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Soil-site suitability evaluation for coconut and oil palm in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat

Chouthu Ram Hakla, SG Savalia, Kalu Ram Kumawat, Devendra Dambiwal and Mahendra Choudhary

Abstract
Six representative pedons were evaluated for their soil site suitability for coconut and oil palm in the soils of different land slopes of north-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat. The soils of lower piedmont belong to Vertic Haplusterts (P_3), plain area belong to Typic Haplusterts (P_4) and depression area belong to Sodic Haplusterts (P_5) were marginally suitable (S_3) for coconut and oil palm. The soils of hill slopes belong to Lithic Ustorthents (P_1) and upper piedmont belong to Lithic Ustorthents (P_2) were currently not suitable (N_1) for coconut and oil palm. The soils of upper coast belong to Fluventic Calciustepts (P_6) were marginally suitable (S_3) for coconut and currently not suitable (N_1) for oil palm. Topography, drainage, shallow soil depth, low rainfal, texture, poor soil fertility (soil pH) soil salinity and alkalinity are the major limitations for cultivation of coconut and oil palm in soils of north-west Gir Madhuvanti toposequence of south Saurashtra.

Keywords: soil-site suitability, land slopes, coconut, oil palm, toposequence

Introduction
The coconut Kalpvriksh (Tree of heaven) is a most beautiful and useful versatile tropical plant plays a major role in the economy of India. The coconut palm exerts a profound influence on the rural economy of the many states where it is grown extensively and it provides sustenance to more than 10 million people. Coconut is widely used coconut oil, milk, cream, coconut water, desiccated coconut, coconut flour, oil cake, soaps, hair oil, cosmetics, coir and coconut fiber. Oil palm is a tropical tree crop which is demand continues to grow because it is the most versatile of all vegetable oils. Increasing population requirement increases of edible oil demand. 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. With the increase of demand for land, land evaluation has become more important as people strive to make better use of the limited land resources. Land evaluation is the process of assessment land performance for specified purposes. Yield of any crop is influenced by kind of soils occurring in the area, prevailing climate, topography and management levels. The crop management practices based soil and site suitability criteria may help to overcome the constraints of crop planning for maximizing the production. It also helps in appraisal of suitability of a particular crop in specific soil / area. Land suitability evaluation is the process of estimating the potential of land for land use planning (F. A. O., 1976, Sys *et al.*, 1991, Savalia, 2005, Patel, 2010 and Gandhi *et al*., 2013) [2, 11, 10, 9, 3].

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. Horizon-wise soil samples collected from the typifying pedons were analysed for their physical and chemical characteristics following standard procedure and soils were classified according to Key to Soil

Taxonomy (Anonymous, 2003) [1].
The soil-site suitability for coconut and oil palm were carried out using limitation method and matched with generated data (Table: 1 and 2) at different limitation level: S_1- highly suitable, S_2- moderately suitable, S_3- marginally suitable, N_1- currently not suitable and N_2- not suitable. The soil-site suitability for coconut was carried out by Naidu *et al.,* (1997) [6] and for oil palm was carried out by NBSS & LUP (1994) [7].

Results and discussion
In general, the soils of of north-west Gir Madhuvanti toposequence were moderately alkaline in reaction, low in organic carbon and highly calcareous in nature. The soil at higher elevation have low in pH, EC, CEC, BSP and ESP then the lower elevation (Table - 3).
Soil-site suitability for different land uses is very important for alternate and suitable land use planning. The soil site evaluation and land use criteria of different land slope are given in Table-4 and Table-5. The soil-site suitability evaluation for coconut and oil palm based on comparison of land qualities and crop requirements is given in Table 6.

