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Soil-Site Suitability Evaluation for Rice and Wheat 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 two cereal crops (rice and wheat) 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 Rice and moderately suitable (S_2) for wheat. The upper piedmont belong to Lithic Ustorthents (P_2) were currently not suitable (N_1) for rice and marginally suitable (S_3) for wheat. The soils hill slopes belong to Lithic Ustorthents (P_1) were currently not suitable (N1) for rice and not permanently suitable (N_2) for wheat. The plain area belongs to Typic Haplusterts (P_4) were marginally suitable (S_3) for rice and wheat. The depression area belong to Sodic Haplusterts (P_5) were marginally suitable (S_3) for rice and currently not suitable (N_1) for wheat. The upper coast belong to Fluventic Calciustepts (P_6) were currently not suitable (N_1) for rice and not permanently suitable (N_2) for wheat. Topography, drainage, shallow soil depth, high $CaCO_3$, poor soil fertility (low O.C.), 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.

Keywords: *Soil-site suitability, Land slopes, North-West Gir Madhuvanti Toposequence, Rice and Wheat*

Introduction

It is clear that there is an urgent need to match land resource and land use in the most effective and logical way to continue sustainable production and to meet the needs of society, while conserving fragile ecosystems. Land resources are gradually becoming scarce as increases in population put pressure on natural resources. Population increases and urbanization have resulted in increased pressure on agricultural resources. The challenge in the next decades is to ensure that global and regional food security increases food production for the survival of the growing population. However, this puts increased pressure on land resources, which may result in land degradation, particularly in countries with restricted water and other natural resources. Therefore, increases in food production are urgently required to tackle poverty and land degradation problems in developing countries. Land suitability evaluation is well suited for identifying land boundaries, land use planning, specialization of crops in different regions, providing optimal cropping pattern and food policy. Land evaluation is concerned with the assessment of land performance when used for specified purposes. Rice and wheat is the most important human food crop in the world. Rice is the crop of tropical climate. About 90 % of rice grown in the world is produced and consumed in the Asia region. Wheat is an important winter cereal contributing about 32 % of the total food grain production in India. It is a second important staple food crop after rice.

Materials 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

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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 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 were carried out using limitation method according to NBSS & LUP (1990) for rice and Sys *et al.* (1991) and NBSS & LUP (1994) for wheat 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 permanently suitable (Sys *et al*., 1991).

Results and discussion

The soils of different pedons of north-west Gir Madhuvanti toposequence of south Saurashtra region, the total sand, silt and clay content 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 dSm^{-1} and 2.75 to 31.80 per cent with the overall mean value of 7.89, 0.58 per cent, 5.00 $dSm^{-1}$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^{-1}, 88.73 to 96.31 and 0.51 to 16.93 with the mean value of 33.18 cmol (p+) kg^{-1}, 92.71 and 8.27. 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 had low in pH, EC, 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 rice and wheat. Land suitability for rice and wheat crops and land quality ratings are those suggested by NBSS & LUP (1990) for rice and Sys *et al.* (1991) and NBSS & LUP (1994) for wheat. The rice and wheat suitability evaluations of pedons P_1 to P_6 of north-west Gir Madhuvanti toposequence are presented in Table 3-6.

Pedon-1 (Karsangadh) from the Hill slope:

The soil associated with this pedon (P_1) was currently not suitable (N_1) for rice cultivation because of major limitations topography, somewhat excessive drainage, shallow soil depth and high pH of soil. The soil was not permanently suitable (N_2) for wheat cultivation because of major limitations 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

Table 1: Climate and soil-site suitability criteria for Rice NBSS & LUP (1990)

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)	30-34	35-38	39-40	≥40
	Total rainfall (mm)	1110-1250	900-1110	750-900	<750
Oxygen availability to roots	Soil drainage	ID	MWD	WD, SED	ED
Nutrient availability	Texture	c, sic, cl, sicl, sc	scl, sil, l	sl, is	s
	pH (1:2.5)	5.5-6.5	6.4-7.5	7.6-8.5	>8.5
	$CaCO_3$ in root zone (%)	<15	15-25	25-30	>30
Rooting conditions	Effective soil depth (cm)	>75	51-75	25-50	<25
Soil toxicity	Salinity (ECe) ($dS\ m^{-1}$)	<3	3-6	6-10	>10
	Sodicity (ESP) (%)	<15	15-40	40-50	>50
Erosion hazard	Slope (%)	0-1	1-3	3-5	>5

Table 2: Climate and soil-site suitability criteria for Wheat (Sys *et al.* 1991 and NBSS & LUP 1994)

