Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7386

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (2):** 91-97 (2019)

Research Article

Soil Site Suitability Assessment for Mulberry Crop Using Remote Sensing and GIS Techniques in Northern Dry Zone of Karnataka, India

Manjunatha Chari K.*, Manjunatha Hebbara, Hanamantarao Jogan and Nagendra B. R.

[1]Department of Soil Science and Agricultural Chemistry, UAS, Dharwad, Karnataka, India

*Corresponding Author E-mail: manju520.agri@gmail.com

Received: 15.02.2019 | Revised: 18.03.2019 | Accepted: 26.03.2019

ABSTRACT

Soil survey and Crop suitability assessment for Mulberry was carried out using RS and GIS technique. Based on survey, Eighteen mapping units belonged to the land capability class IV with two sub classes viz; IVsf and IVts and seven belongs to land capability class III with three sub classes viz; IIItsf, IIItwsf and IIIts. Having slight to severe limitations of texture, coarse fragments, soil depth, drainage, cation exchange capacity, base saturation and organic carbon. About 276.66 ha (42.73 % of TGA) were highly suitability sub class S1 having none to slight limitations of climate, soil physico-chemical properties. Other mapping units of the study area were assessed to be slightly to marginally suitable for mulberry.

Key words: *Mulberry, Land capability, Suitability, Mapping unit.*

INTRODUCTION

Soils provide food, fodder and fuel for meeting the basic needs of human beings and animals. With the growth of population, demand for food production is on the increase. However, the capacity of the soil to produce is limited. The production is limited mainly by intrinsic soil characteristics, agro-ecological settings and its management. It is very important for developing an effective land use system for augmenting agricultural production on a sustainable basis. A detailed characterization of land resources assessing its potential and constraints becomes a pre-requisite for planning. For this, soil survey helps to describe and classify soils and predict their potentials for sustainable land uses.

India needs 350 million tonnes of food grains to feed the projected population of 1.48 billion by 2030. According to Anon[2], sustainable land management (SLM) approach is crucial to minimize land degradation, rehabilitate degraded areas and ensure the optimal use of land resources for the benefit of present and future generations. Akash[1] reported that about 32 per cent (105.19 M ha) of the country's total geographical area of 328.73 M ha is being degraded, while 25 per cent (82.18 M ha) is undergoing desertification.

Cite this article: Manjunatha C.K., Hebbara, M., Jogan, H. and Nagendra, B.R., Soil Site Suitability Assessment for Mulberry Crop Using Remote Sensing and GIS Techniques in Northern Dry Zone of Karnataka, India, *Int. J. Pure App. Biosci.* **7(2):** 91-97 (2019). doi: http://dx.doi.org/10.18782/2320-7051.7386

Recent advances in science have led to development of techniques capable of rapidly and effectively mapping out area. These techniques include remote sensing (RS) and geographical information systems (GIS). The opportunities offered by the above advances can be used to map out patterns of land degradation at various (1: 7920 m) scales relatively faster and with reasonably low cost[7]. Remote Sensing can facilitate studying the features, such as soil type, slope gradient, drainage, geology and land cover.

MATERIAL AND METHODS

Chikmegeri-3 micro-watershed belongs to Bedwatti sub-watershed (4D4A1F1d) located in yelburga taluk of Koppal district, Karnataka. The study area belongs to "Northern dry zone" (Zone 3), which receives lowest rainfall among all the dry zones of Karnataka. The availability of moisture is the limiting factor for crop production. The length of growing period (LGP) is <90 days which in turn influenced by soil type; red or black. The climate is semi-arid with a mean annual average rainfall of 572 mm. The selected Chikmegeri-3 micro-watershed is located between 15° 35′ 50.69″ and 15° 33′ 52.19″ N latitude, 76° 06′ 23.08″ and 76° 05′ 36.78″ E longitude and the location of micro-watersheds is shown in Fig. 1.

