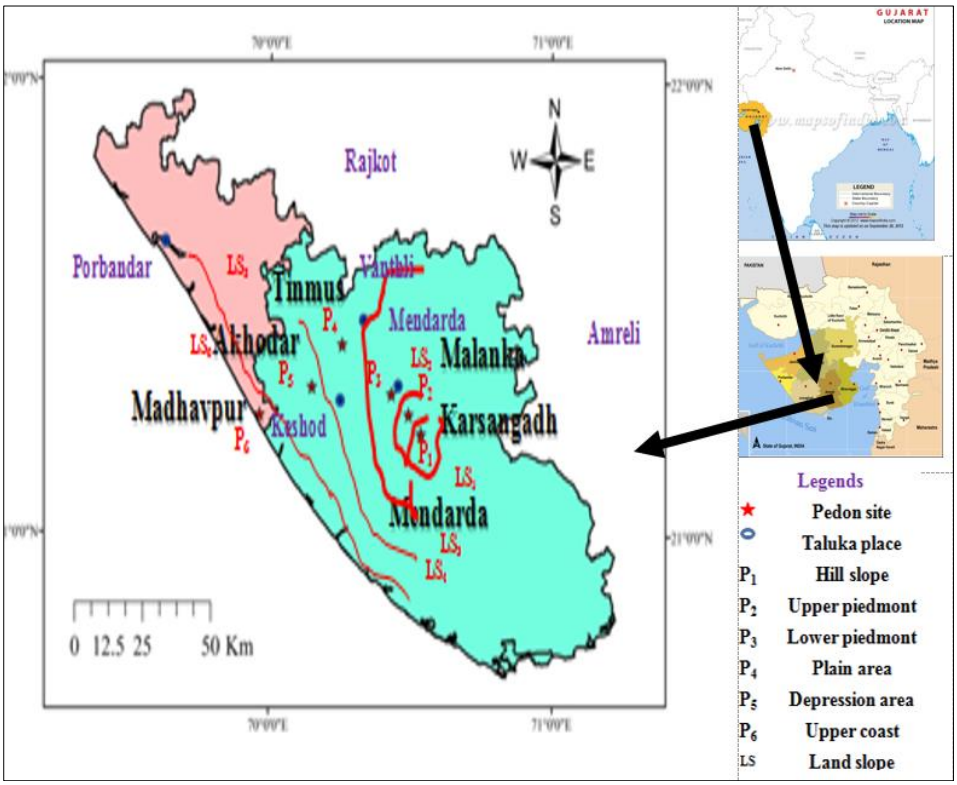

Fig 1: Site of pedons of north-west Gir Madhuvanti toposequence in South Saurashtra

Result and discussion

Morphological Characteristics

The soil depth increases from hill slope to upper coast. The pedon P_1 (hill slope) and P_2 (upper piedmont) were shallow depth indicating the soils were less developed as there was a little observable changes. The soils of Pedon P_3 (lower piedmont) were moderately shallow in depth, pedon P_4 (plain area) and P_5 (depression area) were moderately deep, whereas the soils of pedon P_6 (upper coast) was deep. Soil slope influences soil formation primarily through its effect upon drainage, runoff and erosion through variations in exposure to the sun, wind and air drainage. The soils of hill slope (LS-1) have developed on moderately gentle slopes (15-30 % slope). The soils of upper piedmont (LS-2) have developed on gentle sloping (3-8 % slopes), Lower piedmont (LS-3) have developed on very gently sloping land (1-3 % slope), while the soils of plain area (LS-4), depression area (LS-5) and upper coast (LS-6) have developed on near level to very gently sloping land (0-1 % slope). The soils of the area have developed from basalt and limestone parent material as the dominant geological formation, the difference is only on the extent of weathering. On the hill slope (LS-1), the weathered trap basalt parent material was observed. The upper piedmont (LS-2) and lower piedmont (LS-3) posses limestone and weathered basaltic limestone parent materials, respectively. The soils of plain area (LS-4), depression area (LS-5) and upper coast (LS-6) developed from alluvium parent materials. The soils of hill slope area exhibits dark brown (10 YR, 3/3 M) colour throughout the profile. The soils of upper piedmont area exhibits dark greyish brown (10 YR 4/2 M) colour in surface as well as sub-surface horizons. The soils of lower piedmont area have very dark brown (10 YR 2/2 M) colour in surface as well as sub-surface horizons, whereas the soils of plain area as well as depression area have very dark greyish brown (10 YR 3/2 M) to dark greyish brown (10 YR 4/2 M) colour in surface as well as sub-surface horizons, respectively. The soils of upper coast area were dark brown (10 YR 3/3 M) and dark grey (10 YR 4/1 M) colour in surface and sub-surface horizons, respectively. The moderate sub-angular blocky structure was commonly observed in the soils of pedon P_1 to P_6 indicating no variation in the soil structure in relation to altitude. Similar observation was also recorded by Singh *et al.* (1991) [15], Gandhi (2013) [1], Pulakeshi *et al.* (2014) [9], Kharlyngdoh *et al.* (2015) [2] and Singh and Rathore (2015) [14].