Pedon-1 (Karsangadh) from the Hill slope: The soils associated with this pedon were currently not suitable (N_1) for coconut and oil palm cultivation. Major limitations for coconut like low rainfall, topography, somewhat excessive drainage, shallow soil depth and poor soil fertility (high soil pH) and for oil palm like low rainfall, high temp., topography, somewhat excessive drainage, shallow soil depth and poor soil fertility (high soil pH). Soil conservation measures like graded narrow bunds, bench terracing and trenches are recommended to increase soil depth/rooting volume and contour bunding should be adopted. Similar results were obtained by Gundalia *et al.,* (2000) [5].

Pedon-2 (Malanka) from the Upper piedmont: The soils associated with pedon P_2 have been found to be currently not suitable (N_1) for coconut and oil palm cultivation. Major limitations for coconut like low rainfall, shallow soil depth and poor soil fertility (high soil pH). Major limitations for oil palm like high temperature, low rainfall, shallow soil depth and poor soil fertility (high soil pH). Graded narrow base terrace bunds or trenches are recommended to increase soil depth/rooting volume, conservation tillage and forage-based crop rotations which reduce erosion and allow soil forming factors to maintain and rehabilitate top soil. Similar results were obtained by Gundalia *et al.,* (2000) [5], Savalia (2005) [10] and Patel (2010) [9].

Pedon-3 (Mendarda) from the Lower piedmont: The soils associated with pedon P_3 have been found to be marginally suitable (S_3) for coconut major limitation like low rainfall, soil depth, texture and poor soil fertility (high soil pH) and also marginally suitable (S_3) for oil palm major limitation like low rainfall, high temperature, texture, soil depth, poor soil fertility (high soil pH), soil salinity and alkalinity. On adoption of corrective measures of mulching, use of organic manures, zero or minimum tillage, broad beds and furrow system should be practiced the suitability class could be corrected. Similar observations were also made by Patel (2010) [9] and Niranjana *et al.,* (2011) [8].

Pedon-4 (Tinmus) from the Plain area: The soils associated with pedon P_4 have marginally suitable (S_3) for coconut major limitation like low rainfall, soil depth, texture and poor soil fertility (high soil pH) and also marginally suitable (S_3) for oil palm major limitation like low rainfall, high temperature, texture, soil depth, poor soil fertility (high soil pH), soil salinity and alkalinity. On adoption of corrective measures of mulching, broad beds and furrow system, rain water leaching, use of organic manures and use of gypsum *etc* the suitability class could be corrected. Similar observations were also made by Patel, (2010) [9] and Niranjana *et al.,* (2011) [8].

Pedon-5 (Akhodar) from the Depression area: The soils associated with pedon P_5 have been found to be marginally suitable (S_3) for coconut major limitation like low rainfall, drainage, texture and poor soil fertility (high soil pH). Oil palm have been found to be marginally suitable (S_3) major limitation like low rainfall, high temperature, texture, drainage, poor soil fertility (high soil pH), soil salinity and alkalinity. On adoption of corrective measures like provision of surface drainage through lateral ditch, mulching, use of organic manures, use of gypsum and soil and water conservation practices could be adopted these soils to make them productive. Similar observations were made by Savalia (2005) [10] and Patel (2010) [9].

Pedon-6 (Madhavpur) from the Upper coast: The soils associated with pedon P_6 have been evaluated to be marginally suitable (S_3) for coconut major limitation like low rainfall, drainage and poor soil fertility (high soil pH). Oil palm have been found to be currently not suitable (N_1) major limitation like low rainfall, high temperature, drainage, texture, poor soil fertility (high soil pH), severe soil salinity and alkalinity. On adoption of corrective measures like provision of surface drainage through lateral ditch (Giri *et al.,* 1999) [4], use of organic manures along with gypsum and nitrogenous fertilizers and soil and water conservation practices could be adopted in these soils to make them productive. Similar observations were done by Savalia (2005) [10] and Patel (2010) [9].