The climate of the district as a whole is semi-arid type characterized by hot summer and low rainfall. The hot summer starts from middle of February to end of May. The climate is cool and pleasant during major part of the year except during the summer months of March to middle of June. The minimum temperatures during winter (December to January) reach up to 16 °C and maximum reaches up to 45 °C during hot summer. The district is characterized by dryness for the major part of the year because of less rainfall. The annual normal rain fall is 571.92 mm. Normally, rain commences in June and continues up to November and heavy rainfall during the months of September and October contributed by the south west monsoon forms 65 per cent of the annual rainfall. The annual rainfall received through, an average, 46 rainy days and the Chikmegeri-3 micro-watershed received a low rainfall of about 450 mm during 2014[4].

Land evaluation and soil site suitability

Land capability classification

The land capability was mainly based on the inherent soil characteristics, external land features and environmental factors. The land capability classes and sub classes were arrived as per the guidelines of NBSS and LUP[3]. The criteria used for land capability classification are presented in Table 1.

Soil site suitability evaluation for mulberry crop

The structure of the classification is based on the FAO framework for land evaluation, it includes four categories: orders, classes, sub classes and units. There are two orders (S, N), which reflect the kind of suitability (S for suitable and N for unsuitable). There are three classes (S-1 to 3) under the order S and two classes (N-1 and 2) under the order N, reflecting degree of suitability within the order. The appraisal of the classes, within an order is done according to evaluation of land limitations. The sub classes reflect the kinds of limitations or the main kinds of improvement measures required within a class. They are indicated by the symbol, using lower case letters following the Arabic numeral used for the class. The land suitability unit suggests the relative importance of land improvement works. It is indicated by Arabic numerals enclosed in parenthesis following the sub class symbol. The soil site suitability for some of the major crops mulberry was evaluated based on the criteria[8].

Soil map

Using the field survey and laboratory analysis results, the soil heterogeneity units were determined using remote sensing and GIS by following the guidelines of soil survey staff[9]. By comparing soil-site characteristics and soil-site suitability requirements for mulberry crop, the suitability of the soil units of the study area for different crops were identified. A database file (dbf) consisting of these information was created in ArcGIS 10 to prepare thematic maps for crop suitability.

RESULTS AND DISCUSSION

The ground truth sites for the collection of the observational data required for the current study were selected from the watershed after conducting a preliminary survey of the study area. Based on the permanent land features like roads, river and water bodies along with major drainage lines were demarcated using SOI toposheets. Rapid traversing of the entire micro watershed area by considering the geographic distribution and frequency of occurrence of physiographic unit, transects were delineated. For non transact areas of a given physiographic unit was checked at random for the accuracy of soil composition. In such physiographic units, profiles were studied depending upon slope element or length of the slope in order to establish the relationship between physiography and soils. Based on soil texture, depth, slope and erosion, twenty one soil mapping units were identified and mapped (Table 1).

Land capability classification

Land capability classification is an interpretative grouping of soil units to understand the capability of soils to produce crops, raise forestry or any other benefits on a sustained basis. One of the earliest and certainly the best known soil survey interpretation was land capability classification developed by the soil conservation service of the USDA. The classification of soil units provide information on the nature of parent material, colour, texture, structure of soil, type of clay mineral, consistence, permeability, depth of soil and soil reaction. Each of these factors have definite role to play in soil behavior and management (Table 1).

Based on the capability or limitations, lands are grouped into eight classes. The first four classes (I-IV) are used for cultivation of crops. Classes V-VIII are not suitable for growing crops but may be used for growing grasses, forestry or used for wild life habitation and recreation. The first four classes are differentiated based on the extent of soil slope, erosion, depth, structure, soil reaction and drainage. The last four classes are normally delineated based on problems such as stream flow, flooding, ponding etc. Depending on the nature and properties of soils, they may be suitable for one or the other purposes.

