Indian J. Soil Cons., ***38*** *(1) : 16-23, 2010*

Characterization and evaluation of land resources of basaltic terrain for watershed management using remote sensing and GIS

Shilpa S. Patil, M.S.S. Nagaraju and Rajeev Srivastava

National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur - 440010, Maharashtra

ABSTRACT : Spatial information of physiography, land use/land cover and soils was derived and subsequenty evaluated to assess their potential for optimal land use planning in Longadga watershed of Chandrapur district of Maharastra using Landsat TM and IRS LISS-III data and ground truth. Physiographically, the watershed was characterized into five units namely subdued plateau, pediment, buried pediment, alluvial plain and valley fills. Major land use / land cover identified in the watershed were cultivated land and wasteland with scrub. Ten soil series (Kharwad-1, Girsawli-1, Kharwad-2, Girsawli-2, Madheri, Kartangadi, Panjurni, Longadga, Wandhali and Girsawli-3) were tentatively identified. Soils are deep to very deep except soils of Kharwad-1 (shallow) and Longadga (moderately shallow), clayey with shrink-swell potential and classified as Typic/Vertic Haplustepts and Typic Haplusterts. Physiographic-soil units (land units) were grouped into IIs and IIIs land capability sub-classes, 2s and 3s land irrigability sub-classes and good and average soil productivity classes. The soils of physiographc units of subdued plateau (Girsawli-1), pediment, buried pediment, alluvial plain and valley fills are moderately suitable and soils of subdued plateau (Kharwad-1) are marginally suitable for cotton and pigeonpea cultivation. Soybean was found moderately suitable in soils of subdued plateau (Girsawli-1), pediment, buried pediment and alluvial plain whereas soils of subdued plateau (Kharwad-1) and valley fills are marginally suitable. Various soil and water conservation measures and management interventions in different land units have been suggested for sustainable development.

Key words: Characterization ; Evaluation ; GIS ; Land resources ; Remote sensing

Over exploitation of natural resources, with increasing competition for land and water, is causing wide spread damage to soil eco-environment. About 148.9 m ha representing 45.3 per cent of the total geographical area (TGA) of the country is affected by various forms of soil degradation by water, wind, chemical and physical agencies (Sehgal and Abrol, 1994) and a threat to long term productivity (Bhattacharyya *et al*., 2007 ; Pratap Narain, 2008). To maintain or enhance the present level of productivity, management of land resources on scientific principles is very important. In this endeavor, soil resource inventory provides an insight into the potentialities and limitations for their optimum utilization through characterization and evaluation of land resources. It also provides adequate information in terms of landform, terrain, vegetation as well as characteristics of soils which can be utilized for land resource management and development (Manchanda *et al*., 2002). The requirements for both accurate and timely information on resources had exploded considerably over the last decade, for integrated resource management with watershed as a unit of planning by integrating information on geomorphology, land use, slope and soils (Srinivasa *et al*., 2008)

Remote sensing data provides information on geology, geomorphology, soil and land use/land cover through systematic analysis following the synoptic and multispectral coverage of a terrain and the information generated can be interpreted for various themes *viz*. land capability, land irrigability and crop suitability, *etc.* for better management and conservation of resources on watershed basis (Solanke *et al*., 2005). Several studies have been initiated on potential use of remote sensing data for characterization and management of land resources at watershed level (Sarkar *et al*., 2006 ; Srinivasa *et al*., 2008 ; Elvis *et al*., 2009).

In the present study, an attempt has been made to characterize and evaluate the land resources for management of Longadga watershed in Chandrapur district of Maharashtra using IRS LISS-III and Landsat TM (Thematic Mapper) data and GIS techniques.

MATERIALS AND METHODS

Longadga watershed with an area of 38.98 km^2 located between 20^{0}16’ to 20^{0}21’ N latitudes and 78^{0}51’ to 78^{0}55’ E longitudes at an elevation between 200 to 260 m above msl in Warora tahsil of Chandrapur district of Maharashtra. The geology of the area is Deccan basalt. Physiographically, the watershed is characterized into five major physiographic units, *viz*, subdued plateau, pediment, buried pediment, alluvial plain and valley fill. The climate of the area is subtropical and dry sub-humid. The maximum and minimum temperature ranges from 37^0C to 42^0C and 13^0C to 15^0C, respectively with mean annual temperature of 27.1^0C. The area receives an average annual precipitation of 1349 mm and qualify for ustic and hyperthermic soil moisture and soil temperature regimes, respectively. The natural vegetation comprises a wide variety of dry deciduous mixed tree species, shrubs interspersed with grasses. Commonly occurring tree species are Teak (*Tectona grandis*), Shivan (*Gmelina arborea*), Babul (*Acacia arabica*), Khair (*Acacia catechu*), Wilayathi Babul (*Prospis juliflora*), Palas (*Butea monosperma*), Charoli (*Buchananea lanjan*) and Ber (*Ziziphus jujuba*). A large percentage of cultivated land is under *kharif* crops ; cotton (*Gossypium spp.*), soybean (*Glycine max*) and pigeonpea (*Cajanus cajan*). The dominant *rabi* crops; wheat (*Triticum aestivum*) and gram (*cicer arietinum*) generally raised on residual moisture/protective irrigation.

