ACTA SCIENTIFIC AGRICULTURE (ISSN: 2581-365X)

Volume 3 Issue 2 February 2019

Research Article

Soil Resource Inventory, Land Capability and Crop Suitability Assessment of Haradanahalli Micro-Watershed using Remote Sensing and GIS

Anilkumar SN[1]*, Chikkaramappa T[2], Gopala YM[1], Arunkumar JS[1] and Veerendra Patel GM[1]

[1]Research Associate, Department of Soil science and Agricultural Chemistry, University of Agricultural Sciences, Bangalore, India

[2]Professor, Department of Soil science and Agricultural Chemistry, University of Agricultural Sciences, Bangalore, India

***Corresponding Author:** Anilkumar SN, Research Associate, Department of Soil science and Agricultural Chemistry, University of Agricultural Sciences, Bangalore, India.

Received: January 24, 2019; **Published:** February 19, 2019

Abstract

Remote sensing (RS) plays a key role for generating spatial information and mapping of natural resources and inventory, especially in the soil resource mapping for optimal land use towards sustainable development of agriculture. A study was conducted in Haradanahalli micro-watershed with the objective of assessing crop suitability with field crops viz., sorghum, redgram, turmeric and horticulture crops like mango, custard apple and guava using land capability classification (LCC) through Geographic Information System (GIS) techniques. The land capability classes and sub-classes were assigned based on depth (cm), slope (%), erosion status, surface and sub-surface gravel (%) and soil texture of each physiographic unit. These assignments were translated into a land capability map. The LCC of the study area indicated that, out of 680 ha of micro watershed area, 557.2 ha was under class II with moderate limitation of soil (depth, gravelliness, texture salinity/alkalinity), while 2.5 ha was under class III due to severe limitation of soil (depth, gravelliness, texture salinity/alkalinity). The crop suitability of the various physiographic units indicated that 45.5 ha was 'highly suitable' for sorghum and pigeonpea and 49.7 ha in case of turmeric. About 514.2 ha, 510.4 and 203.1 ha were 'moderately suitable' for sorghum, pigeonpea and turmeric respectively. In case of horticulture species like mango, custard apple and guava, 28.5 ha, 58.3 ha and 45.5 ha area were 'highly suitable'; while 507.4 ha, 501.4 ha and 180 ha was 'moderately suitable' due to limitation of rooting depth and gravelliness and severe gravelliness (35-60%). Based on the study, the farmers could grow the suggested crops based on the land capability and soil suitability criteria and attain maximum productivity and profitability under semi-arid regions of Southern Karnataka.

Keywords: Crop Suitability; GIS; LCC; LMU; Remote Sensing

Introduction

Intensive agriculture is the cultivation of land where there are very high inputs of labour, fertilizers, pesticides, herbicides, and fungicides to obtain the maximum output. This involves the use of mechanical ploughing, chemical fertilizers, plant growth regulators and/or pesticides. It is associated with the increasing use of agricultural mechanization, which has enabled a substantial increase in production. But it also dramatically increases deforestation and conversion of grassland to agriculture, soil degradation by increasing soil erosion, compaction, crusting and water logging, salinisation, alkalisation, acidification, soil pollution and nutrient depletion, reduction of organic matter content in the soil and poisoning water with agricultural chemicals which leads to low soil productivity and managing such soil is a formidable challenge to ensure productivity, profitability and national food security on sustainable basis. Sustained food security calls for increasing the crop production by maintaining the productivity of existing crop lands, preventing degradation of fertile lands and bringing erstwhile degraded lands under plough. The importance of sustainable utilisation of natural resources has been widely recognized for which information on the nature, extent spatial distribution and temporal behaviour of land resources is a pre-requisite. Space borne remote sensing can effectively fulfill this role as it is proven tool for fast and accurate appraisal of natural resources. The information thus generated can be put in a Geographic Information System (GIS) that aids planners in decision-making as well as in scientific management of land resources.

Land capability and soil suitability evaluates land for alternative land use patterns for the purpose of selecting the best choice. Planning decisions deal sometimes with interest of competing land users and may therefore be questioned and/or criticized. Hence, it is recommended that those plans and the different scenarios being taken into consideration are based on scientifically sound approaches and objective of suitability assessments. Though India has overcome the situation of food shortage and increased its production from less than 100 million tons per year in the early sixties to 250 million tons per year in this decade. The goal of self sufficiency in the dynamic, socio-economic framework in a sustainable nature needs urgent attention and scientific guidance. This can be achieved through sustainable land management [1].