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. The soils of lower piedmont belong to Vertic Haplusterts (P_3), plain area belong to Typic Haplusterts (P_4) and depression area belong to Sodic Haplusterts (P_5) were marginally suitable (S_3) for coconut and oil palm. The soils of hill slopes belong to Lithic Ustorthents (P_1) and upper piedmont belong to Lithic Ustorthents (P_2) were currently not suitable (N_1) for coconut and oil palm. The soils of upper coast belong to Fluventic Calciustepts (P_6) were marginally suitable (S_3) for coconut and currently not suitable (N_1) for oil palm.

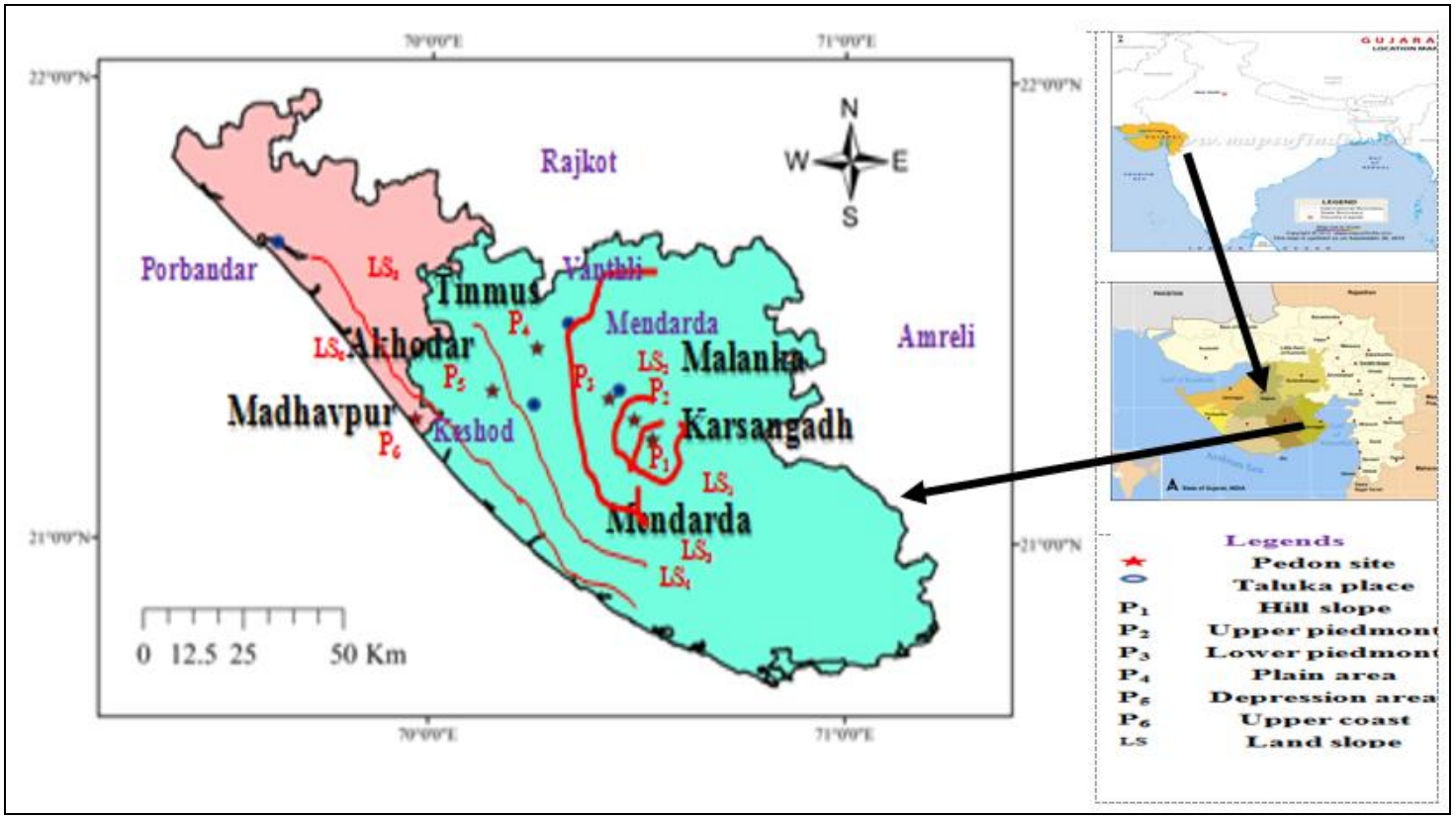

Fig 1: Site of pedons of north-west Gir Madhuvanti toposequence in South Saurashtra