Mechanical composition and soil physical characteristics

Mechanical composition and other soil physical characteristics from different pedons of the soils of north-west Gir Madhuvanti toposequence in south Saurashtra (Table -2, 3) that the total sand, silt and clay content varied from 14.26 to 34.81, 29.50 to 46.61 and 28.90 to56.23 per cent with the

mean values of 22.83, 38.90 and 38.26 per cent, respectively. The total sand content was found to be in the decreasing order of, Hill slope > Plain area > Upper piedmont > Upper coast > Depression area > Lower piedmont. The distribution of coarse sand and fine sand from hill slope to upper coast were not found consistent in the soils of different land slopes of north-west Gir Madhuvanti toposequence. As far as silt content is concerned, it was found to be decreasing in following sequence: Upper coast > Upper piedmont > Depression area > Plain area > Hill slope > Lower piedmont indicating no distinct difference among the pedons in relation to their landscape position and ingration of silt fraction (fine fraction) of the soil particles from higher topography to lower topography as silt particles are highly venerable to water erosion (Prasad *et al*., 1989; Singh *et al*., 1991) [8, 15]. Looking to the clay content, it was found to be in the decreasing order of Lower piedmont > Depression area > Plain area > Upper piedmont > Upper coast > Hill slope indicating no definite trend in distribution of clay fraction from hill slope to upper coast might be due to the clay is less affected by weathering process. Similar results were also reported by Pulakeshi *et al*. (2014) [9] and Singh & Rathore (2015) [14].

The bulk density ranged from 1.23 to 1.43 Mg m^{-3} with the mean value of 1.31 Mg m^{-3}. The bulk density values observed in the increasing order of Hill slope < Lower piedmont < Upper piedmont < Plain area < Depression area < Upper coast indicating the higher bulk density observed at lower elevation as compare to higher elevation. The higher bulk density observed in lower elevation might be attributed to the presence of some heavy minerals and compaction of all the micropeds (Paramasivam, 1992) [6]. The soils of hill slope to lower piedmont area have low value of bulk density from 1.23 and 1.28 Mg m^{-3} indicating easy penetration of roots to the lower depth and are more favourable for horticultural crops, orchards, forestry and deep rooted crops. The pore space and expansion of soil ranged from 39.91 to 47.00 and 7.27 to 15.71 per cent, with the mean value of 44.63 and 11.55 per cent, respectively. The packing patterns of soil fragments determined the total porosity of the soils. The pore space of soils was observed in the decreasing sequences of Lower piedmont > Hill slope > Upper piedmont > Plain area > Depression area > Upper coast, whereas expansion of soils were in the decreasing order of Lower piedmont > Plain area > Depression area >Upper coast > Hill slope > Upper piedmont. The pedon-P_6 of upper coast area has < 40.00 per cent pore space (39.91 per cent) in the profile indicating poor air-moisture regime. These findings are parallel to those of Pal (1976) [5] and Savalia (2005) [12], who suggested that the total porosity less than 40 per cent in the profile indicated the poor air-moisture regime.