Digital data of Landsat TM (Thematic Mapper) of November with a spatial resolution of 30 m and IRS LISS-III of February 2004 with a spatial resolution of 23.5 m was geo-referenced with Survey of India (SOI) toposheet using Geomatica image processing software. The standard False Colour Composite (FCC) was visually interpreted in association with SOI toposheet to delineate physiographic units. For physiography delineation, contours were digitized from SOI toposheet and transferred as a layer on to satellite image. The physiographic units from the highest to the lowest elevation were identified and digitized using ArcGIS software, validated for digitization erros and polygonized. Attributes were added to each identified unit and a physiography map was prepared using ArcMap. Satellite data was interpreted for various land use/land cover classes. Agriculture land was separated from non agriculture (wasteland with scrub) using image interpretation elements like size, shape and pattern. Further sub-division of agricultural land into single and double crops, was done based on *kharif* and *rabi* season data. These two maps were integrated to prepare physiography-land use (PLU) map. The PLU map with 16 land units was verified during field visit and finalized after incorporation of necessary changes and used for preparation of soil map and other thematic maps *viz.*; land capability, land irrigability and soil productivity.

Soil profiles were exposed in each physiographic unit, their location was recorded through Global Positioning System (GPS) and studied for morphological properties (Soil Survey Division Staff, 2003). Horizon-wise soil samples were collected from representative soil series for studying physical and chemical properties following standard procedures (Black, 1965 ; Jackson, 1967). Soils were classified according to Soil Taxonomy (Soil Survey Staff, 1998). The soils were classified under different land capability as per Klingebiel and Montgomery (1961) and land irrigability grouping as per AIS&LUS (1971). After evaluation for land capability, land irrigability, soil productivity and suitability for cotton, pigeonpea and soybean, these attributes were added in the attribute table and linked to the spatial data and thematic maps, *viz*; land capability, land irrigability. Soil productivities were generated using ArcMap.

RESULTS AND DISCUSSION

Land Use/Land Cover

Based on tonal variations and the pattern in the satellite imagery and supported by ground truth, the land use/land cover were classified into cultivated land, wasteland with scrub, waterbody and habitation (Fig. 1). Major area is under cultivation (94.2% of TGA) followed by wasteland with scrub (5.2% of TGA). Out of the total cultivated area, 72.9 per cent area is under rainfed.

Physiography-Soils Relationship

Five major physiographic units, *viz ;* subdued plateau, pediment, buried pediment, alluvial plain and valley fills were identified (Fig. 2). Based on degree of slope and present land use/land cover, these units were further divided into 16 land