The twenty one mapping units were grouped under two land capability classes and four sub classes. Three mapping units belonged to land capability class III with three sub classes such as IIItsf, IIItwsf and IIIts. These soils showed slight to moderate limitations ranging from texture, coarse fragments, subsurface coarse fragments, soil depth, drainage, cation exchange capacity, base saturation and organic carbon. Eighteen mapping units belonged to land capability class IV having two sub classes IVsf and IVts. These soils showed moderate to severe limitations ranging from erosion, slope, texture, coarse fragments, cation exchange capacity, base saturation and organic carbon. Most of the mapping units had limitations of texture, soil depth and organic carbon.

The mapping unit CHK10-c-d5/Be2g1 belonged to land capability sub class IIItsf. This mapping unit exhibited slight to severe limitation in respect of erosion, drainage, texture and organic carbon. The CHK18-sl-l4/Ae2 mapping unit belonged to IIItwsf and had slight to moderate limitation with respect to erosion, drainage, texture and organic carbon. CHK20-cl-d2/Ae2g1 mapping belonged to subclass IIIts which had slight to moderate limitation with respect to erosion, soil depth and organic carbon. The soils of the micro-watershed were evaluated for their suitability for sustainable agriculture by employing land capability classification system. Following the guidelines used by Mani *et al*.[5] in upper Vellar basin and Rajeev Srivastava *et al*.[6] in basaltic terrain, the micro-watershed area was classified under land capability classes viz., class III and IV, and sub classes on the basis of their susceptibility to erosion.

In Chikmegeri-3 micro-watershed, three mapping units belonged to land capability class III with three sub classes *viz.*, IIItsf, IIItwsf and IIIts. Eighteen mapping units belonged to land capability class IV with two sub classes *viz.*, IVsf and IVts. In case of land

capability class III. The mapping unit CHK20-cl-d2/Ae2g1 belonged to subclass IIIts with slight to moderate limitations in respect of erosion, soil depth and organic carbon, occupied 60.70 ha (9.38 % of TGA) (Fig. 10). The mapping unit CHK10-c-d5/Be2g1 belonged sub class IIItsf due to slight to severe limitations in respect of erosion, drainage, texture and organic carbon. It occupied 44.99 ha area accounting for 6.95 per cent of TGA. The mapping unit CHK18-sl-l4/Ae2 belonged to sub class IIItwsf. This had slight to moderate limitations in respect of erosion, drainage, texture and organic carbon. It occupied 56.51 ha (8.73 per cent of TGA).

The mapping unit CHK13-scl-d2/Ae2g2 was rated as land capability class IV with sub class IVtsf indicating limitations in respect of erosion, slope and organic carbon. It occupied an area of 20.63 ha area accounting for 3.19 per cent of TGA. The mapping units of class IV with sub class IVsf occupied an area of 481.21 ha (74.31 % of TGA). Soil texture, depth and organic carbon were the major constraints in 21 mapping units while, one mapping unit had limitation of slope and erosion. It was observed that major portion of the study area was under land capability class IV. Three mapping units belonging to land capability class III with three sub classes *viz.*, IIItsf, IIItwsf and IIIts were marginally suitable for cultivation of crops with varying suitability for different crops. They are marginally suitable for growing vegetable crops can be used for grazing, wild life and forestry. Eighteen mapping units belonged to land capability class IV with two sub classes *viz.*, IVsf and IVts. Lands belonging to land capability class IV were fairly suitable for occasional cultivation, which had very severe limitations that restrict their use.