Hydrological characteristics

The maximum water holding capacity (%) and MWHC (v/v) of the soils ranged from 42.30 to 50.77 and 54.22 to 63.46 per cent, with the overall mean value of 45.99 and 59.74 per cent, respectively (Table -4, 5). Maximum water holding capacity (%) and MWHC (v/v) were observed in the following decreasing order across the slope: Lower piedmont > Depression area > Hill slope> Plain area > Upper coast > Upper piedmont and Lower piedmont > Depression area > Upper coast > Plain area > Hill slope > Upper piedmont, respectively. The saturated hydraulic conductivity ranged from 0.00 to 0.18 cm hr^{-1} with the overall mean value of 0.06 cm hr^{-1} indicating, very slow saturated hydraulic conductivity in soils of north-west Gir Madhuvanti toposequence which may be due to high clay content and dominant expandable smectite clay minerals in the soils of different land slopes of north-west Gir Madhuvanti toposequence in south Saurashtra region. The saturated hydraulic conductivity of the studied soils was recorded in the following decreasing order: Hill slope > Lower piedmont > Upper piedmont > Plain area > Depression area = Upper Coast. The moisture held at 0.03 and 1.5 MPa ranged from 0.29 to 0.50 and 0.13 to 0.24 m^3 m^{-3} with the overall mean value of 0.40 and 0.20 m^3 m^{-3}, respectively. The moisture held at 0.03 and 1.5 MPa were observed in decreasing sequence of Lower piedmont > Upper coast = Depression area> Plain area > Hill slope > Upper piedmont and Hill slope > Lower piedmont > Depression area = Plain area > Upper coast > Upper piedmont, respectively.

The AWC ranged between 0.14 to 0.27 m^3 m^{-3}, with the overall mean of 0.20 m^3 m^{-3}. The AWC was recorded in the decreasing order: Lower piedmont > Upper coast > Depression area> Plain area > Upper piedmont > Hill slope indicating, AWC at higher elevation observed lower than at lower elevation. The total PAWC and water storage capacity (WSC) of the soils associated in different pedons of north-west Gir Madhuvanti toposequence ranged from 0.035 to 0.272 and 0.140 to 0.778 m ha^{-1} with the mean of 0.156 and 0.455 m ha^{-1}, respectively indicating the total PAWC and water storage capacity of the soils at lower topography observed higher then higher topography.

The total PAWC and water storage capacity were found in the decreasing sequence of Upper coast > Depression area > Lower piedmont > Plain area > Upper piedmont > Hill slope and Upper coast > Depression area > Plain area > Lower piedmont> Upper piedmont > Hill slope, respectively. The PAWC/WSC ratio ranged from 0.250 to 0.428 with the mean value of 0.329 indicating the 33 per cent water is available for plant out of 0.455 m ha^{-1} of total water capacity of the soils of different pedons of north-west Gir Madhuvanti toposequence of south Saurashtra. These finding are in agreement with those of Savalia (2005) [12], Gandhi (2013) [1] and Shirgire *et al.* (2015) [13].

Conclusion

Based on the present study it can be concluded that the soils of study area were moderately alkaline in reaction and highly calcareous in nature. Soils of this area shallow to deep, somewhat excessive to imperfectly drained, dark gray (10YR 4/1 M) to very dark brown (10YR 2/2 M), near level to moderately gently sloping, slightly to severely eroded, loam to clay in texture and moderate to strong sub angular blocky structure. The weighted mean of total sand, silt and clay content were 22.83, 38.90 and 38.26 per cent, respectively. B.D. was 1.31 Mg m^{-3}. The saturated hydraulic conductivity, MWHC and AWC were 0.06 cm hr^{-1}, 45.99 percent and 0.20 m^3 m^{-3}, respectively. The total PAWC and WSC increased with decreasing elevation.