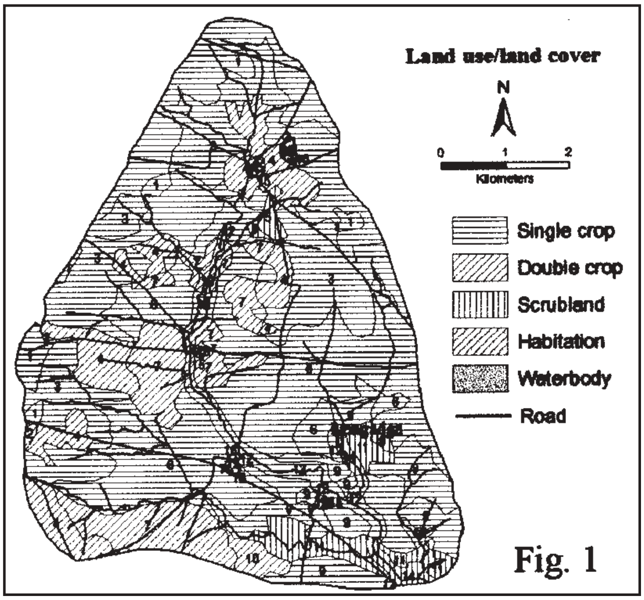

Fig. 1

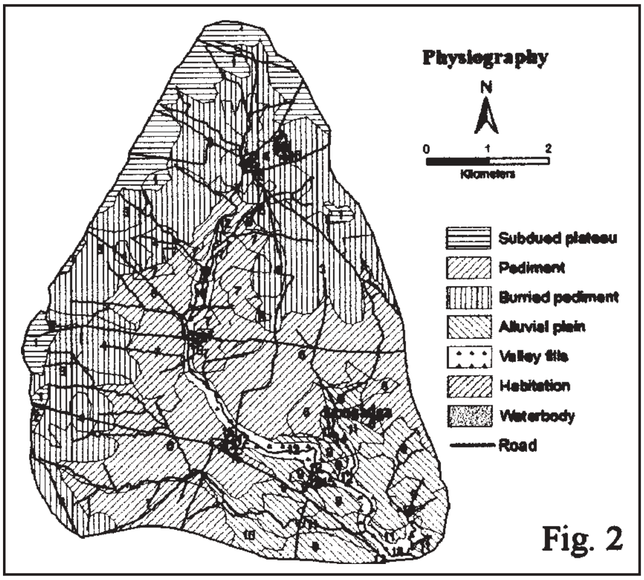

Fig. 2

use/land cover units (Table 1). Subdued plateau is located at upper reaches of the watershed at an elevation of 240-260 m above msl and immediately below the subdued plateau, pediments exist within 220-240 m above msl and acts as runoff zones, while buried pediments were in the middle reaches (210-220 m above msl). The alluvial plain predominantly depositional was identified at the lower reaches (200-210 m above msl). The valley fills are formed on either side of main stream and mainly composed of colluvium and alluvium. The major soil and land characteristics under different physiographic units are presented in Table 2.

Table 1. *Characterization of different physiography and land use/land cover units*

Land Unit	Description
A.	Very gently sloping (1-3%)
1	Subdued plateau under single crop
2	Subdued plateau under double crop
3	Pediment under single crop
4	Pediment under double crop
5	Pediment under wasteland with scrub
6	Buried pediment under single crop
7	Buried pediment under double crop
8	Buried pediment under wasteland with scrub
B.	Nearly level (0-1%)
9	Alluvial plain under single crop
10	Alluvial plain under double crop
11	Alluvial plain under wasteland with scrub
12	Valley fill under single crop
13	Valley fill under double crop
14	Valley fill under wasteland with scrub
15	Habitation
16	Waterbody

Physical and Chemical Properties

High clay content in general, has reflected high bulk density and available water capacity (Table 3). The data on chemical properties of soils (Table 4) indicates that the soils are neutral to moderately alkaline with 7.3 to 9.1 pH. The electrical conductivity (EC) of the soils is within the acceptable limits (0.19 to 1.3 dSm^{-1}) and there is no

Table 2. *Major soil and land characteristics under different physiographic units*

Physiography	Soil series	Soil taxonomy	Soil depth (cm)	Soil texture	Soil pH (1:2.5)	Slope (%)	Erosion	Drainage
Subdued plateau	Kharwad-1	Fine, smectitic, hyperthermic (calcareous) Typic Haplustepts	32	Clay	7.3	1-3	Moderate	Mod. well drained
	Girsawli-1	Very-fine, smectitic, hyperthermic (calcareous) Typic Haplustererts	150	Clay	8.0	1-3	Slight	Poor
Pediment	Kharwad-2	Very-fine, smectitic, hyperthermic (calcareous) Typic Haplustererts	150	Clay	8.0	1-3	Moderate	Poor
	Girsawli-2	Very-fine, smectitic, hyperthermic (calcareous) Vertic Haplustererts	84	Clay	8.1	1-3	Moderate	Poor
Buried pediment	Madheri	Very-fine, smectitic, hyperthermic (calcareous) Typic Haplustererts	150	Clay	8.1	1-3	Moderate	Poor
	Kartangadi	Fine, smectitic, hyperthermic (calcareous) Vertic Haplustererts	75	Clay	8.2	1-3	Slight	Poor
Alluvial plain	Panjurni	Fine, smectitic, hyperthermic (calcareous) Typic Haplustepts	150	Clay	8.0	1-3	Moderate	Poor
	Longadga	Fine, smectitic, hyperthermic (calcareous) Vertic Haplustererts	66	Clay	7.9	1-3	Slight	Poor
Valley fill	Wandhali	Fine, smectitic, hyperthermic (calcareous) Vertic Haplustererts	150	Clay	8.2	0-1	Moderate	Poor
	Girsawli-3	Fine, smectitic, hyperthermic (calcareous) Typic Haplustepts	150	Clay	8.2	0-1	Moderate	Mod.well drained

