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Land evaluation for cotton suitability in a part of eastern Maharashtra plateau using remote sensing and GIS

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Abstract: The land resources in and around Mohgaon and Degma villages of Hingna tehsil, Nagpur district, Maharashtra were characterized using remote sensing and GIS techniques for cotton suitability. The variation in morphological, physical and chemical characteristics was governed by physiography, slope and erosion. Extremely shallow and well drained soils (Lithic Ustorthents) were found on the plateau summits and isolated mounds whereas deep soils (Vertic Haplustepts) were noticed in the main valley floor. The pH of soils ranged from 6.7 to 9.2 and organic carbon from 0.08 to 1.08 per cent in different horizons. The results revealed that Mohgaon-8 (Typic Haplustert) and Mohgaon-10 (Vertic Haplustept) were highly suitable; Mohgaon-5 (Typic Ustorthent), Mohgaon-9 (Typic Haplustept) were moderately suitable; Mohgaon-1, 2 and 7 (Lithic Haplustept) and Mohgaon-6 (Typic Ustorthent) were marginally suitable, whereas pedons representing Mohgaon-3 and 4 (Typic Ustorthents) were permanently not suitable.

***Additional Key words:** GIS, landform, land evaluation, remote sensing*

Introduction

The competing demands for finite land resources by different sectors emphasize the need for appropriate land use planning. This has focused our attention to develop alternative suitable land use options for sustaining the increasing population with environmental security. Therefore, the knowledge on nature and properties of soils, their relationship with landforms and spatial distribution is very essential for developing a suitable land use plans. Remote sensing

data has been found very useful for soil mapping at different levels (Ahuja *et al.* 1992). Maji and Krishna (1996) described reclassification techniques in GIS for thematic map generation and criterion based analysis for soil suitability evaluation. Spatial overlay, map generalization and feature extraction are some of the operations very useful in crop suitability analysis. Through present study, an attempt has been made to characterize the land resources for suitability evaluation of contton using remotely sensed data and GIS techniques.

Materials and methods

Study area in and around Mohgaon and Degma villages forms a part of Hingna Tehsil of Nagpur district, Maharashtra. It extends between 21°00' to 21°05' N latitudes and 78°50' to 78°55' E longitudes and covers an area of 8000 hecaters. The mean annual rainfall is 1070 mm and mean annual temperature is 26.6°C. The dominant vegetation observed are Palas (*Butea frondosa*), Teak (*Tectona grandis*), Tendu (*Diospyros tometosa*), Ber (*Zizyphus jujuba*), Anjan (*Terminalia arjuna*) and Neem (*Azadirachta indica*). IRS-1D, LISS-III digital data, acquired on 7th March 2000, and Survey of India toposheet (55K/16 on 1:50,000 scale) were used for delineation of landform units. On each landform, soil profiles were exposed and studied for their morphological properties. Horizon-wise soil samples were collected, processed and anlysed for physical and chemical properties following standard procedures. The area qualifies for *ustic* and *hyperthermic* moisture and temparature regiems respectively. The typifying pedons were classified (Soil survey staff 1999) and assessed for suitability of cotton following the criteria of NBSS&LUP (1994). Crop suitability model has been adopted in AGROMA GIS enviroment, where each class of different themes was assigned weightages based on the characteristics of the respective class. In the composite layer, the higher the cumulative value, the lower is the suitability of the soil unit, whereas, the lower the value, higher the suitability. Based on the relative cumulative values, the final map was reclassified and suitability classes for cotton were generated.

Results and discussions

Landform units

Ten distinct landform units namely, plateau summits, isolated mounds, linear ridges, escarpments, plateau spurs, subdued plateau, rolling plains, pediments, narrow valleys and main valley floor have been identified in the study area (Fig.1). Plateau summits are protruding towards the mainland with sharp side slopes. Isolated mounds are circular in nature and got influenced by circum-denudational geomorphic processes. Linear ridges are formed due to detachment as influenced by fluvial processes. The narrow and elongated escarpments (30-50 per cent slope) are associated with slope wash followed by rill and protogully formation. Plateau spurs are protruding towards rolling plains. Subdued plateau is under the influence of physical and chemical weathering processes. Pediments are the

