SOIL-SITE SUITABILITY EVALUATION FOR GRAM, GREEN GRAM AND CLUSTER BEAN IN THE SOILS OF NORTH-WEST GIR MADHUVANTI TOPOSEQUENCE OF SOUTH SAURASHTRA REGION OF GUJARAT

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ABSTRACT

Six representative pedons were evaluated for their suitability of three legume crops (gram, green gram and cluster bean) in the soils of different land slope of north-west Gir Madhuvanti toposequence of south Saurashtra region of Gujarat. The land slopes, lower piedmont belong to Vertic Haplusterts (P_3) were marginally suitable (S_3) for gram, green gram and cluster bean, whereas upper piedmont belong to Lithic Ustorthents (P_2) were marginally suitable (S_3) for green gram and gram. The soils hill slopes belong to Lithic Ustorthents (P_1), plain area belong to Typic Haplusterts (P_4), depression area belong to Sodic Haplusterts (P_5) and upper coast belong to Fluventic Calciustepts (P_6) were currently not suitable (N_1) for gram, green gram and cluster bean, whereas upper piedmont belong to Lithic Ustorthents (P_2) were currently not suitable (N_1) for cluster bean. Topography, drainage, shallow soil depth, high $CaCO_3$, poor soil fertility (high pH), soil salinity and sodicity are the major limitations in most soils of north-west Gir Madhuvanti toposequence of south Saurashtra. Results showed that the suitability classes can be improved if the correctable limitations (soil fertility characteristics) are altered through soil amelioration measures.

KEY WORDS: Cluster bean, Gran, Green gram, Land slopes, North-West Gir Madhuvanti Toposequence, Soil-site suitability

INTRODUCTION

The demands on the finite land resources are increasing exponentially due to the growing population for meeting the needs of food, fodder, fuel, fiber and other raw materials. Gram, green gram and cluster bean are grown extensively in different parts of the country. Pulses are second important constituent of Indian diet after cereals. Over 60 per cent of total utilization of pulses is for human consumption. The share of food use in total utilization of pulses in the developing countries is over 75 per cent. In order to develop some understanding on the nature of the and / or the potential for agriculture production such evaluation will help in the future planning for optimum use of natural resources. Soil degradation is a

major threat to food security in many areas. The improving legumes based cropping system for food security reduces soil degradation. Legumes, because of their role in improving sustainability notably through soil management also impact food security. The present study was undertaken to evaluate soil-site suitability of gram, green gram and cluster bean.

MATERIALS AND METHODS

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 meter above mean sea level. IRS IA LISS II FCC imagery on 1:50,000 scale in conjunction with Survey of India (SOI) topographical 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) (Figure 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 analyzed for their physical and chemical characteristics following standard procedure and soils were classified according to Key to Soil Taxonomy (Anonymous, 2003). The soil-site suitability for legumes were carried out using limitation method according to FAO, 1976 and Sys *et al.* (1991) for gram and green gram and Natarajan *et al.* (2002) for cluster bean, and matched with generated data (Table 1, 2, 3 and 4) 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 (Sys *et al*., 1991).

RESULTS AND DISCUSSION

The soils of different pedons of north-west Gir Madhuvanti toposequence of south Saurashtra region contained the total sand, silt and clay content with mean values of 22.83, 38.90 and 38.26 per cent, respectively indicating dominant of loam to clayey texture. The soil pH, organic carbon, ECe and $CaCO_3$ ranged from 6.79 to 8.28, 0.37 to 0.84 per cent, 0.63 to 11.82 dS/m and 2.75 to 31.80 per cent with the overall mean value of 7.89, 0.58 per cent, 5.00 dS/m and 19.93 per cent, respectively. The cation exchange capacity, BSP and ESP in the studied soils ranged from 20.60 and 43.96 cmol (P^+)/kg, 88.73 to 96.31 and 0.51 to 16.93 with the mean value of 33.18 cmol(p+)/kg, 92.71 and 8.27 (Table 5). In general, the soils 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 were low in pH, ECe, CEC, BSP and ESP then lower elevation (Savalia, 2005; Leelavathi *et al*., 2009; Gandhi *et al*., 2013 and Shirgire *et al.*, 2015).

Soil-site suitability for different land uses is very important for alternate and suitable land use planning. The soils under study have been rated for legumes. Land suitability for legume crops and land quality ratings was carried out according to FAO, 1976 and Sys *et al.* (1991) for gram and green gram, and Natarajan *et al.* (2002) for cluster bean. The legume suitability evaluations of pedons P_1 to P_6 of north-west Gir Madhuvanti toposequence are presented in Table 5-8.

