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Characterization and evaluation of soils of Itagi watershed using remote sensing and GIS techniques

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Abstract: Visual interpretation of IRS IC LISS III + PAN merged satellite data (1:12,500 scale) in conjunction with Survey of India (SOI) toposheet was carried out to identify major physiographic units for soil resources mapping of Itagi watershed in Haveri district of Karnataka. Based on elevation and slope, five physiographic units namely mounds (>10% slope), undulating lands (5-10%), gently sloping lands (3–5%), very gently sloping lands (1-3%) and nearly level lands (0-1%) were delineated and further sub-divided into 15 photomorphic units based on image characteristics. Eleven soil series were identified based on morphological, physical and chemical characteristics. Taxonomically, these soil series were grouped under Entisols, Inceptisols, Alfisols and Vertisols. The soil-site evaluation of these series indicated that four soil series were not suitable for field crops (cotton, sorghum, soybean, chillies and groundnut), three series were marginally suitable, two series were moderately suitable and two series were highly suitable for field crops. Based on the soil potential and limitations of soils, different land use options and suitable interventions were suggested.

Additional key words: *Remote sensing, physiographic units, soil mapping, suggested land use*

Introduction

The non-renewable soil resource is presently under tremendous pressure due to increasing population and other competing land use demands. The problem is further aggravated due to indiscriminate and unscientific management practices resulting in various types of land degradation problems. The information on soils with regard to their nature, extent and spatial distribution, problems and potentials is required for varied uses.

Satellite based remote sensing data has emerged as powerful tool in soil resource survey and generation of information, which helps to prepare an optimum land use plan for development of an area. Wide spectrum of remote sensing data is available to researchers for study of natural resources. Studies have been conducted by various workers about the utility of remote sensing in characterization of soil resources (Solanke *et al.,* 2005; Shukla *et al*.2009). The present study was taken up to characterize and evaluate the soils of Itagi watershed for land resource management using remote sensing and GIS techniques.

Material and Methods

Study area:

The Itagi watershed (14°30'30" to 14°36'45" N; 75°37'30" to 75°41'15" E) covers an area of 4818 hectares and have unique red and black soils side by side derived from chlorite schist and quartzite of Dharwar group. The climate is semi-arid with 623 mm average annual rainfall.

Base map and image interpretation

The base map showing permanent features like road, settlements, rivers, streams and tanks *etc.* were delineated using survey of India toposheet (SOI) and was updated using satellite data. The available village map (1:7920 scale) was reduced to 1:12,500 scale for easy comparison and overlaying on the image.

Visual interpretation of FCC imagery of IRS - IC LISS III + PAN merged data (January, 2002) on 1:12,500 scale was carried out in conjunction with Survey of India (SOI) toposheet to identify the physiographic units in the watershed.

Soil mapping

Rapid traversing of the entire watershed area was undertaken in order to check the physiographic units. Correction of physiographic units was done wherever necessary. The transects were delineated in such a way that each transect should cut across at least three or more physiographic units. In each physiographic unit, profiles were studied to establish relationship between physiography and soils depending on slope element or length of slope (Table 1). Based on soil characteristics, eleven soil series were identified and mapped with their bases (AIS&LUS 1971). Soil samples collected from typifying pedons were analyzed for physical and chemical properties as per standard procedure (Klute 1986). The soils were classified as per USDA Soil Taxonomy (Soil Survey Staff 2003).

Land suitability evaluation

The land suitability for growing different field crops were evaluated by matching the crop requirements with soil-site characteristics of watershed (Naidu *et al.* 2006). The soils were grouped into S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable) and N (not suitable) as per FAO guideline (FAO 1976) considering the soil-site limitations.

Results and Discussion

Based on elevation and slope, the Itagi watershed was divided into five physiographic units such as mounds (>10% slope), undulating lands (5-10%), gently sloping lands (3-5%), very gently sloping lands (1-3%) and nearly level lands (0-1%) were identified from IRS-IC LISS III image interpretation. The landform and morphological features of soils is given in tabale 1. The soil map (series) is depicted in figure 1. Details of each physiographic unit are discussed below.