Table 1. Site characteristics of the pedons

Pedon	Landform Unit	Slope (%)	Erosion	Runoff	Drainage	Surface stoniness (%)	Area (sq.km)	Area (%)
Mohgaon-1	Plateau summits	1-3	Moderate	Medium	Well	3-15	12.15	15.24
Mohgaon-2	Isolated mounds	3-8	Moderate	Medium	Some what excessive	15-40	0.92	1.15
Mohgaon-3	Linear ridges	30-50	Very severe	Very rapid	Excessive	15-40	0.40	0.50
Mohgaon-4	Escarpments	30-50	Severe	Rapid	Excessive	15-40	8.04	10.08
Mohgaon-5	Plateau spurs	1-3	Moderate	Medium	Well	15-40	6.45	8.09
Mohgaon-6	Subdued plateau	8-15	Severe	Rapid	Some what excessive	40-75	14.11	17.70
Mohgaon-7	Rolling plain	1-3	Moderate	Medium	Mod. well	<3	15.85	19.88
Mohgaon-8	Pediments	1-3	Moderate	Medium	Mod. well	<3	10.23	12.84
Mohgaon-9	Narrow valleys	0-1	Slight	Medium	Mod. well	3-15	7.27	9.11
Mohgaon-10	Main valley floor	1-3	Slight	Medium	Mod. well	3-15	3.40	4.27

result of deposits by alluvial sediments, which are regularly carried from upland areas and are mixed with sandy loam and clay fragments. Narrow valleys are elongated and are scooped out by the tributaries and subsequently filled up by the final sediments transported from the uplands. Main valley floor is predominantely depositional in nature and occupies the lowest portion of the study area. These sediments consist of fine to very fine clay particles, however, few pebbles and cobbles are also noticed at places.

Site and soil characteristics

Site characteristics of pedons are presented in Table 1. The pedons occurring on plateau summits, isolated mounds, plateau spurs, subdued plateau showed their colour in 5YR hue (Table 2). The pedons on escarpments are dark brown in colour in 7.5 YR hue, which may be due to the release of oxidized form of iron under well drained condition. The soils on linear ridges, rolling plain, pediments, narrow valleys, main valley floor are dark brown to very dark greyish brown in 10YR hue because pedon remain moist for longer period favouring reduction of iron. In this area, the textural variability is limited to clay (dominant) and sandy clay loam.

The medium, weak, subangular blocky structures are found in soils of plateau summits, isolated mounds, linear ridges, escarpments, plateau spurs, subdued plateau, narrow valleys and main valley floor. The soils occurring on pediments and rolling plains had medium moderate subangular blocky and medium strong angular blocky structure. The lower horizons of the soils in the pediments comprised of coarse strong angular blocky structures. Extremely shallow soils were associated with plateau summits and isolated mounds and shallow soils with linear ridges, escarpments and rolling plains (Fig.2). Moderately shallow soils occur on plateau spurs