Pedon-1 (Karsangadh) from the Hill slope

The soils associated with this pedon (P_1) were currently not suitable (N_1) for gram, green gram and cluster bean

cultivation because of major limitations like topography, somewhat excessive drainage and shallow soil depth. Soil conservation measures like graded narrow base terrace bunds or trenches and contour bunding should be adopted (Savalia *et al*., 2009).

Pedon-2 (Malanka) from the Upper piedmont

The soils associated with pedon (P_2) have been found to be marginally suitable (S_3) for gram and green gram cultivation as well as currently not suitable (N_1) for cluster bean because of major limitations like topography, shallow soil depth and high CaCO3. On adoption of corrective measures like 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 Savalia *et al*. (2009), Patel *et al*. (2012) and Gandhi *et al*., (2013).

Pedon-3 (Mendarda) from the Lower piedmont

The soils associated with pedon (P_3) have been found to be marginally suitable (S_3) for gram, green gram and cluster bean cultivation on account of major limitations like soil depth, soil pH, soil salinity and texture for gram and green gram; and texture, soil depth, high $CaCO_3$, soil pH and soil salinity for cluster bean. On adoption of corrective measures like use of organic manures along with balanced fertilizers, zero or minimum tillage, frequent inter culturing operations and application of weathered materials, gypsum and sand in furrow are found to be effective. Similar observations were made by Savalia (2005) and Patel *et al*. (2012).

Pedon-4 (Tinmus) from the Plain area

The soils associated with pedon (P_4) have currently not suitable (N_1) for gram, green gram and cluster bean cultivation on account of major limitations like soil pH, texture and soil salinity for green gram; texture, low soil fertility (low O.C.), soil pH, soil salinity and sodicity for gram; and texture, high $CaCO_3$, soil pH, soil salinity and sodicity for cluster bean. On adoption of corrective measures of mulching, rain water leeching and use of organic manures, continuous cropping with well ranged crops, reduce, zero or minimum tillage, frequent inter, application of *tanch* (murrum) gypsum and sand in furrow found effective, constant monitoring of soils and entire root zone requires to be flushed for which availability of good quality water is essential. Similar observations were made by Savalia (2005), Patel *et al*. (2012) and Gandhi *et al*. (2013).

Pedon-5 (Akhodar) from the Depression area

The soils associated with pedon (P_5) have been found currently not suitable (N_1) for gram, green gram cluster bean cultivation on account of major limitations like drainage, texture, high soil pH and salinity for green gram; drainage, texture, soil pH as well as salinity and sodicity for gram; and high $CaCO_3$, soil pH, soil salinity and sodicity for cluster bean. On adoption of corrective measures like provision of surface drainage through lateral ditch (Giri *et al*, 1999), adoption of salt tolerant varieties, mulching, use of organic manures, application of *tanch* (murrum) gypsum and sand in furrow found effective, constant monitoring of soils, soil and water conservation practices could be adopted these soils to make them productive. Similar observations were made by Savalia (2005), Patel *et al*. (2012) and Gandhi *et al*. (2013).

Pedon-6 (Madhavpur) from the Upper coast

The soils associated with pedon (P_6) have been found currently not suitable (N_1) for gram, green gram and cluster bean cultivation on account of major limitations like drainage, texture, soil pH as well as soil

salinity for green gram; drainage, texture, poor soil fertility (low O.C.), soil pH as well as soil salinity and sodicity for gram; and drainage, texture, high $CaCO_3$, soil pH, soil salinity and sodicity for cluster bean. On adoption of corrective measures like provision of surface drainage through lateral ditch (Giri *et al*, 1999), adoption of salt tolerant varieties, use of organic manures along with gypsum and nitrogenous fertilizers and soil and water conservation practices, proper sub-surface drainage need to be ascertained, lateral ditches can serve to drain the soils of excessive salts could be adopted these soils to make them productive. For severely degraded soils, xerophytic, halophytic trees, shrubs and grasses should be grown. Similar observations were done by Savalia (2005), Patel *et al*. (2012) and Gandhi *et al*. (2013).

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 land slopes, lower piedmont belong to Vertic Haplusterts (P_3) were marginally suitable (S_3) for gram, green gram and cluster bean, whereas upper piedmont belong to Lithic Ustorthents (P_2) were marginally suitable (S_3) for gram and green gram. The soils hill slopes belong to Lithic Ustorthents (P_1), plain area belong to Typic Haplusterts (P_4), depression area belong to Sodic Haplusterts (P_5) and upper coast belong to Fluventic Calciustepts (P_6) were currently not suitable (N_1) for gram, green gram and cluster bean, whereas upper piedmont belong to Lithic Ustorthents (P_2) were currently not suitable (N_1) for cluster bean. Corrective measures like use of organic manures along with gypsum and balanced fertilizers, soil and water conservation practices, could be adopted these soils to make them productive.