Soil suitability for different crops

The climate and soil site characteristics play a significant role in maximizing crop yields. The soil properties of the study area were matched with the soil site suitability criteria for a mulberry crop. The kind and degree of limitations of each mapping unit were evaluated and the results are presented Table 2. All the mapping units of the study area were slightly to marginally suitable for mulberry because of constraints due to climate and soil physico-chemical properties. Mapping units such as CHK1-sc-d4/Ae1, CHK4-sc-d4/Ae1, CHK6-scl-d5/Ae1, CHK7-sc-d4/Ae1, CHK8-sc-d4/Ae1, CHK11-sc-d4/Be1, CHK12-scl-d4/Ae2, CHK15-scl-d4/Ae1, CHK16-scl-d5/Ae1 and CHK21-scl-d4/Be1 possessed none to slight limitations of climate and soil physico-chemical properties and were grouped under suitability sub class S1ctws. Moderate to marginal limitation in respect of soil depth was observed in CHK3-scl-d3/Ae1, CHK5-sc-d4/Be2, CHK9-sc-d3/Ae2 and CHK13-scl-d2/Ae2g2 mapping units. These were grouped under suitability sub class S2s. Marginal to severe limitation of soil depth (i.e., shallowness) was observed in CHK2-sc-d2/Ae1, CHK14-scl-d2/Ae2, CHK19-sc-d2/Ae1g1 and CHK20-cl-d2/Ae2g1 mapping units and were grouped under suitability sub class S3s. The mapping units CHK18-sl-l4/Ae2 and CHK10-c-d5/Be2g1 had moderate to marginal limitations in respect of drainage and texture (S2ws).

Rainfall, temperature, slope, depth, texture and base saturation of soils are considered to significantly influence the yield of mulberry. Based on these parameters, the mapping units of the study area were assessed to be slightly to marginally suitable for mulberry. None to slight limitations of climate, soil physico-chemical properties were observed in 276.66 ha (42.73 % of TGA) and were grouped under suitability sub class S1ctws. In the study area, 149.65 (23.11 % of TGA) and 101.50 ha (17.85 % of TGA) were found to have moderate to marginal limitations of depth, texture and drainage (S2ws) and depth and texture (S2s), respectively. Because of marginal to severe limitation of soil depth, 115.50 ha (17.85% of TGA) of the study area were assessed under suitability sub class S3s. Saurabh *et al.*[8] reported that soils of Dehradun district were moderately to marginal suitable for mulberry because of depth and drainage. It is concluded that, study area is suitable for mulberry cultivation with highly, moderate to

marginal limitation of physico-chemical parameters. Farmers can choose mulberry crop as alternate crop, this helps in increase in area, employment opportunities and overall socio-economic development.

Table 1: Land capability classification – quantification of the criteria

Characteristics	Class-I	Class-II	Class-III	Class-IV	Class-V	Class-VI	Class-VII	Class-VIII
Topography (t)								
Slope (%)	0-1	1-3	3-8	8-15	upto 3	15-35	35-50	>50
Erosion	Nil	Slight	Moderate	Severe	Nil	Severe	Severe	
Wetness (w)								
Flooding	nil (F0)	nil (F0) (F0/F1)	nil to slight (F1/F2)	slight to mod. (F3)	mod. to severe (F0/F3)	nil to severe (F0/F4) excessive	nil to very	-
Drainage (l)	Well	Mod. well	Imperfect	Poor	V. poor	Excessive	Excessive	Excessive
Permeability	Moderate	Mod. rapid	Raid slow	V. rapid, v slow	-	-	-	-
Infiltration rate (cm/hr)	2-3.5	1-2.0, 3.0-5.0	0.5-1.0, 5.0-10.0	<0.5, >10.0	2.0			
Physical characteristics (s)								
Surface texture	Loam	sil & cl	sl & c	scl	s, c(m)	ls-cl	ls, s, c	ls, s, c(m)
Surface coarse fragments (vol %)	1-3	3-15	15-40	40-75	15-75	75+		
Surface stoniness (%)	<1	1-3	3-5	5-8	8-15	15-40	40-75	>75
Subsurface coarse fragments (%)	<15	<15	15-35	35-50	50-75	50-75	50-75	>75
Soil depth (cm)	>150	150-100	100-50	50-25	-	25-10	25-10	<10
Profile Development	Cambic/ Argillic hor. A-(B)-C	A-B-C	stratified A-C; A-B-C,	Salic(Z)/Calcic (K) hor. A-BzC/A-Bk-C	Az-C, A-B, C	Gypsic (y) hor. A-cy	A-C (stony)	A-C (bouldary)
Fertility (f)								
CEC [cmol (p^+) kg^{-1}]	40-16	16-12	16-12	-	-	-	-	-
Base saturation (%)	80+	80+	80-50	50.35	50-35	35-15	<15	-
OC (0-15 cm) (%)	>1.0	0.75-1.0	0.5-0.75	<0.5	<0.5	-	-	-
Salinity EC (dS m^{-1})	<1.0	1-2	2-4	4-8	8-15	15-35	35-50	>50
Gypsum (%)	0.3-2.0	2-5	5-10	10-15	15-25	>25	-	-