Soils of mounds

This unit is located in the north and northeastern part of the watershed (>10 % slope) and have very shallow (10-20 cm) soils underlain by quartzite rock. These highly eroded mounds (table 2) support shrubs and grasses. These soils are represented by soils of Hunsikatti series and their colour is in 5YR and 2.5YR hues, loamy texture with 60 to 70 per cent gravel, neutral in reaction (pH 6.6) with severe erosion. The contour bunding, contour trenching were suggested to intercept the run-off flowing down the slope by an embankment whose ends may be closed or open to conserve moisture as well as reduce soil erosion. Gullies can be controlled by constructing a series of checks like boulder/rubble checks. Growing of fodder and fuel wood species like subabul, glyricidia (green leaf manure) and grasses was suggested.

Soils of undulating lands

This unit is located in the northern part of the watershed and has 5 to 10 per cent slope. It is characterized by erosional surfaces, adjoining the mounds. This physiographic unit is divided into two sub-units based on the image characteristics and represented by Chalageri and Devagondankatti series. The soils of Chalageri series are shallow (25-50 cm), gravelly clay whereas soils of Devagondankatti series are very shallow (10-25 cm), gravelly loam in texture (Table 1). These are either cultivated to sorghum or under pasture land. Soil and water conservation measures like contour bunding, boulder checks and check dams were suggested. The suggested land use is agro-forestry by growing tree like neem, pongamia and acacia on the bunds, vacant areas and marginal lands.