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Table 1: Climate and soil-site suitability criteria for gram (FAO, 1976 and Sys *et al.*, 1991)

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 at different stages (°C)	20-25	15-19	5-15, 26-30	<5>30,
	Total rainfall (mm)	800-1000	600-800	400-600	<400
Land quality					
Moisture availability	LCP (days) Short-duration varieties	>100	90-100	70-90	<70
	Long-duration varieties	>150	120-150	90-120	<90
Oxygen availability to roots	Soil drainage	WD	MWD, SED, ID	PD, ED	VPD
Nutrient availability	Texture	I, sil, cl, scl	sic, sicl, c	si, c > 60%	s, Is
	pH (1:2.5)	6.0-7.5	7.6-8.0	8,1-9.0	>9.0
Rooting conditions	Effective soil depth (cm)	>75	51-75	25-50	<25
	Gravel (%)	<15	15-35	>35	-
Soil toxicity	Salinity (ECe) (dSm^{-1})	<1.0	1.0-2.0	2.0-4.0	>4.0
	Sodicity (ESP)	<10	10-15	>15	-
Erosion hazard	Slope (%)	<3	3-5	5-10	-

Table 2: Climate and soil-site suitability criteria for green gram (FAO, 1976 and Sys *et al.*, 1991)

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 at different stages (°C)	20-35	18-20, 36-40	15-18, >40	
	Total rainfall (mm)	600-750	500-650, 1200-1500	300-500, >1500	
Land quality					
Moisture availability	LCP (days)	>60	45-60	<45	
Oxygen availability	Soil drainage	WD	MWD, SED, ID	PD, ED	VPD
Nutrient availability	Texture	*l, cl, scl, sil, c (m + k)*	sic, sicl, c(s)	Sl c > 60	Is, s
	pH (1:2.5)	6-7.5	5-5.9	>8.5	
Rooting conditions	Effective soil depth (cm)	*>75*	50-75	50-25	<25
	Gravel (%)	<15	15-35	35-40	>40
Soil toxicity	Salinity (ECe) ($dS\ m^{-1}$)	<1.0	1.0-2.0	2.0-4.0	>4.0
Erosion hazard	Slope (%)	<3	3-5	5-10	>10

Table 3: Climate and soil-site suitability criteria for cluster bean (Natarajan *et al*., 2002)

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)	24-33	22-23	20-21	<20
	Total rainfall (mm)	750-1000	500-750	250-500	<250
Oxygen availability to roots	Soil drainage	WD, MWD	SED, ID	PD	VP
Nutrient availability	Texture	sl, l scl, cl, sc	sic, sicl, c, ls	Heavy c	-
	pH (1:2.5)	6.0-8.0	8.1-8.5	8.6-9.5	>9.5
	$CaCO_3$ in root zone (%)	<15	15-25	25-30	>30
Rooting conditions	Effective soil depth (cm)	>75	50-75	25-50	<25
Soil toxicity	Salinity (ECe) (dSm^{-1})	<1.0	1.0-2.0	2.0-4.0	>4.0
	Sodicity (ESP)	<10	10-15	15-20	>20
Erosion hazard	Slope (%)	<5	5-10	10-15	>15

Table 4: Soil-site suitability evaluation and land qualities for gram, green gram and cluster bean of the soils of north-west Gir Madhuvanti toposequence of south Saurashtra

Pedon No.	Climate (c)		Wetness (w)		Physical and 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)	pH	ECe (dS/m)	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 5: Soil-site suitability evaluations for gram in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra (Sys *et al*., 1991 and FAO, 1976)

Pedon No.	Climate (c)		Wetness (w)		Physical Characteristics (s)		Soil Fertility Characteristics (f)			Salinity/ Alkalinity (n)		Crop Suitability Class
	Rainfall (mm)	Temp. (^{0}C)	Topography (slope %)	Drainage	Texture	Soil Depth (cm)	BSP	CEC (cmol(p^+)/kg)	pH	ECe (dS/m)	ESP	
P_1	S_1	S_1	N_1	S_2	S_1	S_3	S_1	S_1	S_1	S_1	S_1	N_1 ws
P_2	S_1	S_1	S_2	S_1	S_1	S_3	S_1	S_1	S_2	S_1	S_1	S_3 wsf
P_3	S_1	S_1	S_1	S_1	S_2	S_2	S_1	S_1	S_3	S_3	S_1	S_3 sfn
P_4	S_1	S_1	S_1	S_1	S_2	S_1	S_1	S_1	S_3	N_1	S_2	N_1 sfn
P_5	S_1	S_1	S_1	S_2	S_2	S_1	S_1	S_1	S_3	N_1	S_2	N_1 wsfn
P_6	S_1	S_1	S_1	S_2	S_2	S_1	S_1	S_1	S_3	N_1	S_3	N_1 wsfn