Table 3. *Physical properties of soils*

Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	BD (Mgm^{-3})	Water retention (%) 33kPa	1500 kPa	AWC
Kharwad-1 series								
Ap	0-15	9.1	33.4	57.5	1.68	30.7	17.1	13.6
Bw	15-32	8.2	32.3	59.5	1.79	32.2	18.2	14.0
Crk	32-70	Weathered basalt with $CaCO_3$ nodules						
R	70+	Hard basalt						
Girsawli-1 series								
Ap	0-21	12.5	31.4	56.1	1.68	31.5	18.1	13.4
Bw	21.53	12.1	30.8	57.1	1.71	34.3	20.2	14.1
Bss1	53-87	7.9	28.3	63.8	1.76	32.5	21.3	11.2
Bss2	87-119	7.2	27.1	65.7	1.79	38.9	23.5	15.4
Bss3	119-150	6.6	26.9	66.5	1.81	40.4	24.6	15.8
Kharwad-1 series								
Ap	0-19	10.0	33.0	57.0	1.65	36.0	19.9	16.1
Bw	19-49	8.5	30.4	61.1	1.81	37.7	20.8	16.9
Bss1	49-85	7.9	29.9	62.2	1.80	38.8	21.3	17.4
Bss2	85-118	6.8	28.8	64.4	1.81	43.0	23.7	19.3
Bss3	118-150	5.4	28.2	66.4	1.82	44.5	25.0	19.5
Girsawli-2 series								
Ap	0-20	9.2	30.5	60.3	1.68	32.4	17.3	15.1
Bw1	20-48	8.5	29.8	61.7	1.66	33.6	18.2	15.4
Bw2	48-84	7.8	28.5	63.7	1.72	35.9	19.1	16.9
Crk	84-100	Weathered basalt with $CaCO_3$ nodules						
R	100+	Hard basalt						
Madheri series								
Ap	0-21	3.2	30.4	66.4	1.57	38.5	21.6	16.9
Bw	21-56	3.1	28.8	68.1	1.82	40.2	23.7	16.5
Bss1	56-92	2.8	26.3	70.9	1.79	41.7	25.4	16.3
Bss2	92-20	2.5	25.9	71.6	1.80	43.4	26.3	17.1
Bss3	120-150	2.3	25.4	72.3	1.81	44.6	27.4	17.2
Kartangadi series								
Ap	0-18	8.1	35.1	56.8	1.58	30.2	16.2	14.1
Bw1	18-45	7.6	34.3	58.1	1.63	32.4	18.6	13.8
Bw2	45-85	6.2	32.5	61.3	1.68	34.3	19.1	15.2
Crk	85-110	Weathered basalt with $CaCO_3$ nodules						
R	110+	Hard basalt						
Panjurni series								
Ap	0-20	7.4	33.1	59.5	1.55	39.0	19.5	19.5
Bw	20-59	6.7	32.2	61.1	1.79	35.1	20.7	14.4
Bss1	59-98	5.8	30.8	63.4	1.81	37.5	21.8	15.7
Bss2	98-122	4.6	28.9	66.5	1.82	37.7	22.6	15.1
Bss3	122-150	3.8	28.3	67.9	1.84	41.7	24.6	17.1
Longadga series								
Ap	0-20	8.8	34.6	56.6	1.67	30.6	16.6	14.0
Bw1	20-42	7.9	32.4	59.7	1.69	32.9	18.3	14.6
Bw2	42-66	7.5	31.8	60.7	1.74	33.2	19.6	13.6
Crk	66-95	Weathered basalt with $CaCO_3$ nodules						
R	95+	Hard basalt						
Wandhali series								
Ap	0-20	9.6	34.5	55.9	1.56	30.7	16.5	14.2
Bw1	20-55	8.7	33.2	58.1	1.59	31.2	17.4	13.8
Bw2	55-98	8.3	31.8	59.9	1.62	32.4	18.4	14.0
Bw3	98-132	7.8	30.8	61.4	1.63	34.5	19.6	15.0
Bw4	132-150	7.4	29.8	62.8	1.69	36.3	20.4	15.9
Girsawli-3 series								
Ap	0-19	7.9	33.9	58.2	1.63	31.0	16.6	14.4
Bw1	19-36	6.6	32.8	60.6	1.60	31.9	18.1	13.8
2C	36-51	90.3	3.9	5.8	1.40	20.6	10.7	9.9
3Bw2	51-89	10.8	28.4	60.8	1.48	28.3	12.3	16.0
3Bw3	89-120	11.6	27.0	61.4	1.68	32.4	18.6	14.1
3Bw4	120-150	11.5	25.6	62.9	1.71	39.6	18.2	21.4