Table 1: Morphological features of the soils of different pedons of north-west Gir Madhuvanti toposequence of south Saurashtra

Horizon	Depth (cm)	Colour		Texture	Structure	Consistency			Boundary	Special features
		Dry	Moist			Dry	Moist	Wet		
Pedon-1 Hill slope (Karsangadh) slope:15-30%, drainage: somewhat excessive, erosion: severe, MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents										
A1	0-25	10 YR 4/3	10 YR 3/3	l	m 2 sbk	sh	fr	ss p	cs	Reddish yellow mottles, medium many roots, and trap gravel.
R	25+									
Pedon-2 Upper piedmont (Malanka) slope:3-8 %, drainage: well, erosion: moderate, MSL : 155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents										
Ap	0-12	10 YR 5/2	10 YR 4/2	cl	m 2 sbk	h	fr	ss pp	cw	Hard surface crust, very fine roots.
BCk	12-27	10 YR 5/2	10 YR 4/2	cl	m 2 sbk	h	fr	ss pp	cw	
R	27+									
Pedon-3 Lower piedmont (Mendarda) slope:1-3%, drainage: well, erosion: slight, MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts										
Ap	0-28	10 YR 3/2	10 YR 2/2	c	m 2 sbk	h	fr	s p	cs	White mottles of limestone, many fine roots and 2.5 cm of vertical cracks up to 25 cm.
B1	28-44	10 YR 3/2	10 YR 2/2	c	m 2 sbk	ex h	fi	s p	cs	
BC	44-70	10 YR 3/2	10 YR 2/2	c	m 2 sbk	ex h	fi	vs vp	cs	
R	70+									
Pedon-4 Plain area (Tinmus) slope:0-1%, drainage: well, erosion: slight, MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts										
Ap	0-19	10 YR 4/2	10 YR 3/2	c	m 2 sbk	h	fr	s p	cs	Vertical wide cracks throughout the profile, disturbed surface layer, white mottles and fine few roots
A2	19-45	10 YR 4/2	10 YR 3/2	c	m 2 sbk	h	fr	s p	cs	
A3ss	45-60	10 YR 4/2	10 YR 3/2	c	m 2 sbk	vh	fi	s p	as	
AC1	60-74	10 YR 5/2	10 YR 4/2	cl	m 2 sbk	vh	fi	s p	as	
AC2	74-94	10 YR 5/2	10 YR 4/2	cl	m 2 sbk	vh	fi	s p	as	
Pedon-5 Depression area (Akhodar) slope:0-1%, drainage: moderately well, erosion: slight, MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts										
Ap	0-28	10 YR 4/2	10 YR 3/2	c	s 2 sbk	h	fr	s p	cs	Vertical wide cracks throughout the profile, disturbed surface layer, white mottles and fine few roots
A2	28-57	10 YR 4/2	10 YR 3/2	c	s 2 sbk	h	fr	s p	cs	
A3	57-76	10 YR 4/2	10 YR 3/2	c	s 2 sbk	vh	fi	s p	as	
AC1	76-87	10 YR 4/2	10 YR 3/2	sicl	s 2 sbk	vh	fi	s p	as	
AC2	87-105	10 YR 5/2	10 YR 4/2	sicl	s 2 sbk	vh	fi	s p	as	
Pedon-6 Upper coast (Madhavpur) slope:0-1%, drainage: imperfect, erosion: slight, MSL : 5 m, 21^{0}16' N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts										
Ap	0-20	10 YR 4/3	10 YR 3/3	sicl	s 2 sbk	h	fr	s p	as	Vertical wide cracks throughout the profile, disturbed surface layer, white mottles and fine few roots
B1	20-48	10 YR 4/3	10 YR 3/3	sicl	s 2 sbk	h	fr	s p	as	
B2k	48-65	10 YR 4/3	10 YR 3/3	sicl	s 2 sbk	vh	fi	vs vp	as	
IC1k	65-90	10 YR 4/3	10 YR 3/3	cl	s 2 sbk	vh	fi	vs vp	as	
IIC1k	90-127	10 YR 5/1	10 YR 4/1	sil	s 2 sbk	vh	fi	vs vp	as	