Table 1: Climate and soil-site suitability criteria for coconut (Naidu *et al.*, 1997) [6]

Land-use requirement	Soil-site characteristics	Highly suitable S_1	Moderately suitable S_2	Marginally suitable S_3	Currently not suitable N_1
Climatic regime	Mean temp, in growing season (°C)	26-29	23-25 30-32	33-34 20-22	
	Total rainfall (mm)	1500-2500	1000-1500	500-1000	<500
	Dry months (months with <50 mm rainfall)	<3	4-5	6-7	-
Land quality	Land characteristics				
Oxygen availability to roots	Depth of water table (M)	2-3	1-2	0.5-1	-
	Soil drainage	WD	MW	IM to ED	PD
Nutrient availability	Texture	scl, sil, cl, sc, sicl	sl, sic, c (non-swelling)	C (swelling), ls, s	-
	pH (1:2.5)	5.1-6.5	6.6-7.5; 4.5-5.0	7.6-8.5; 4.0-4.4	-
Rooting conditions	Effective soil depth (cm)	>100	75-100	50-75	<50
	Coarse fragments (vol %)	<15	>15-35	35-50	>50
Erosion	Slope	<8	8-15	15-30	-

Table 2: Climate and soil-site suitability criteria for oil palm (NBSS & LUP, 1994) [7].

Land-use requirement	Soil-site characteristics	Highly suitable S_1	Moderately suitable S_2	Marginally suitable S_3	Currently not suitable N_1
Climatic regime	Mean temp, in growing season (°C)	28-33	27-26 34-35	>35	
	Total rainfall (mm)	2000-2800	1500-2000	1000-1500	<1000
	Mean relative humidity (%)	>75	75-60	50-60	<50
	Months with rainfall <100 (mm)	<3	3-4	>4	-
Land quality	Land characteristics				
Oxygen availability to roots	Soil drainage	WD	MW to IM	ED to P	PD
	Depth of water table (cm)	>250	100-250	<100	-
Nutrient availability	Texture	cl, scl, l, sil	sl, sicl, c, sic	ls, s, c (swelling)	-
	pH (1:2.5)	5.0-6.5	6.6-8.0; 4.0-4.9	>8.0; <4.0	>6.5
Rooting conditions	Effective soil depth (cm)	>100	75-100	50-75	<50
	Stoniness (%)	Nil	>15-35	>35	>35
Soil toxicity	Salinity (ECe) (dS m^{-1})	1-2	2-4	4-8	>8
	Sodicity (ESP)	Non-sodic	<10	10-15	-
Erosion	Slope	5-10	10-17	18-25	>25

Table 3: Soil-site suitability evaluation and land qualities for the coconut and oil palm of the soils of north-west Gir Madhuvanti toposequence of south Saurashtra

Pedon No.	Climate (c)		Wetness (w)		Physical & chemical characteristics (s)			Soil fertility characteristics (f)				Salinity/ alkalinity (n)	
	Rainfall (mm)	Temp. (^{0}C)	Topography (slope %)	drainage	Texture	Soil depth (cm)	$CaCO_3$ (%)	O.C. (%)	BSP	CEC (cmol(p^+) kg^1)	pH	ECe (dSm^{-1})	ESP
P_1	1120	27.31	15-30	Somewhat excessive	L	25	2.75	0.84	88.44	20.60	6.79	0.63	0.53
P_2	1120	27.31	3-8	Well	Cl	27	31.80	0.68	91.36	25.78	7.90	0.88	2.56
P_3	1120	27.31	1-3	Well	C	70	19.81	0.60	92.03	30.83	8.04	2.86	5.80
P_4	1120	27.31	0-1	Well	C	94	19.98	0.50	94.04	34.66	8.13	5.95	10.80
P_5	1120	27.31	0-1	Moderately Well	C	105	21.05	0.49	94.10	42.94	8.20	7.86	13.03
P_6	1120	27.31	0-1	Imperfect	Sicl	127	25.20	0.37	96.31	43.96	8.28	11.82	16.93