Table 2: Land capability classification (LCC) of mapping units

Mapping unit	Topography (t)		Drainage (w)	Physical soil characteristics (s)				Profile development	Soil fertility factors (f)			LCC
	Slope	Erosion		Texture	Surface coarse fragments	Subsurface coarse fragments	Soil depth		CEC	BS	OC	
CHK1-sc-d4/Ae1	I	II	I	IV	II	II	II	I	I	I	IV	IVsf
CHK2-sc-d2/Ae1	I	II	I	IV	II	II	III	I	I	I	IV	IVsf
CHK3-scl-d3/Ae1	I	II	I	IV	III	III	III	I	I	I	IV	IVsf
CHK4-sc-d4/Ae1	I	II	I	IV	II	II	II	I	I	I	IV	IVsf
CHK5-sc-d4/Be2	II	III	I	IV	II	IV	III	I	I	I	IV	IVsf
CHK6-scl-d5/Ae1	I	II	I	IV	II	II	II	I	I	I	IV	IVsf
CHK7-sc-d4/Ae1	I	II	I	IV	II	II	II	I	I	I	IV	IVsf
CHK8-sc-d4/Ae1	I	II	I	IV	I	II	II	I	I	I	IV	IVsf
CHK9-sc-d3/Ae2	I	III	I	IV	II	II	III	I	I	I	IV	IVsf
CHK10-c-d5/Be2g1	II	III	II	III	II	II	I	I	I	I	III*	IIItsf
CHK11-sc-d4/Be1	II	II	I	IV	II	IV	II	I	I	I	IV	IVsf
CHK12-scl-d4/Ae2	II	II	I	IV	II	II	III	I	I	I	III	IVsf
CHK13-scl-d2/Ae2g2	I	IV	I	IV	III	IV	II	I	I	I	IV	IVtsf
CHK14-scl-d2/Ae2	I	II	I	IV	III	III	III	I	I	I	IV	IVsf
CHK15-scl-d4/Ae1	II	II	I	IV	II	II	II	I	I	I	IV	IVsf
CHK16-scl-d5/Ae1	I	II	I	IV	II	II	I	I	I	I	IV	IVsf
CHK17-scl-d3/Be2	II	III	I	IV	II	III	III	I	I	I	IV	IVsf
CHK18-sl-l4/Ae2	I	III	III	III	II	III	I	I	I	I	III*	IIItwsf
CHK19-sc-d2/Ae1g1	I	III	II	IV	III	II	III	I	I	I	IV	IVsf
CHK20-cl-d2/Ae2g1	I	III	II	II	II	II	III	I	I	I	III*	IIIts
CHK21-scl-d4/Be1	I	II	II	IV	III	IV	I	I	I	I	IV	IVsf

Table 3: Soil site suitability criteria (crop requirements) for Mulberry

Soil characteristics	Unit	Highly suitable (S1)		Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
		None	Slight	Moderate	Severe	Very severe
Temperature	Degree C	20 -30	20- 30	30- 37	30- 37	<15 >37
Slope	degree	1-3	3-5	5-10	10-15	15-35
Drainage	class	well	well	Moderately well	Imperfect	Poor, excess
Ground water		Very good	Good	Fair	Fair to moderate	Poor
Texture		loam	Clay loamy	Fine loamy	Coarse loamy	Sandy fragments
Depth	cm	>150	100- 150	100 - 50	25- 50	<25