Texture: c: clay, cl: clay loam, sicl: silty clay loam, sil: silt loam, l: loam, Structure: 0: structure less, 1: weak, 2: moderate, 3: strong, 4: massive, f: fine, m: medium, s: strong, sbk: sub-angular blocky, Consistency: sh: slightly hard, h: hard, ex h: extremely hard, vh: very hard, fr: friable, fi: firm, ss: slightly sticky, s: sticky, vs: very sticky, sp: slightly plastic, vp: very plastic, p: plastic, Boundary: cs: clear and smooth, cw: clear and wavy, as: abrupt smooth

Table 2: Mechanical composition and other physical characteristics of representative pedons of north-west Gir Madhuvanti toposequence of south Saurashtra

Horizon	Depth (cm)	Coarse sand (%)	Fine sand (%)	Total sand (%)	Silt (%)	Clay (%)	Textural class	Bulk density (Mg m^{-3})	Pore space (%)	Expansion (%)
Pedon-1 Hill slope (Karsangadh) slope:15-30%, drainage: somewhat excessive, erosion: severe, MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents										
A1	0-25	17.73	17.08	34.81	36.29	28.90	l	1.23	46.75	9.29
R	25+									
Pedon-2 Upper piedmont (Malanka) slope:3-8 %, drainage: well, erosion: moderate, MSL : 155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents										
Ap	0-12	11.39	12.86	24.25	40.35	35.40	cl	1.25	46.12	9.37
BCk	12-27	10.87	11.03	21.90	46.30	31.80	cl	1.31	44.72	5.59
R	27+									
Pedon-3 Lower piedmont (Mendarda) slope:1-3%, drainage: well, erosion: slight, MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts										
Ap	0-28	5.79	7.98	13.77	28.73	57.50	c	1.23	47.43	16.71
B1	28-44	5.49	7.97	13.46	28.70	57.84	c	1.24	47.23	16.65
BC	44-70	6.77	8.51	15.28	30.82	53.90	c	1.27	46.41	14.05
R	70+									
Pedon-4 Plain area (Tinmus) slope:0-1%, drainage: well, erosion: slight, MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts										
Ap	0-19	11.44	9.08	20.52	37.48	42.00	c	1.31	44.72	14.66
A2	19-45	12.36	9.25	21.61	36.79	41.60	c	1.32	45.22	14.70
A3ss	45-60	12.03	9.16	21.19	35.21	43.60	c	1.32	44.76	14.18

AC1	60-74	15.65	10.09	25.74	36.86	37.40	cl	1.36	44.26	12.21
AC2	74-94	18.76	13.57	32.33	38.87	28.80	cl	1.38	43.90	9.77
Pedon-5 Depression area (Akhodar) slope:0-1%, drainage: moderately well, erosion: slight, MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts										
Ap	0-28	11.07	9.4	20.47	38.53	41.0	c	1.32	45.00	13.44
A2	28-57	10.56	8.78	19.34	39.20	41.46	c	1.34	43.93	12.11
A3	57-76	9.82	8.45	18.15	39.05	42.80	c	1.35	44.21	13.85
AC1	76-87	9.13	11.12	20.25	42.15	37.60	sicl	1.36	43.33	12.93
AC2	87-105	10.48	9.76	20.24	44.76	35.00	sicl	1.37	43.85	11.62
Pedon-6 Upper coast (Madhavpur) slope:0-1%, drainage: imperfect, erosion: slight, MSL : 5 m, 21^{0}16' N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts										
Ap	0-20	9.20	10.27	19.47	44.93	35.60	sicl	1.38	41.27	12.19
B1	20-48	8.84	10.59	19.43	43.57	37.00	sicl	1.40	40.67	12.23
B2k	48-65	8.35	10.15	18.50	42.50	39.00	sicl	1.43	38.88	15.07
IC1k	65-90	9.82	12.74	21.56	48.04	30.40	cl	1.45	38.81	9.18
IIC1k	90-127	10.19	14.86	24.05	50.75	25.20	sil	1.48	39.83	8.94