Land capability, suitability and vocation have been used indistinctly to recommend the most appropriate land use for a given soil [2]. Information on soil and related properties obtained from the soil survey and soil classification can help in better delineation of soil and land suitability for irrigation and in efficient irrigation water management. So, depending on the suitability of the mapped land units for a set of crops, optimum cropping patterns have to be suggested taking into consideration the present cropping system and the socio-economic conditions of the farming community [3]. Keeping these points in view a study was conducted in Haradanahalli micro-watershed with the objective of assessing crop suitability with field crops viz., sorghum, pigeonpea, turmeric and horticulture crops like mango, custard apple and guava using land capability classification (LCC) through Geographic Information System (GIS) techniques.

Experimental details

Materials and procedures

Haradanahalli micro-watershed (Haradanahalli sub-watershed, Chamarajanagara block and district, Karnataka) is located at North latitude 110 52’ 3.091” and 110 53’ 54.775” and East longitude 760 55’ 53.545” and 760 58’ 7.336” Longitude covering an area of 680 ha bounded by 3 villages (Haradanhalli, Bandigere and Kotaganahalli). The micro-watershed is located in Central Karnataka plateau, hot, moist, semi-arid eco-sub region, Southern Plateau and Hill Region (Figure 1). Most of the zone is at an elevation of 800-900m MSL in major areas, in remaining areas 450-800m MSL. Average annual rainfall of the zone ranges from 670.6 to 888.6 mm. The major soils are Red Sandy loams and in remaining areas, pockets of black soils. The main cropping season is Kharif. Major crops in Chamaraanagar district are paddy, ragi, jowar, maize, cotton, sunflower and turmeric.

Figure 1: Location map of Haradanahalli micro watershed area, Chamarajanagara District, Karnataka.

The methodology followed for extraction of information from satellite data is essentially of standard monoscopic visual interpretation based on tone, texture, shape and size. The topographic features, major physiographic units and land use were extracted. The origin of soil deposits were extracted from geological map provided by Geological Survey of India. The data extracted from both the sheets were converted into defined soil units using satellite imagery and were verified by ground truthing through field observation and soil sample collection. Based on the variations of these factors sample strips have been selected for detail morphological study of the soils.

The study area was delineated with the help of toposheet of 1:50,000 scale and soil survey was carried out using cadastral base map at 1:7920 scale. A detailed traverse of the micro watershed was made to identify the major landforms like uplands, midlands and lowlands. Twenty seven representative pedons were selected on different landforms in transect along the slope from the upper to lower slope (Figure 2). The profiles were dug up to 150 cm depth or up to parent rock whichever was shallower based on variations in physiographic unit, parent material type, land use land cover and slope map and studied for their morphological characteristics as per Soil Survey manual [4]. The horizon wise soil samples were collected, air dried and passed through 2mm sieve and analysed for particle size distribution following international pipette method [5]. Based on soil site characteristics and the crop requirements, the soil suitability classes were developed as per the criteria suggested by Sys., *et al*. [6] and NBSS and LUP [7]. The land capability classes and sub classes were arrived at as per the guidelines in Soil Survey Manual [8].

Figure 2: Pedon location map of Haradanahalli micro watershed.

Land capability classification involves an evaluation of the degree of limitation posed by permanent or semi-permanent attributes of land to one or more land use. It is essentially a negative approach whereby as the degree of constraint increases, the capability of land decreases.

Land capability classification scheme

The land is divided into eight capability classes, which are numbered in roman numerals from I to VIII. These eight classes are grouped under two categories viz. i) "Land suited for cultivation and other uses (class I to class IV)", ii) "Land not suited for cultivation, but suitable for other uses" (Class V to Class VIII) [9].

Arable lands

- Class I good cultivable land, deep, nearly level, productive land, soils have slight limitations that restrict their use.
- Class II good cultivable land on almost level plain or non gentle slope and soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.
- Class III moderately good cultivable land almost level plains or slight slope. The area have limitation(s) of moderate erosion, soil depth, soil salinity, soils have severe limitations that reduce the choice of plants or require special conservation practices, or both.
- Class IV fairly good land on almost level plains or moderately suitable for occasional or limited cultivation unsuitable for growing crops because of strong, very strong soil salinity, shallow depth, poor erosion, poor drainage. Soils have very severe limitations that restrict the choice of plants or require very careful management, or both.

Non Arable lands

- Class V soils have little or no hazard of erosion but have other limitations, impractical to remove that limit their use mainly to pasture, range, forestland, or wildlife food and cover.
- Class VI soils have severe limitations that make them generally unsuited for cultivation and that limit their use mainly to pasture, range, forestland, or wildlife food and cover.
- Class VII soils have very severe limitations that make them unsuited for cultivation and that restrict their use mainly to grazing, forestland, or wildlife.
- Class VIII soils and miscellaneous areas have limitations that preclude their use for commercial plant production and limit their use to recreation, wildlife, or water supply or for aesthetic purposes.