Table 2. Some morphological, physical and chemical characteristics of soils

Soils	Land form unit	Depth (cm)	Horizon	Matrix colour D	Matrix colour M	Texture	Structure	Consistency	PH (1:2.5)	EC (1:2.5) (dsm^{-1})	OC (%)	Taxonomy
Mohgaon-1	Plateau summits	0-8	AP	10YR 4/3	10YR 4/2	c	m1 sbk	sh fr sp	7.1	0.10	0.52	Clayey, mixed Lithic Ustorthents
Mohgaon-2	Isolated mounds	0-8	AP	5YR 3/3	5YR 3/2	sc	m1 sbk	sh fr sp	6.8	0.10	0.87	Clayey- skeletal, mixed Lithic Ustorthents
Mohgaon-3	Linear ridges	0-10	AP	10YR 4/4	10YR 4/3	sc	m1 sbk	sh fr sp	6.7	0.12	0.75	Clayey, mixed Typic Ustorthents
Mohgaon-4	Escarpments	0-11	AP	7.5YR 4/4	7.5YR 4/3	c	m1 sbk	sh fr ss ps	7.1	0.07	0.29	Clayey, mixed Typic Ustorthents
Mohgaon-5	Plateau spurs	0-21	AP	5YR 3/2	5YR 3/2	c	m1 sbk	sh fr sp	6.8	0.07	0.67	Clayey, mixed Typic Ustorthents
Mohgaon-6	Subdued plateau	0-17	AP	5YR 3/3	5YR 3/2	sc	m1 sbk	sh fr sp	6.7	0.04	1.08	Clayey, mixed Typic Ustorthents
Mohgaon-7	Rolling plains	0-13	AP	10YR 4/2	10YR 3/2	sc	m2 sbk	h fr sp	7.7	0.11	0.43	Clayey, mixed Lithic
		13-32	Bw	10YR 3/2	10YR 3/2	c	m2 sbk	vh fr sp	7.9	0.04	0.43	Haplustepts
Mohgaon-8	Pediments	0-12	AP	10YR 4/2	10YR 3/2	c	m1 sbk	h fr vs vp	8.5	0.11	0.52	Fine, smectitic
		12-33	Bw1	10YR 4/2	10YR 3/2	sc	m3 abk	h fr vs vp	8.5	0.10	0.40	(calcareous) Typic
		33-73	Bw2	10YR 4/2	10YR 3/2	c	c3 abk	vh fr vs vp	8.8	0.17	0.38	Haplusterts
		73-95	Bss1	10YR 4/2	10YR 3/2	c	c3 abk	vh fr vs vp	9.0	0.25	0.14	
		95-109	Bss2	10YR 4/2	10YR 4/3	c	c3 abk	vh fr vs vp	9.2	0.27	0.11	
Mohgaon-9	Narrow valleys	0-12	AP	10YR 4/2	10YR3/3	sc	m1 sbk	sh fr sp	8.3	0.14	0.29	Fine, smectitic Typic
		12-36	Bw1	10YR 4/2	10YR3/3	c	m1 sbk	sh fr sp	8.4	0.11	0.17	Haplustepts
		36-52	Bw2	10YR 4/2	10YR3/3	c	m1 sbk	sh fr sp	8.5	0.09	0.20	
Mohgaon-10	Main valley floor	0-20	AP	10YR 4/2	10YR3/2	sc	m1 sbk	sh fr sp	8.2	0.25	0.38	Fine, smectitic
		20-44	Bw1	10YR 4/2	10YR4/3	c	m1 sbk	sh fr sp	8.3	0.14	0.20	(calcareous) Vertic
		44-65	Bw2	10YR 4/2	10YR4/3	c	m1 sbk	sh fr sp	8.4	0.12	0.14	Haplustepts
		65-87	Bw3	10YR 4/2	10YR4/3	c	m1 sbk	sh fr sp	8.3	0.13	0.08	