Texture: c: clay, cl: clay loam, sicl: silty clay loam, sil: silt loam, l: loam

Table 3: Mechanical composition and other physical characteristics of representative pedons of north-west Gir Madhuvanti toposequence of south Saurashtra (Weighted mean)

Pedon & toposequence	Coarse sand (%)	Fine sand (%)	Total sand (%)	Silt (%)	Clay (%)	Bulk density (Mg m^{-3})	Pore space (%)	Expansion (%)
1	2	3	4	5	6	7	8	9
Pedon-1 Hill slope (Karsangadh), MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents								
P_1	17.73	17.08	34.81	36.29	28.90	1.23	46.75	9.29
Pedon-2 Upper piedmont (Malanka), MSL :155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents								
P_2	11.10	11.84	22.94	43.65	33.40	1.28	45.34	7.27
Pedon-3 Lower piedmont (Mendarda), MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts								
P_3	6.08	8.17	14.26	29.50	56.23	1.24	47.00	15.71
Pedon-4 Plain area (Tinmus), MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts								
P_4	13.97	10.24	24.22	37.13	38.65	1.33	44.62	13.19
Pedon-5 Depression area (Akhodar), MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts								
P_5	10.39	9.28	19.67	40.25	40.07	1.34	44.19	12.78
Pedon-6 Upper coast (Madhavpur), MSL : 5 m, 21^{0}16 N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts								
P_6	9.42	12.14	21.07	46.61	32.31	1.43	39.91	11.04
Overall mean	11.44	11.46	22.83	38.90	38.26	1.31	44.63	11.55

Table 4: Hydrological characteristics of representative pedons of north-west Gir Madhuvanti toposequence of south Saurashtra

Horizon	Depth (cm)	MWHC (%)	Sat. H.C. (cm hr^{-1})	Moisture retention (m^{-3}m^{-3}) at different tension (MPa)						AWC (m^{-3}m^{-3})	MWHC (v/v %)	PAWC	Moisture retention	Total PAWC	Total WSC	PAWC / WSC
				0.03	0.05	0.10	0.50	1.0	1.5			(cm ha^{-1})		(m ha^{-1})		
Pedon-1 Hill slope (Karsangadh) slope:15-30%, drainage: somewhat excessive, erosion: severe, MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents																
A1	0-25	45.66	0.18	0.38	0.34	0.31	0.29	0.26	0.24	0.14	56.18	3.50	14.04	0.035	0.140	0.250
R	25+															
Pedon-2 Upper piedmont (Malanka) slope:3-8 %, drainage: well, erosion: moderate, MSL : 155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents																
Ap	0-12	44.70	0.10	0.31	0.26	0.22	0.19	0.16	0.14	0.17	55.87	2.04	6.70	0.044	0.146	0.301
BCk	12-27	40.39	0.07	0.29	0.25	0.21	0.17	0.14	0.13	0.16	52.90	2.40	7.93			
R	27+															
Pedon-3 Lower piedmont (Mendarda) slope:1-3%, drainage: well, erosion: slight, MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts																
Ap	0-28	51.28	0.11	0.51	0.41	0.38	0.34	0.29	0.23	0.28	63.33	7.84	17.73	0.190	0.444	0.428
B1	28-44	52.44	0.12	0.53	0.45	0.41	0.36	0.31	0.24	0.29	65.28	4.64	10.44			
BC	44-70	49.21	0.14	0.48	0.40	0.37	0.32	0.28	0.23	0.25	62.48	6.50	16.24			
R	70+															
Pedon-4 Plain area (Tinmus) slope:0-1%, drainage: well, erosion: slight, MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts																
Ap	0-19	47.86	0.03	0.45	0.40	0.36	0.32	0.28	0.23	0.22	62.69	4.18	11.91	0.177	0.569	0.311
A2	19-45	46.21	0.02	0.42	0.37	0.34	0.30	0.27	022	0.20	60.99	5.20	15.85			
A3ss	45-60	48.04	0.01	0.43	0.39	0.35	0.32	0.28	0.21	0.22	63.41	3.30	9.51			
AC1	60-74	43.70	0.01	0.37	0.33	0.30	0.28	0.25	0.21	0.16	59.43	2.24	8.32			
AC2	74-94	41.12	0.00	0.34	0.31	0.29	0.26	0.23	0.20	0.14	56.74	2.80	11.34			
Pedon-5 Depression area (Akhodar) slope:0-1%, drainage: moderately well, erosion: slight, MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts																
Ap	0-28	47.48	0.02	0.44	0.39	0.36	0.32	0.28	0.22	0.22	62.67	6.16	17.54	0.220	0.655	0.336
A2	28-57	46.44	0.01	0.43	0.39	0.35	0.30	0.27	0.21	0.22	62.22	6.38	18.04			
A3	57-76	48.15	0.01	0.43	0.38	0.34	0.29	0.26	0.22	0.21	65.48	3.99	12.44			