To determine the land capability classes, soil texture, soil depth, drainage, coarse fragments, erosion hazards and slope were taken into consideration for the study area.

Soil suitability

Soil site characteristics were studied for each parcel of land which is essential for generating land suitability. Crop suitability maps were generated under GIS platform using the soil-site suitability criteria developed for field and horticulture crops by Naidu., *et al*. [10] and were categorised as highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and unsuitable (N) for production of these crops. Available climatic information with regard to temperature, rainfall and length of growing period [11] were also used for crop suitability assessment. Soil site characteristics of the different phases were matched with criteria for land suitability classification (Table 1) of Haradanahalli micro watershed and suitability maps were generated.

LMU	Mapping units	Area (ha)	Total area (ha)	LCC	Soils	Area (ha)	Total area (ha)
LMU-1	ACPcB1	5.79	8.53	IIs	ACPcB1	5.79	557.2
	ACPiB1	0.81			ACPiB1	0.81	
	TDHcB1	1.93			TDHcB1	1.93	
LMU-2	BDGbB1g1	2.38	15.12		CKMcB1g1	4.14	
	CKMcB1g1	4.14			TGRhB1	8.60	
	TGRhB1	8.60			JDGhB1	17.02	
LMU-3	JDGhB1	17.02	17.02		KVRmA1	4.74	
LMU-4	KVRmA1	4.74	45.04		KVRmB1	11.54	
	KVRmB1	11.54			LGDmB1	19.14	
	LGDmB1	19.14			LGDmB1g1	4.66	
	LGDmB1g1	4.66			MNLiB1	1.33	
	MNLiB1	1.33			SRRmA1	3.63	
	SRRmA1	3.63			HLKiB1	4.04	
LMU-5	HLKiB1	4.04	28.5		RTRiB1	14.20	
	RTRiB1	14.20			RTRhB1	10.26	
	RTRhB1	10.26			AWDiB1	23.59	
LMU-6	AWDiB1	23.59	266.8		AWDmA1	109.20	
	AWDmA1	109.20			AWDmB1	133.97	
	AWDmB1	133.97			KUGhB1	28.24	
LMU-7	KUGhB1	28.24	178.6		KUGiB1	11.84	
	KUGiB1	11.84			KUGmA1	38.41	
	KUGmA1	38.41			KUGmB1	98.25	
	KUGmB1	98.25			SMHmA1	1.88	
	SMHmA1	1.88		IIIs	BDGbB1g1	2.48	2.48

Table 1: Land management units and Land capability classification of Haradanahalli micro watershed.

All theses maps were transferred to GIS environment, overlaid and used as base map for field survey to incorporate the results with field observations. The soil boundary was delineated based on the boundary inferred by combination of different layers representing soil forming factors that were used in as base map. The polygons representing similar physiographic unit, parent material, slope and vegetation cover was put under same soil type which is confirmed by image characteristics and field survey. Different kind of soil can be expected if there is any change of these factors. The soil map was used for land evaluation. The spatial data were analysed for interpreting capability class of soils based on their characteristics and limitations to evaluate their present and future potentialities. The land capability map was generated for planners to be used as a vital input to prepare a strategic planning for effective and efficient decision making.

The spatial analyses technique was adapted to evaluate the agricultural land capability in the study area. The different landforms were identified which was used as a base to delineate soil boundaries to identify different soil types and soil map layer was produced using ArcGIS. The attributed data of land slope, soil organic matter, pH, textural class, soil depth, acidity, CEC, Soil erosion and drainage condition were linked with the units of the digitised soil map in GIS. The incorporated attributes were used to generate thematic layers of spatial distribution of the above mentioned characteristics and properties. The produced layer includes information on capability class and spatial distribution for the soil characteristics. The data obtained indicated that the main limiting factors in the micro- watershed are soil factors such as slope, terrain, soil texture, drainage, erosion and CEC.

Results and Discussion

The land holdings of the micro watershed extending over 560 ha were slight in erosion. Clay textures prevails in 425 ha on the surface soils,very deep soils (>150 cm) are spread in 474 ha (69.7%) of area followed by deep soils (62.1 ha). The majority of area was found tobe non gravelly (548 ha) and 402 ha belongs to very gently slope class (1-3% slope). The land slope is an important factor which has a predominant influence on the extent and intensity of soil erosion. The farmers of the area have been cultivating their lands along the slopes since ancient times. The fact that farmers have been constructing contour bunds in their fields as a soil and waters conservation measure is a testimony of their awareness about the problem of soil erosion.