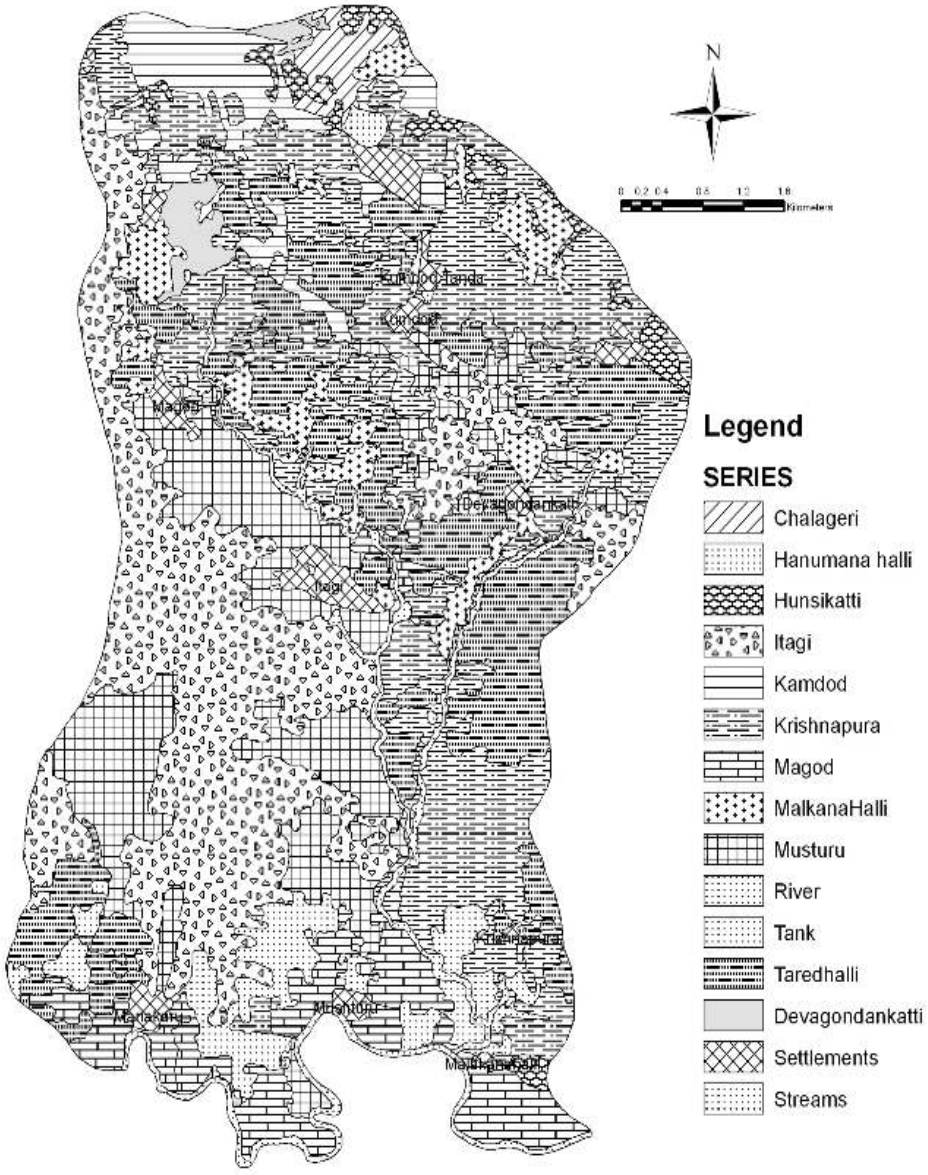

Fig.1. Soil map of Itagi watershed

Soils of gently sloping lands

This physiographic unit is located pre-dominantly in the north and eastern part of the watershed. This physiographic unit is further sub-divided into five sub-units based on the image characteristics (Table 1). Soils associated with these units are very shallow to slightly deep and moderately eroded. Their colour is dominantly in hue 5YR and texture is clay to gravelly clay. Kamdod, Krishnapura, Malkanhalli and Taredhalli series represent of this physiographic unit. These are cultivated to sorghum, sunflower and partly under pasture. The contour bunding, field bunding, vegetative checks and check dams were recommended to conserve soil and water. The suggested land use was agri-horticulture by growing field crops between horticultural crops like mango, sapota, pomegranate, amla and custard apple.

Table 1. Morphological characteristics of soils of Itagi watershed

Horizon	Depth (cm)	Colour (moist)	Texture	Coarse fragments (v/v)	Structure	Consistency
Hunsikatti series : Loamy- skeletal, smectitic Lithic Ustorthents (Mound)						
A1	0-10	5YR 4/4	gl	60	f-m 1 sbk	sh fr ss ps
A2	10-21	2.5 YR 3/6	gl	70	m 1 sbk	sh fr s p
R	21^{+}	Hard rock				
Taredhalli series: Clayey, smectitic, Typic Ustorthents (Gently sloping land)						
Ap	0-10	10 YR 3/2	c	10	m 2 sbk	- fi s p
A2	10-21	10 YR 3/2	c	10	m 2 sbk	- fi s p
Cr	$21\text{-}40^{+}$	Weathered schist				
Devagondankatti series: Loamy- skeletal, smectitic, Typic Ustorthents (Undulating land)						
Ap	0-11	10YR 4/4	gscl	40	m 1 sbk	l fr ss ps
Cr	$11\text{-}39^{+}$	Weathered schist				
Chalageri series: Clayey- skeletal, mixed Lithic Haplustepts (Undulating land)						
A	0-12	5YR 4/4	cl	10	m 2 sbk	sh fr s p
Bw	12-34	5YR 4/4	gc	45	m 1 sbk	- fr s p
R	34^{+}	Hard quartzite rock				
Kamdod series: Clayey, mixed Typic Haplustepts (Gently sloping land)						
A	0-13	5YR4/4	cl	-	m 2 sbk	sh fr s p
Bw	13-26	5YR3/3	c	15	m 2 sbk	sh fr s p
Cr	26^{+}	Weathered banded ferruginous quartzite				
Krishnapura series: Clayey- skeletal, mixed Typic Haplustepts (Gently sloping land)						
Ap	0-15	5YR4/6	gcl	30	m 1 sbk	sh fr s p
Bw	15-35	5YR3/4	gc	60	m 1 sbk	sh fr s p
Cr	$35\text{-}70^{+}$	Weathered quartzite				
Malkanhalli series: Clayey- skeletal, mixed Typic Haplustepts (Gently sloping land)						
A	0-12	7.5 YR 3/4	gcl	20	m 2 sbk	sh fr s p
Bw1	12-36	5YR3/4	gc	70	m 1 sbk	- fr s p
Bw2	36-67	5YR3/3	gc	80	m 1 sbk	- fr s p
Cr	$67\text{-}100^{+}$	Weathered quartzite				
Hanumanahalli series: Clayey- skeletal, mixed Typic Haplustalfs (Very gently sloping lands)						
A	0-10	7.5YR4/6	gscl	40	m 1 sbk	sh fr ss ps
Bt1	10-22	5YR3/4	gscl	45	m 1 sbk	sh fr ss ps
Bt2	22-62	5YR3/4	gcl	40	m 1 sbk	sh fr s p
Cr	62-90	Weathered ferruginous quartzite				
Musturu series: Fine, smectitic, calcareous, Vertic Haplustepts (Very gently sloping land)						
Ap	0-17	10YR 3/3	c	15	m 2 sbk	sh fi s p
A2	17-30	10YR 3/2	gc	50	m 2 sbk	sh fi s p
Bw	30-54	10YR 3/1	c	5	m 3 sbk	sh fi s p
Cr	54^{+}	Weathered schist				