Land characteristics	S_1	S_2	S_3	N_1	N_2
Climatic (c)					
Precipitation	700-350	350-250	250-200	-	<200
Monthly rainfall veg. stage	65-20	20-12	12-8	-	<8
Monthly rainfall flowering stage	75-30	30-15	15-10	-	<10
Monthly rainfall ripening stage	60-30	30-10	<10	-	-
Mean temperature (^{0}C)					
Mean temp. vegetative stage	10-6	6-4	4-2	-	<2
Flowering stage	18-12	12-10	10-8	-	<8
Ripening stage	20-14	14-12	12-10	-	<10
Topography (t)					
Slope (%)	0-2	2-4	4-6	-	>6
Wetness					
Drainage	Good to moderate	Imperfect, **SED**	Poor	Poor but drain able	Poor, but not drainable
Physical characteristics (s)					
Texture	cl, l	Sicl, c	sl, lfs	-	cm, sicm
Coarse fragments (%)	0-15	15-35	35-55	-	>55
Soil depth (cm)	>50	50-20	20-10	-	<10
$CaCO_3$ (%)	3-30	30-40	40-60	-	>60
Gypsum (%)	0-5	5-10	10-20	-	>20
Soil fertility characteristics (f)					
CEC cmol (p^+) kg^{-1}	>16	<16 (-)	<16 (+)	-	-
BS (%)	>50	50-35	<35	-	-
pH, H_2O	7.0-8.2	8.2-8.3	8.3-8.5	-	>8.5
Organic carbon (%)	>0.4	<0.4	-	-	-
Salinity alkalinity (n)					
ECe (dsm^{-1})	0-3	3-5	5-6	6-10	>10
ESP (%)	0-20	20-30	30-45	-	>45

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

Pedon	Climate (c)		Wetness (w)		Physical & chemical characteristics (s)			Soil fertility characteristics (f)			Salinity/ alkalinity (n)	
No.	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	Some 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

been found to be currently not suitable (N_1) for rice cultivation because of major limitations like topography, drainage, shallow soil depth, soil pH as well as high $CaCO_3$ for rice. The soil was marginally suitable (S_3) for wheat on account of limitations like topography and shallow soil depth. 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 marginaly suitable (S_3) for rice cultivation

Table 4: Soil-site suitability evaluations for Rice crops in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra (NBBS & LUP, 1990)

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	drainage	Texture	Soil depth(cm)	$CaCO_3$(%)	pH	ECe (dSm^{-1})	ESP	
P_1	S_1	S_1	N_1	S_3	S_2	S_3	S_1	S_2	S_1	S_1	N_1 wsf
P_2	S_1	S_1	N_1	S_3	S_1	S_3	N_1	S_3	S_1	S_1	N_1 wsf
P_3	S_1	S_1	S_2	S_3	S_1	S_2	S_2	S_3	S_1	S_1	S_3 wsf
P_4	S_1	S_1	S_1	S_3	S_1	S_1	S_2	S_3	S_2	S_1	S_3 wsfn
P_5	S_1	S_1	S_1	S_2	S_1	S_1	S_2	S_3	S_3	S_1	S_3 wsfn
P_6	S_1	S_1	S_1	S_1	S_1	S_1	S_3	S_3	N_1	S_2	N_1 sfn

Table 5: Soil-site suitability evaluations for Wheat crops in the soils of north-west Gir Madhuvanti toposequence of south Saurashtra (Sys *et al*., 1991 and NBBS & LUP, 1994)

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	drainage	Texture	Soil depth(cm)	pH	O.C.	ECe (dSm^{-1})	ESP	
P_1	S_1	S_1	N_2	S_2	S_1	S_2	S_1	S_1	S_1	S_1	N_2 ws
P_2	S_1	S_1	S_3	S_1	S_1	S_2	S_1	S_1	S_1	S_1	S_3 ws
P_3	S_1	S_1	S_2	S_1	S_2	S_1	S_1	S_1	S_1	S_1	S_2 ws
P_4	S_1	S_1	S_1	S_1	S_2	S_1	S_1	S_1	S_3	S_1	S_3 sn
P_5	S_1	S_1	S_1	S_1	S_2	S_1	S_1	S_1	N_1	S_1	N_1 sn
P_6	S_1	S_1	S_1	S_2	S_2	S_1	S_2	S_2	N_2	S_1	N_2 wsfn

Table 6: Limitation levels of the land characteristics and land suitability class for Rice and Wheat