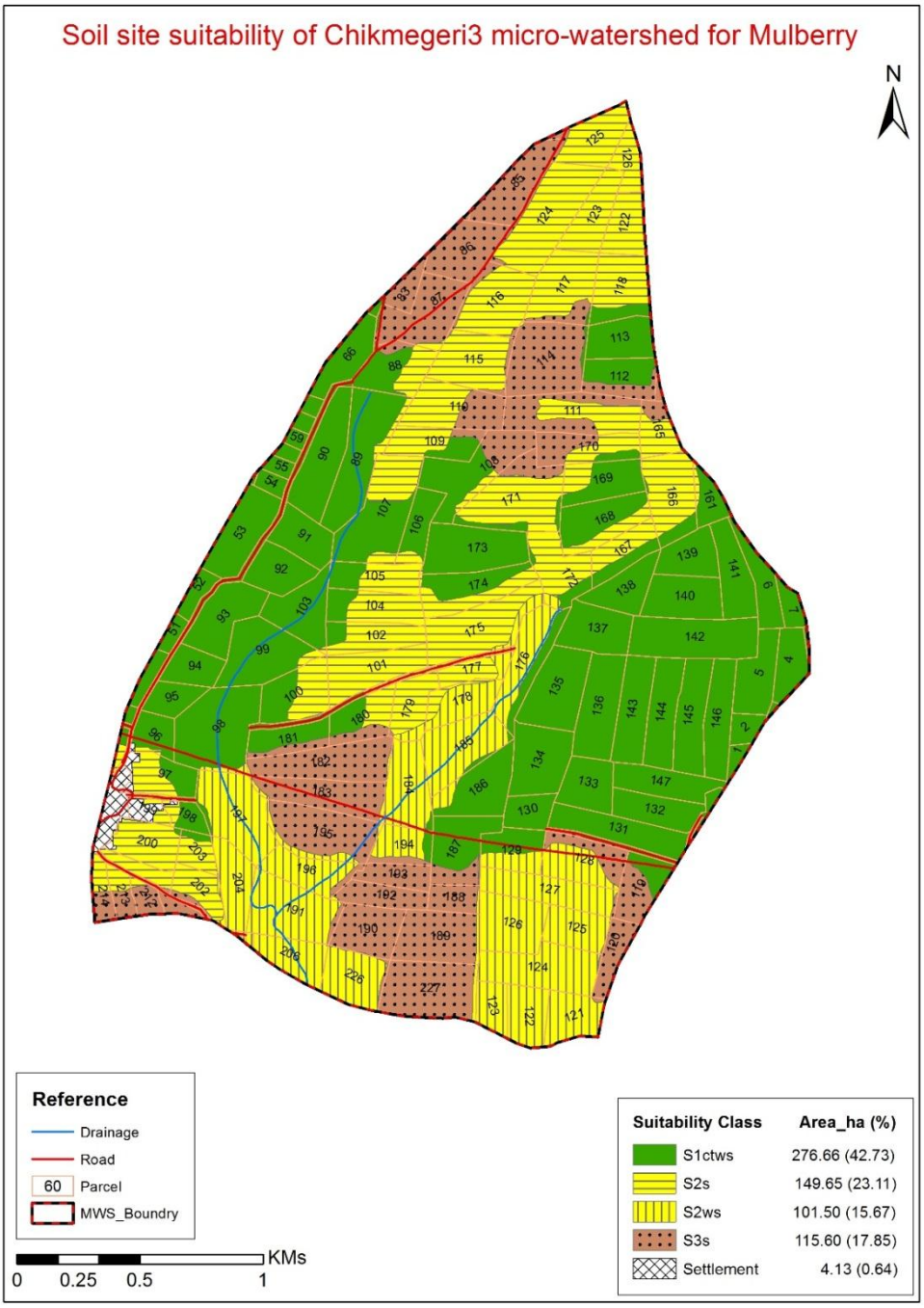

Fig. 1:

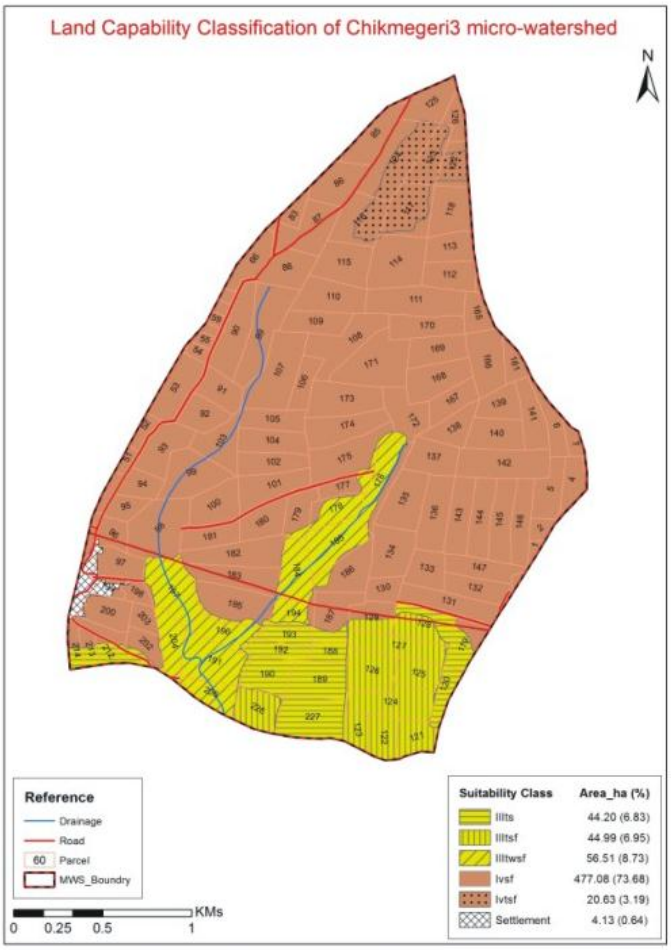

Fig. 2: Land capability classification of Chikmeger-3 micro-watershed

REFERENCES

1. Akash, V., *Mailonlineindia*. 5-6 (2014).
2. Anonymous, ESLM: An International Framework for evaluating sustainable land management. World soil resource report No. 73, FAO, Rome, pp. 160 (1993).
3. Anonymous, NBSS and LUP Staff, Benchmark soil series of India: Mondha series- characteristics, classification and interpretation for land use planning. *Bull. No.*15, NBSS and LUP, Nagpur, p. 24 (1994).
4. Anonymous, Central ground water board. *Koppal District Report* (2014).
5. Mani, S., Natarajan, S., Mariappan, M. S. and Sivakumar, K., Soil resource appraisal for sustainable agriculture and irrigation in upper Vellar basin using remote sensing techniques. Proceedings of ISRS National Symposium, pp. 159-163 (1999).
6. Rajeev Srivastava, S. T., Gaikwad and Jagatram, Water retention characteristics of some swell shrink soils of Chandrapur district of Maharashtra. *Agropedology*, **8:** 15-18 (1998).
7. Sanchez, P. A., Ahamed, S., Carre, F., Hartemink, A. E., Hempel, J., Huising, J., Digital soil map of the world. Science, 325 (2009).
8. Saurabh, P., Uniyal, D., Kandwal, D., Kimothi, M. M. and Pant, D., Site suitability analysis using geospatial techniques for identification of mulberry plantation sites: A case study of Dehradun district of Uttarakhand state. *International Journal of Remote Sensing and Geoscience*, **4(3):** 28-32 (2015).
9. Soil Survey Staff, Soil Taxonomy-A basic system of soil classification for making and interpreting soil surveys. 2nd Eds. Agricultural Hand Book No. 436, United States Department of Agriculture, Washington, D. C., USA (1999).