Itagi series: Fine, smectitic, Typic Haplusterts (Very gently sloping land)										
Ap	0-13	2.5Y3/2	c	-	m	2	sbk	sh	fi	vs vp
Bss1	13-30	10YR3/1	c	-	c	2	sbk-abk	-	fi	vs vp
Bss2	30-67	10YR3/1	c	-	c	2	abk	-	fi	vs vp
Bss3	67-101	10YR3/1	c	-	c	3	abk	-	fi	vs vp
Magod series: Fine, smectitic, Typic Haplusterts (Nearly level land)										
Ap	0-22	10YR3/2	c	-	m	2	sbk	-	fi	vs vp
Bss1	22-46	10YR3/2	c	-	m-c	2	sbk	-	fi	vs vp
Bss2	46-70	10YR3/1	c	-	m-c	2	sbk-abk	-	fi	vs vp
Bss3	70-103	10YR3/1	c	-	m-c	2	abk	-	fi	vs vp
Bss4	103-150+	10YR3/1	c	-	m-c	2	abk	-	fi	vs vp

The soil temperature regime is *isohyperthrmic*

Soils of gently sloping lands

This physiographic unit is located pre-dominantly in the north and eastern part of the watershed. This physiographic unit is further sub-divided into five sub-units based on the image characteristics (Table 1). Soils associated with these units are very shallow to slightly deep, moderately eroded. Their colour is dominant in hue 5YR and texture is clay to gravelly clay. Kamdod, Krishnapura, Malkanhalli and Taredhalli series represent of this physiographic unit. These are cultivated to sorghum, sunflower and partly under pasture. The contour bunding, field bunding, vegetative checks and check dams were recommended to conserve soil and water. The suggested land use was agri-horticulture by growing field crops between horticultural crops like mango, sapota, pomegranate, amla and custard apple.

Soils of very gently sloping lands

This physiographic unit is situated pre-dominantly in the southern and western part of the watershed. This unit is further divided into 3 sub-units based on image characteristics. Soils associated with this unit are slightly deep to deep, dark greyish brown to very dark grey and dark reddish brown (5YR and 10YR), clay and gravelly sandy clay loam to gravelly clay loam in texture. These soils are mapped as Hanumanahalli, Musturu and Itagi series. These soils are cultivated to sorghum, sunflower and cotton. Field bunding, vegetative checks and check dams were suggested to conserve soil and water. Commercial seed production like growing hybrid sorghum, sunflower and tomato and chillies are suggested.

Soils of nearly level lands

This physiographic unit is situated in the southern part of the watershed and divided into two units based on image characteristics and mapped as Magod soil series. The soils are very deep (>150 cm), strongly alkaline (pH 8.6), very dark greyish brown to very dark grey in colour (10YR) with clay texture. These soils are cultivated to cotton and sorghum. The soil and water conservation measures like field bunding and farm ponds were recommended. Commercial seed production by growing hybrid sorghum, sunflower and vegetables are suggested.

Land suitability evaluation

The eleven soil series identified in the watershed were evaluated for their suitability for growing major field crops of the region. The soils of Itagi and Magod series were assessed as highly suitable (Table 2) for growing cotton, sorghum, chillies and moderately suitable for sunflower and groundnut due to limitation of texture. Hanumanahalli and Musturu series were grouped as moderately suitable for growing sorghum and groundnut due to moderate limitation of depth and gravelliness. Chalageri and Krishnapura series were assessed as marginally suitable for the crops due to severe limitations of gravelliness and depth. The soils of Hunsikatti, Taredhalli, Devangondankatti and Kamdod series were assessed as not suitable for crops due to very severe limitation of depth.