Table 4. *Chemical properties of soils*

Horizon	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)	CEC (cmol (p+)kg^{-1}	BS (%)	Available micronutrients (mg kg^{-1})			
								Fe	Mn	Cu	Zn
Kharwad-1 series											
Ap	0-15	7.3	0.10	1.1	3.1	54.0	79.6	22.0	8.6	2.3	0.4
Bw	15-32	7.3	0.13	1.0	3.9	59.1	94.2	19.9	6.2	2.1	0.4
Crk	32-70	Weathered basalt with $CaCO_3$ nodules									
R	70+	Hard basalt									
Girsawli-1 series											
Ap	0-21	8.0	0.14	1.2	4.8	59.1	95.1	12.3	22.7	1.6	0.3
Bw	21-53	8.1	0.12	1.0	5.9	56.5	99.2	10.4	12.1	1.3	0.2
Bss1	53-87	8.2	0.14	0.8	3.7	56.5	98.6	10.6	8.7	1.3	0.2
Bss2	87-119	8.1	0.14	0.7	4.5	56.5	100.5	11.8	11.0	1.4	0.3
Bss3	119-150	8.1	0.15	0.6	4.8	61.7	90.5	11.7	10.4	1.4	0.2
Kharwad-1 series											
Ap	0-19	8.0	0.19	0.8	6.2	53.0	101.3	13.8	24.8	1.9	0.4
Bw	19-49	8.6	0.32	0.6	5.6	57.4	104.4	12.8	17.4	1.7	0.2
Bss1	49-85	8.7	0.41	0.5	5.8	55.2	91.5	10.7	5.3	1.5	0.2
Bss2	85-118	8.8	0.73	0.4	7.6	58.5	99.8	10.1	5.0	1.4	0.2
Bss3	118-150	8.8	1.14	.4	5.5	61.1	99.9	10.2	9.1	1.6	0.2
Girsawli-2 series											
Ap	0-20	8.1	0.14	0.9	5.9	61.7	96.3	13.7	21.2	2.0	0.4
Bw1	20-48	8.2	0.14	0.7	7.7	59.1	95.3	10.7	8.3	1.6	0.2
Bw2	48-84	8.2	0.14	0.5	8.9	56.5	102.6	11.0	6.7	1.6	0.2
Crk	84-100	Weathered basalt with $CaCO_3$ nodules									
R	100+	Hard basalt									
Madheri series											
Ap	0-21	8.1	0.16	1.1	7.4	57.4	98.5	13.7	17.2	1.6	0.3
Bw	21-56	8.2	0.12	0.9	7.2	59.1	91.8	13.0	13.3	1.5	0.3
Bss1	56-92	8.2	0.15	0.9	6.6	60.4	89.4	12.8	9.3	1.3	0.2
Bss2	92-20	8.4	0.21	0.8	5.6	59.1	84.2	12.0	10.2	1.2	0.2
Bss3	120-150	8.5	0.26	0.8	3.7	59.1	104.3	11.0	7.1	1.1	0.2
Kartangadi series											
Ap	0-18	8.2	0.21	0.7	12.8	49.6	103.4	15.0	23.6	2.0	0.3
Bw1	18-45	8.2	0.23	0.7	9.3	51.3	108.5	11.6	12.9	1.3	0.2
Bw2	45-85	8.5	0.31	0.5	11.0	61.8	104.2	11.2	7.7	1.2	0.2
Crk	85-110	Weathered basalt with $CaCO_3$ nodules									
R	110+	Hard basalt									
Panjurni series											
Ap	0-20	8.0	0.18	0.7	11.1	49.6	105.9	11.3	15.6	1.8	0.4
Bw	20-59	8.1	0.18	0.5	7.6	61.7	101.7	9.6	2.8	1.1	0.2
Bss1	59-98	8.1	0.17	0.4	5.9	63.6	97.5	9.2	1.7	1.0	0.2
Bss2	98-122	8.1	0.18	0.3	5.9	63.5	103.9	9.2	0.2	1.0	0.2
Bss3	122-150	7.8	0.13	0.2	5.5	66.5	101.6	8.9	2.9	0.9	0.2
Longadga series											
Ap	0-20	7.9	0.18	0.7	5.9	52.2	105.7	9.0	10.0	0.9	0.2
Bw1	20-42	7.8	0.15	0.6	5.4	55.2	95.8	11.4	14.1	1.4	0.3
Bw2	42-66	8.1	0.16	0.6	5.6	57.8	95.1	11.2	12.0	1.4	0.2
Crk	66-95	Weathered basalt with $CaCO_3$ nodules									
R	95+	Hard basalt									
Wandhali series											
Ap	0-20	8.2	0.14	0.9	7.7	56.5	88.0	15.9	19.9	2.7	0.3
Bw1	20-55	8.3	0.17	0.8	7.5	51.3	101.1	13.6	16.7	2.1	0.2
Bw2	55-98	8.6	0.32	0.7	6.6	52.2	98.3	13.1	10.9	2.0	0.2
Bw3	98-132	8.8	0.55	0.7	6.5	52.2	101.2	13.2	9.6	2.2	0.2
Bw4	132-150	9.0	0.45	0.5	19.1	36.2	112.2	12.6	10.9	1.3	0.2
Girsawli-3 series											
Ap	0-19	8.3	0.19	0.9	4.7	53.0	99.0	18.3	20.6	3.3	0.4
Bw1	19-36	8.6	0.30	0.9	6.8	50.4	104.2	16.8	26.5	2.4	0.3
2C	36-51	8.7	0.38	0.5	19.2	43.0	93.0	18.6	23.4	1.4	0.2
3Bw2	51-89	9.1	0.56	0.7	19.3	49.0	92.0	12.0	6.6	0.6	0.2
3Bw3	89-120	8.8	1.03	0.8	17.1	53.3	93.9	12.4	5.5	1.3	0.2
3Bw4	120-150	9.1	1.30	0.5	18.1	53.9	93.7	10.2	4.3	0.4	0.2