No. of Pedon	Sub group	Soil-site suitability class	
		Rice	Wheat
Pedon-1 (P_1)	Hill slope (Karsangadh), MSL : 190 m, 21^{0}13' N latitudes, 70^{0}32' E longitude, Lithic Ustorthents	N_1 wsf	N_2 ws
Pedon-2 (P_2)	Upper piedmont (Malanka), MSL :155 m, 21^{0}16' N latitudes, 70^{0}29' E longitude, Lithic Ustorthents	N_1 wsf	S_3 ws
Pedon-3 (P_3)	Lower piedmont (Mendarda), MSL : 92 m, 21^{0}18' N latitudes, 70^{0}25' E longitude, Vertic Haplusterts	S_3 wsf	S_2 ws
Pedon-4 (P_4)	Plain area (Tinmus), MSL : 27 m, 21^{0}25' N latitudes, 70^{0}15' E longitude, Typic Haplusterts	S_3 wsfn	S_3 sn
Pedon-5 (P_5)	Depression area (Akhodar), MSL : 13 m, 21^{0}19' N latitudes, 70^{0}08' E longitude, Sodic Haplusterts	S_3 wsfn	N_1 sn
Pedon-6 (P_6)	Upper coast (Madhavpur), MSL : 5 m, 21^{0}16 N latitudes, 69^{0}57' E longitude, Fluventic Calciustepts	N_1 sfn	N_2 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

on account of limitations like topography, drainage, soil depth, soil pH as well as high $CaCO_3$. The soil was moderately suitable (S_2) for wheat on account of major limitations like topography and soil texture. On adoption of corrective measures like use of organic manures along with balanced fertilizers, zero or minimum tillage, frequent inter culturing operation and application of weathered materials and sand in furrow are found to be effective. Similar observations were made by Savalia (2005) and Patel *et al*. (2012).

Pedon-4 (Tinmus) fro m the Plain area:

The soils associated with pedon (P_4) have marginally suitable (S_3) for rice on account of limitations like drainage, soil salinity, soil pH as well as high $CaCO_3$. The soils associated with pedon P_4 were marginally suitable (S_3) for wheat on account of limitations like texture and soil salinity. 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,

legumes based crop rotation, frequent Interculture operation, application of 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 marginally suitable (S_3) for rice on account of limitations like high $CaCO_3$, drainage, high soil pH and high salinity. The soils of this area were currently not suitable (N_1) for wheat on account of major limitations like texture and soil salinity. 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 sand in furrow found effective, legumes based crop rotation, 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 rice on account of limitations like high $CaCO_3$, high soil pH and high salinity and sodicity. The soils associated with upper coast were not permanently suitable (N_2) for wheat on account of limitations like drainage, texture, poor soil fertility (low O.C. and high pH), soil salinity and sodicity. 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, legumes based crop rotation 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).

References

Anonymous, (2003). Keys to Soil Taxonomy. USDA Natural Resources Conservation Service, Washington, D.C.

Gandhi, G.; Savalia, S. G. and Verma, H. P. (2013). Soil-site suitability evaluation for sesame in calcareous soils of Girnar toposequence in Southern Saurashtra region of Gujarat. *Journal of Agriculture for Sustainable Development.* **1**(1): 7-11.

Giri, J. D.; Singh, R. S.; Shyampura, R. L. and Jain, B. L. (1999). Soil and evaluation along coastal Gujarat for alternate land use options. *J. Indian Soc. Coastal Agric. Res.,* **17**(1&2): 76-79.

Leelavathi, G. P.; Naidu, M. V. S.; Ramavatharam, N. and Karunasagar, G. (2009). Studies on genesis, classification and evaluation of soils for sustainable land use planning in yerpedu mandal of Chittoor district. Andhra Pradesh. *J. of Indian soc. of soil sci*., **57**: 109-120.

NBSS and LUP, (1990). Soil resources of Tamil Nadu for land use planning- detailed report, Banglore center.

NBSS and LUP, (1994). *Proc*. National meets on soil-site suitability criteria for different crops. Feb. 7-8, 1994 held at NBSS and LUP (ICAR), New Delhi.

Patel, H. P.; Savalia, S.G. and Chopda, M. C. (2012). Evaluation of soil constraints and Soil-site suitability for groundnut in Meghal irrigation command area of southern saurashtra region of Gujarat. *An Asian J. Soil Science.* **7**(1): 131-137.

Savalia, S. G. (2005). Characterization, classification and evaluation of soil and water resources across the toposequences of Southern Saurashtra. Ph.D. Thesis submitted to J.A.U., Junagadh.

Savalia, S. G.; Kachhadiya, S. P.; Solanki, M. S. and Gundalia, J. D. (2009). Assessment and management of Soil Sustainability of calcareous soils in different landforms in a transect over basaltic trap. *An Asian J. Soil Science.* **4**(1): 86-92.

Shirgire, S. T.; Savalia, S. G.; Misal, N. B. and Singh, N. (2015). Evaluation of soil constraints and soil-site suitability for sesame in the soils of coastal area of Jamnagar district of Gujarat. *Research in Environment and Life Sciences.* **8**(3): 501-506.

Sys, I. C.; Vanrasant, B. and Debavye, J. (1991). Land evaluation, Part II and III. Methods in land evaluation. Agric. Pub. General administration for development co-operation place, de, camp de mars, 5 btc, 57-1050, Brussels, Belgium.