c – Clay, sicl – Silty clay loam, l – Loam, cl – Clay loam

Table 4: Soil-site suitability evaluations for coconut in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra

Pedon No.	Climate (c)		Wetness (w)		Physical & chemical characteristics (s)		Soil fertility characteristics (f)		Crop suitability class
	Rainfall (mm)	Temp. (^{0}C)	Topography (slope %)	drainage	Texture	Soil depth (cm)	BSP	pH	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
P_1	S_2	S_1	S_3	S_3	S_1	N_1	S_1	S_2	N_1 cwsf
P_2	S_2	S_1	S_1	S_1	S_1	N_1	S_1	S_3	N_1 csf
P_3	S_2	S_1	S_1	S_1	S_3	S_3	S_1	S_3	S_3 csf
P_4	S_2	S_1	S_1	S_1	S_2	S_2	S_1	S_3	S_3 csf
P_5	S_2	S_1	S_1	S_2	S_2	S_1	S_1	S_3	S_3 cwsf
P_6	S_2	S_1	S_1	S_3	S_1	S_1	S_1	S_3	S_3 cwf

Table 5: Soil-site suitability evaluations for oil palm in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra

Pedon No.	Climate (c)		Wetness (w)		Physical & chemical characteristics (s)		Soil fertility characteristics (f)	Salinity/ alkalinity (n)		Crop suitability class
	Rainfall (mm)	Temp. (^{0}C)	Topography (slope %)	drainage	Texture	Soil depth (cm)	pH	ECe (dSm^{-1})	ESP	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
P_1	S_3	S_2	S_3	S_3	S_1	N_1	S_2	S_1	S_1	N_1 cwsf
P_2	S_3	S_2	S_1	S_1	S_1	N_1	S_2	S_1	S_1	N_1 csf
P_3	S_3	S_2	S_1	S_1	S_3	S_3	S_3	S_2	S_2	S_3 csfn
P_4	S_3	S_2	S_1	S_1	S_2	S_2	S_3	S_3	S_3	S_3 csfn
P_5	S_3	S_2	S_1	S_2	S_2	S_1	S_3	S_3	S_3	S_3 cwsfn
P_6	S_3	S_2	S_1	S_2	S_2	S_1	S_3	N_1	N_1	N_1 cwsfn

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable, N_1= Currently not suitable

Table 6: Limitation levels of the land characteristics and land suitability class for coconut and oil palm

No. of Pedon	Sub group	Soil-site suitability class for	
		Coconut	Oil palm
Pedon-1(P_1)	Hill slope (Karsangadh), MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents	N_1 cwsf	N_1 cwsf
Pedon-2 (P_2)	Upper piedmont (Malanka), MSL :155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents	N_1 csf	N_1 csf
Pedon-3 (P_3)	Lower piedmont (Mendarda), MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts	S_3 csf	S_3 csfn
Pedon-4 (P_4)	Plain area (Tinmus), MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts	S_3 csf	S_3 csfn
Pedon-5 (P_5)	Depression area (Akhodar), MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts	S_3 cwsf	S_3 cwsfn
Pedon-6 (P_6)	Upper coast (Madhavpur), MSL : 5 m, 21^{0}16 N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts	S_3 cwf	N_1 cwsfn

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable, N_1 = Currently not suitable, w = Wetness, s =Physical characteristics, f = Soil fertility characteristics, n = Salinity/Alkalinity hazard

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