salinity threat at present. Organic carbon (OC) content is low and varying from 0.2 to 1.2 per cent. The soils are calcareous with high base saturation. The cation exchange capacity (CEC) ranges from 43.0 to 63.6 cmol(p^+)kg^{-1} soil.

Available Micronutrients

The DTPA extractable micronutrients (Fe, Mn, Cu and Zn) of the soils (Table 4) indicates that DTPA-Fe ranged from 9.0 to 22.0 mg kg^{-1} in surface soils and found to be higher than the critical level of 4.5 mg kg^{-1} (Lindsay and Norvell, 1978) in all the soils. Mn content varied from 8.6 to 22.8 mg kg^{-1} in surface soils against the critical level of 3.0 mg kg^{-1} (Takkar *et al*. 1989). There is no deficiency of copper in the soils as it varied from 0.9 to 3.3 mg kg^{-1} which is higher than the critical value of 0.2 mg kg^{-1} (Katyal and Randhawa, 1983). The available Zn varied from 0.2 to 0.4 mg kg^{-1} in surface soils. All the soils of the watershed showed zinc deficiency against critical value of 0.6 mg kg^{-1} (Sharma *et al*., 1996). The micronutrients particularly Zn needs to be supplemented along with the major nutrients.

Land Capability and Land Irrigability

The soils are grouped under land capability sub-classes IIs and IIIs and land irrigability sub-classes of 2S and 3S (Table 5 and Fig. 3).

Productivity and Suitability of Soils for Crops

The soils of different series evaluated for soils productivity (Table 5 and Fig. 4) indicated that all the soils except Kharwad - 1 are good in productivity. These soils have moderate limitations of soil moisture, depth, organic matter and soil texture/structure. The soils of Kharwad-1 are average with moderate limitation of soil moisture, texture/structure and marginal limitation of soil depth.