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable, N_1 = Currently not suitable (Source: Sys et al., 1991 and NBSS & LUP, 1994)

Table 6: Soil-site suitability evaluations for green gram in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra (Sys *et al*., 1991 and FAO, 1976)

Pedon No.	Climate (c)		Wetness (w)		Physical Characteristics (s)		Soil Fertility Characteristics (f)			Salinity/ Alkalinity (n)	Crop Suitability Class
	Rainfall (mm)	Temp. (^{0}C)	Topography (slope %)	Drainage	Texture	Soil Depth (cm)	BSP	CEC (cmol(p$^+$)/kg)	pH	ECe (dS/m)	
P_1	S_1	S_1	N_1	S_2	S_1	S_3	S_1	S_1	S_1	S_1	N_1 ws
P_2	S_1	S_1	S_2	S_1	S_1	S_3	S_1	S_1	S_2	S_1	S_3 wsf
P_3	S_1	S_1	S_1	S_1	S_2	S_2	S_1	S_1	S_2	S_3	S_3 sfn
P_4	S_1	S_1	S_1	S_1	S_2	S_1	S_1	S_1	S_2	N_1	N_1 sfn
P_5	S_1	S_1	S_1	S_2	S_2	S_1	S_1	S_1	S_2	N_1	N_1 wsfn
P_6	S_1	S_1	S_1	S_2	S_2	S_1	S_1	S_1	S_2	N_1	N_1 wsfn

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable, N_1 = Currently not suitable (Source: Sys et al., 1991 and NBSS & LUP, 1994)

Table 7: Soil-site suitability evaluations for cluster bean in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra (Natarajan *et al*., 2002)

Pedon No.	Climate (c)		Wetness (w)		Physical and 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)	$CaCO_3$ (%)	BSP	CEC (cmol(p$^+$)/kg)	pH	ECe (dS/m)	ESP	
P_1	S_1	S_1	N_1	S_2	S_1	S_3	S_1	S_1	S_1	S_1	S_1	S_1	N_1 ws
P_2	S_1	S_1	S_2	S_1	S_1	S_3	N_1	S_1	S_1	S_1	S_1	S_1	N_1 ws
P_3	S_1	S_1	S_1	S_1	S_2	S_2	S_2	S_1	S_1	S_2	S_3	S_1	S_3 sfn
P_4	S_1	S_1	S_1	S_1	S_2	S_1	S_2	S_1	S_1	S_2	N_1	S_2	N_1 sfn
P_5	S_1	S_1	S_1	S_1	S_2	S_1	S_2	S_1	S_1	S_2	N_1	S_2	N_1 sfn
P_6	S_1	S_1	S_1	S_2	S_2	S_1	S_3	S_1	S_1	S_2	N_1	S_3	N_1 wsfn

S_1 = Highly suitable, S_2 = Moderately suitable, S_3 = Marginally suitable, N_1 = Currently not suitable (Source: Sys et al., 1991 and NBSS & LUP, 1994)

Table 8: Limitation levels of the land characteristics and land suitability class for legumes

Number of Pedon	Sub Group	Soil-site Suitability Class for Legumes		
		Gram	Green gram	Clustebean
Pedon-1 (P_1)	Hill slope (Karsangadh), MSL : 190 m, $21^0$13' N latitudes, $70^0$32' E longitude, Lithic Ustorthents	N_1 ws	N_1 ws	N_1 ws
Pedon-2 (P_2)	Upper piedmont (Malanka), MSL :155 m, $21^0$16 N latitudes, $70^0$29' E longitude, Lithic Ustorthen	S_3 wsf	S_3 wsf	N_1 ws
Pedon-3 (P_3)	Lower piedmont (Mendarda), MSL : 92 m, $21^0$18 N latitudes, $70^0$25' E longitude, Vertic Haplustep	S_3 sfn	S_3 sfn	S_3 sfn
Pedon-4 (P_4)	Plain area (Tinmus), MSL : 27 m, $21^0$25' N latitudes, $70^0$15' E longitude, Typic Haplusterts	N_1 sfn	N_1 sfn	N_1 sfn
Pedon-5 (P_5)	Depression area (Akhodar), MSL : 13 m, $21^0$19' latitudes, $70^0$08' E longitude, Sodic Haplusterts	N_1 wsfn	N_1 wsfn	N_1 sfn
Pedon-6 (P_6)	Upper coast (Madhavpur), MSL : 5 m, $21^0$16 N latitudes, $69^0$57' E longitude, Fluventic Calciustepts	N_1 wsfn	N_1 wsfn	N_1 wsfn