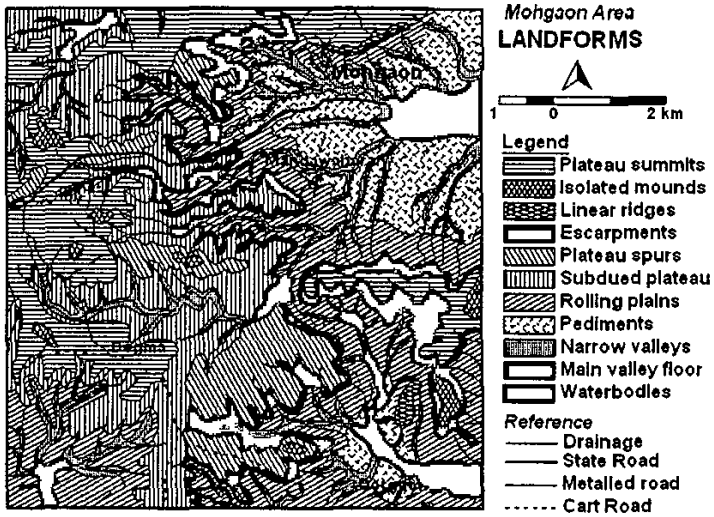

Fig. 1. Landforms

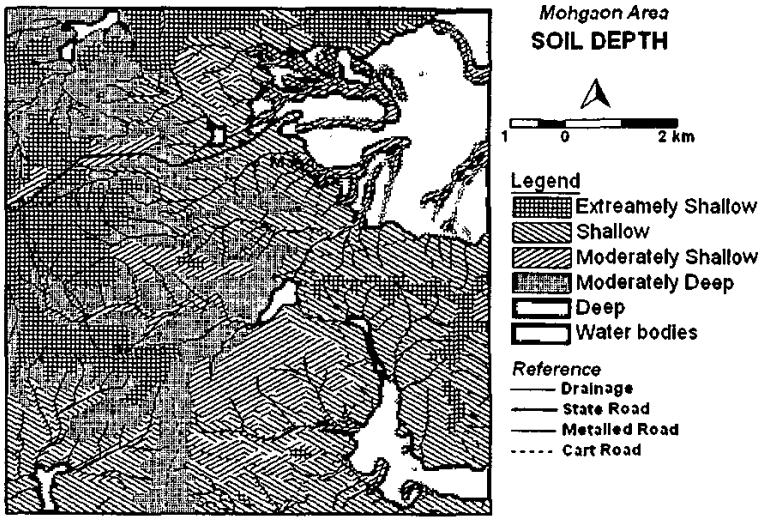

Fig. 2. Soil depth

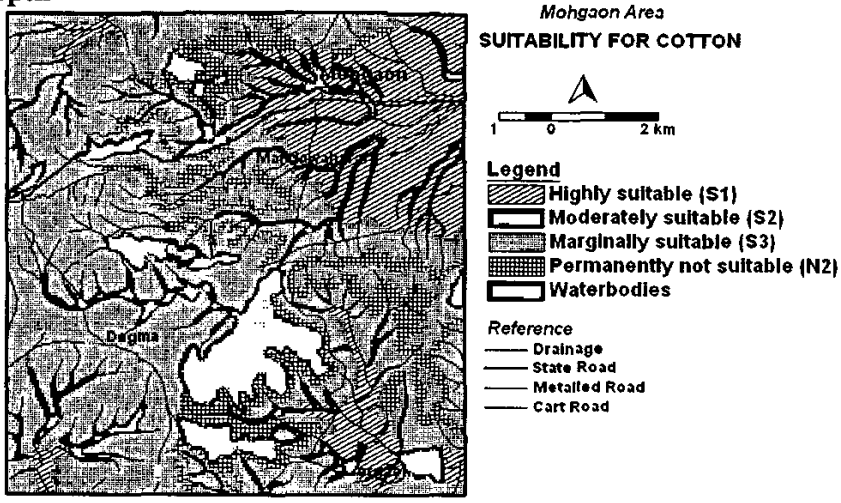

Fig. 3. Suitability for cotton

and moderately deep soils on subdued plateau and narrow valleys. Deep soils were confined in pediments and main valley floor, which cover an area of 17.11 per cent of TGA. The variation in the depth of soils on different geomorphic locations is attributed to manifestation of the geomorphic processes, climate and surficial features (Sarkar 1987).

The pH of the soils ranged from 6.6 to 7.9 in plateau summits, isolated mounds, linear ridges, escarpments, plateau spurs, subdued plateau and rolling plains (Table 2). The pH values ranged from 8.2 to 9.2 in pediments, narrow valleys and mainvalley floor soils. Soils at lower physiographic position had higher pH. Sharma *et al.* (1996) also reported similar findings. The organic carbon ranged from 0.08 to 1.08 per cent in different horizons. Soils of subdued plateau had higher organic carbon because these soils are under fallow/grasslands. Other soils did not have high organic carbon possibly due to intensive cultivation practices.

Suitability for cotton

The computation of limitation levels revealed that Mohgaon-8 and Mohgaon-10 soils qualify for S1 (highly suitable) and Mohgaon-5, Mohgaon-9 for S2 (moderately suitable) (Fig.3). The soils of Mohgaon-1, Mohgaon-2, Mohgaon-6 and Mohgaon-7 are found to be marginally suitable (S3). Soil depth, erosion and drainage are the major limitions in theses soils for cultivation of cotton. The soils of Mohgaon-3 and Mohgaon-4 are grouped under permanently not suitable (N2). Slope, soil depth, erosion, drainage and stoniness are the major limitions in theses soils.

Conclusion

The study demonstrates that analysis of IRS-1D-LISS-III data in conjunction with topographical data is very helpful in delineation of distinct landforms in a toposequence, which in turn, can be used for soil survey. GIS based data generation and cotton suitability analysis reveals that soils of Mohgaon-8 and Mohgaon-10 are highly suitable; Mohgaon-5, Mohgaon-9 are moderately suitable; Mohgaon-1, Mohgaon-2, Mohgaon-6 and Mohgaon-7 are marginally suitable.

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