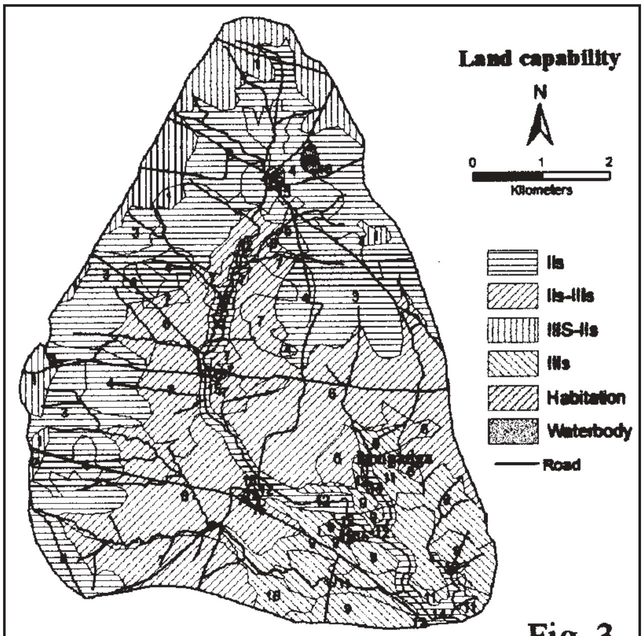

Fig. 3

CONCLUSIONS

In the present study, the remote sensing data supported by SOI toposheet and field survey was used to characterize physiography, land use/land cover and soils. Physiographically, the watershed was characterized into five units namely subdued plateau, pediment, buried pediment, alluvial plain and valley fill. Major land use/land cover identified in the watershed were cultivated land and wasteland with scrub. Based on two season remote sensing data, 73.9 per cent cultivated area was rainfed. Ten soils series were tentatively identified. Soils are deep to very deep except soils of Kharwad-1 (shallow) and Longadga (moderately shallow),

Table 5. *Evaluation of land under different physiographic units.*

Physiography	Soils	Land capability	Land irrigability	Soil productivity	Soil suitability		
					Cotton	Pigeonpea	Soybean
Subdued plateau	Kharwad-1	IIIs	3s	Average	S3	S3	S3
	Girsawli-1	IIs	2s	Good	S2	S2	S2
Pediment	Kharwad-2	IIs	2s	Good	S2	S2	S2
	Girsawli-2	IIs	2s	Good	S2	S2	S2
Buried pediment	Madheri	IIs	2s	Good	S2	S2	S2
	Kartangadi	IIIs	2s	Good	S2	S2	S2
Alluvial plain	Panjurni	IIIs	2s	Good	S2	S2	S2
	Longadga	IIIs	2s	Good	S2	S2	S2
Valley fill	Wandhali	IIs	2s	Good	S2	S2	S3
	Girsawli-3	IIs	2s	Good	S2	S2	S3

S2 : Moderately suitable S3 : Marginally suitably

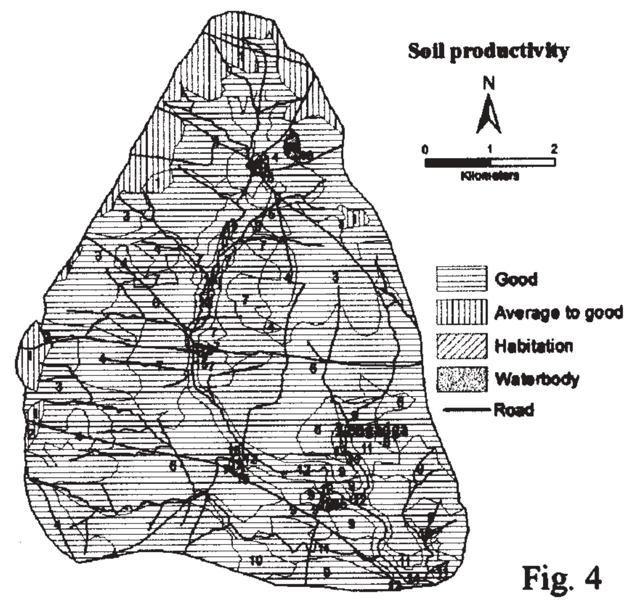

Fig. 4

clayey with shrink-swell potential and classified as Typic/ Vertic Haplustepts and Typic Haplusterts. Physiography-soil units have good to moderately good cultivable lands (land capability : IIs-IIIs) and moderate to severe limitations for sustained use under irrigation (land irrigability : 2s-3s). Majority of land units (pediment, buried pediment and alluvial plain) are moderately suitable for cotton and pigeonpea cultivation. Soybean was found moderately suitable in soils of subdued pleateau (Girsawli-1), pediment (Girsawli-2) buried pediment and alluvial plain and marginally suitable in soils of subdued plateau (Kharwad-1), pediment (Kharwad-2) and valley fills. Various soil and water conservation measures *viz.*; contour cultivation, vegetative barriers, nala bund and management interventions like plantations, silvipasture and agri-horticulture in different land units have been suggested for sustainable development.

ACKNOWLEDGEMENTS

The authors express sincere thanks to the Head, Division of Remote Sensing Applications, NBSS&LUP, Nagpur for providing necessary facilities to carry out this study.

REFERENCES

AIS&LUS (All India Soil and Land Use Survey). 1971. Soil Survey Manual, AIS & LUS, IARI Publication, New Delhi. 121p.

Bhattacharyya, T., Ram Babu, Sarkar, D., Mandal, C., Dhyani, B.L. and Nagar, A.P. 2007. Soil loss and crop productivity model in humid subtropical India. *Curr. Sci*., 93 : 1397-1403.