AC1	76-87	46.93	0.00	0.42	0.38	0.34	0.30	0.27	0.22	0.20	63.41	2.20	6.97			
AC2	87-105	43.92	0.00	0.40	0.37	0.33	0.28	0.25	0.20	0.18	60.17	3.24	10.83			
Pedon-6 Upper coast (Madhavpur) slope:0-1%, drainage: imperfect, erosion: slight, MSL : 5 m, 21^{0}16' N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts																
Ap	0-20	48.88	0.02	0.45	0.39	0.35	0.31	0.27	0.22	0.23	64.52	4.60	12.90			
B1	20-48	47.91	0.01	0.44	0.38	0.34	0.30	0.27	0.21	0.23	63.24	6.44	17.70			
B2k	48-65	49.61	0.00	0.46	0.41	0.36	0.31	0.28	0.21	0.25	65.98	4.25	11.21	0.272	0.778	0.349
IC1k	65-90	42.03	0.00	0.41	0.38	0.33	0.28	0.25	0.20	0.21	58.00	5.25	14.50			
IIC1k	90-127	41.24	0.00	0.37	0.34	0.30	0.26	0.23	0.19	0.18	58.14	6.66	21.51			

Table 5: Hydrological characteristics of representative pedons of north-west Gir Madhuvanti toposequence of south Saurashtra (Weighted mean)

Pedon & toposequence	MWHC (%)	Sat. H.C. (cm hr^{-1})	Moisture retention (m^{-3}m^{-3}) at different tension (MPa)						AWC (m^{-3}m^{-3})	MWHC (v/v %)	Total PAWC	Total WSC	PAWC /WSC
			0.03	0.05	0.10	0.50	1.0	1.5			(m ha^{-1})		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Pedon-1 Hill slope (Karsangadh), MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents													
P_1	45.66	0.18	0.38	0.34	0.31	0.29	0.26	0.24	0.14	56.18	0.035	0.140	0.250
Pedon-2 Upper piedmont (Malanka), MSL :155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents													
P_2	42.30	0.08	0.29	0.25	0.21	0.17	0.14	0.13	0.16	54.22	0.044	0.146	0.301
Pedon-3 Lower piedmont (Mendarda), MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts													
P_3	50.77	0.12	0.50	0.41	0.38	0.33	0.29	0.23	0.27	63.46	0.190	0.444	0.428
Pedon-4 Plain area (Tinmus), MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts													
P_4	45.38	0.01	0.40	0.36	0.33	0.29	0.26	0.21	0.19	60.58	0.177	0.569	0.311
Pedon-5 Depression area (Akhodar), MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts													
P_5	46.64	0.00	0.42	0.38	0.34	0.30	0.26	0.21	0.21	62.70	0.220	0.655	0.336
Pedon-6 Upper coast (Madhavpur), MSL : 5 m, 21^{0}16 N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts													
P_6	45.19	0.00	0.42	0.37	0.33	0.28	0.25	0.20	0.22	61.29	0.272	0.778	0.349
Overall mean	45.99	0.06	0.40	0.35	0.31	0.27	0.24	0.20	0.20	59.74	0.156	0.455	0.329

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