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

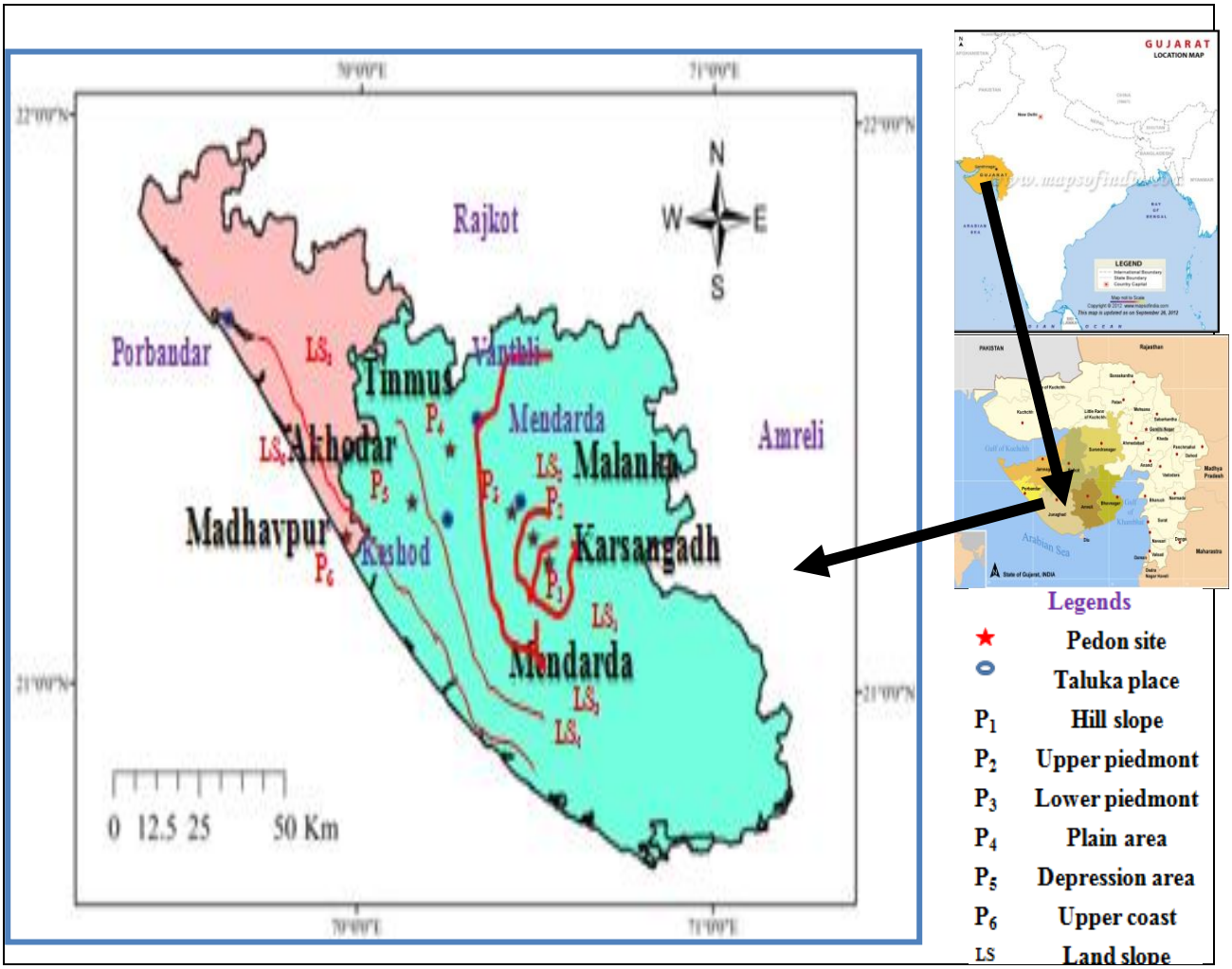

Figure 1: Site of pedons of north-west Gir Madhuvanti toposequence in South Saurashtra

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