Black, C.A. 1965. Methods of Soil Analysis. Part 1&2. Am. Soc. Agron., Medison, Wisconsin, USA.

Elvis, A. Shukla, Jagdish Prasad, Nagaraju, M.S.S., Srivastava, Rajeev and Kauraw, D.L. 2009. Use of remote sensing in characterization and management of Dhamni micro-watershed of Chandrapur district of *Maharashtra. J. Indian Soc. Remote Sens*., 37(1) : 129-137.

FAO, 1976. Framework for Land Evaluation. FAO Soils Bulletin No. 32. Food and Agriculture Organization, United Nations : Rome, Italy.

Hadda, M.S., Arora, S., Bhardwaj, D.D. and Mohan, N. 2008. Soil characteristics and productivity in relation to water erosion on sloping land in foot-hills of Shivaliks. *J.Soil and Water Conserv.*, 7(4) : 14-19.

Jackson, M.L. 1967. Soil chemical analysis. Prentice Hall India Pvt. Ltd., New Delhi.

Katyal, J.C. and Randhawa, N.S. 1983. Micronutrients. FAO fertilizer and plant nutrition, Bulletin 5, Rome. 92p.

Klingebiel, A.A. and Montgomery, P.H. 1961. Land capability classification. Agric. Handbook 210, USDA. Soil Conservation Service, Washington, DC.

Lindsay, W.L. and Norvell, W.A. 1978. Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.*, 42 : 421-427.

Manchanda, M.L., Kudrat, M. and Tiwari, A.K. 2002. Soil survey and mapping using remote sensing. *Tropical Ecol*., 43(1) : 61-74.

NBSS&LUP, 1994. Soil site suitability criteria for different crops. *In* : Proceedings of National meet of soil-site suitability criteria for different crops. 31p.

Pierce, F.J., Larson, W.E., Dowdy, R.H. and Graham, W.A.P. 1983. Productivity of soils : assessing long term changes due to erosion. *J. Soil and Water Conserv.*, 38 : 39-44.

Pratap Narain, 2008. Dryland management in arid ecosystem, *J. Indian Soc. Soil Sci.*, 56:337-347.

Riquier, J., Bramao, D.L. and Cornet, J.P. 1970. A new system of soil appraisal in terms of actual and potential production productivity. FAO Soil Resources, Development and Conservation Service, Land and Water Development Division, FAO : Rome.

Sarkar, D., Gangopadhyay, S.K. and Sahoo, A.K. 2006. Soil resource appraisal towards land use planning using satellite remote sensing and GIS - A case study in Patloinala micro watershed, district Puruliya, West Bengal. *J. Indian Soc. Remote Sens*., 35(1) : 21-30.

Sehgal, J. and Abrol, I.P. 1994. Soil Degradation in India : Status and impact. Oxford and IBH Publishing Co. Pvt. Ltd., N.Delhi.

Sharma, B.L., Bhadoria, A.K.S., Rathore, G.S. and Bapat, P.N. 1996. Evaluation of extractants for available zinc and its forms in Vertisols of Madhya Pradesh. *J. Ind. Soc. Soil Sci*., 44(4) : 701-704.

Soil Survey Division Staff. 2003. Soil Survey Manual. Handbook 18. USDA Washington, DC.

Soil Survey Staff, 1998. Keys to Soil Taxonomy. 9th Edition. USDA Natural Resources Conservation Service, Washington DC.

Sonlanke, Preeti C., Rajeev Srivastava, Jagdish Prasad, Nagaraju, M.S.S., Saxena, R.K. and Barthwal, A.K. 2005. Application of remote sensing and GIS in watershed characterization and management. *J. Indian Soc. Remote Sens.,* 33 : 239-244.

Srinivasa, S.V., Govindaiah, S. and Gowda, H.H. 2008. Prioritization of sub-watersheds for sustainable development and management of natural resources : An integrated approach using remote sensing, GIS and socio-economic data. *Curr. Sci.,* 95(3) : 345-354.

Sys, C.E., Van Ranst and Debayeve, J. 1991. Land Evaluation, Part I and II. Re-edited volumes of Publication No. 7. General Administration of Cooperation Development, Brussels, Belgium.

Takkar, P.N., Chhibba, I.M. and Mehta, S.K. 1989. Twenty Years of coordinated research on micronutrients in soil and plant. Bulletin, Indian Institute of Soil Science, Bhopal. 75p.

Received : May 2009; Revised : January 2010; Accepted : March 2010