Land management unit and Land capability classification

Soils of the Haradanahalli micro-watershed were studied for their inherent characteristics viz. soil depth, texture, permeability, drainage, electrical conductivity, pH, maximum water holding capacity with site specific external land features viz. slope, erosion and climatic factors that limit the use of land for sustained use and damage if misused. In this system, the soils are grouped at three levels viz. land capability class, land capability sub-class and land capability units. The mapping units falling under different LMU and LCC are presented in the Table 1.

In the present study, land management units are classified considering the area having common depth along with common management practices. Based on this seven management units were identified in Haradanahalli micro watershed. Wherein LMU-1 has depth of 50-75cm with an area of 8.53ha, followed by LMU-2 (75-100cm, 15.12ha), LMU-3 (100-150cm, 17.02ha), LMU-4 (100-150cm, 45.04 ha), LMU-5 (>150cm, 28.5 ha), LMU-6 (>150cm, 266.8 ha) and LMU-7 (178.6 ha) (Figure 3).

By combining slope map, physiographic soil map and land capability criteria, the study area was classified according to its capability as shown in figure 4. Two classes viz: class II and III are observed in the micro watershed with limitation of soil factors (s) such as drainage, soil slope, soil depth, soil pH, coarse fragments and soil erosion (e). Class II and class III soils are further classified to two categories based on limitation observed. The study indicates that about 557 ha area have got land capability sub-class IIs because of very gently sloping with slight erosion that reduces the choice of crops. About 2.5 ha is found under capability class IIIs with limitations of very gently sloping associated with sub surface graveliness to the extent of 35-60 percent erosion. Whereas area under capability class IIIs with limitation of very gently sloping and excessive gravelliness makes this land moderately cultivable that required careful selection of crops adapted to slope with soil conservation measure. Similar study was carried out by Suresh., *et al.* [12] and Gahlod., *et al.* [13].

Figure 3: Land management units in Haradanahalli micro watershed.

Figure 4: Land capability classification in Haradanahalli micro watershed.

Land suitability

The optimum requirements of a crop are always region specific. Climate and soil-site parameters play significant role in maximizing the crop yields. The kind and degree of limitations were evaluated and soil properties from the study area (Table 2) were matched with soil site suitability criteria.

Soil Phase	Depth (cm)	Tex-ture	Slope (%)	Erosion	*SSG (%)	Sorghum	Pigeonpea	Turmeric	Mango	Custard	Guava
ACPcB1	50 - 75	sl	1 - 3%	slight	15 - 35	S2gr	S2gr	S2gr	N	S2r	S3rt
ACPiB1	50 - 75	sc	1 - 3%	slight	15 - 35	S2gr	S2gr	S2gr	N	S2r	S3rt
TDHcB1	50 - 75	sl	1 - 3%	slight		S2r	S2r	S2r	N	S2r	S3rt
BDGbB1g1	75 - 100	sl	1 - 3%	slight	35 - 60	S2g	S2g	S2g	S3gr	S2g	S3gr
CKMcB1g1	75 - 100	sl	1 - 3%	slight		S2g	S2g	S1	S3r	S1	S2rt
TGRhB1	75 - 100	scl	1 - 3%	slight		S2z	S2z	S2z	S3rz	S1	S2tz
JDGhB1	100 - 150	scl	1 - 3%	slight		S1	S1	S1	S2r	S1	S2t
KVRmA1	100 - 150	c	0 - 1%	slight	15 - 30	S2gz	S2tz	S3tz	S2tz	S2z	S3tz
KVRmB1	100 - 150	c	1 - 3%	slight		S2z	S2tz	S3tz	S2tz	S2z	S3tz
LGDmB1	100 - 150	c	1 - 3%	slight		S2z	S2tz	S3tz	S2tz	S2z	S3tz
LGDmB1g1	100 - 150	c	1 - 3%	slight		S2gz	S2tz	S3tz	S2tz	S2z	S3tz
MNLiB1	100 - 150	sc	1 - 3%	slight		S2z	S2z	S2z	S2t	S2z	S2tz
SRRmA1	100 - 150	c	0 - 1%	slight		S2z	S3tz	S2tz	S2tz	S2n	N
HLKiB1	>150	sc	1 - 3%	slight		S1	S1	S1	S1	S1	S2t
RTRiB1	>150	sc	1 - 3%	slight		S1	S1	S1	S1	S1	S2t
RTRhB1	>150	scl	1 - 3%	slight		S1	S1	S1	S1	S1	S2t
AWDiB1	>150	sc	1 - 3%	slight		S2z	S2tz	S3tz	S2tz	S2z	S3tz
AWDmA1	>150	c	0 - 1%	slight		S2z	S2tz	S3tz	S2tz	S2z	S3tz
AWDmB1	>150	c	1 - 3%	slight		S2z	S2tz	S3tz	S2tz	S2z	S3tz
KUGhB1	>150	scl	1 - 3%	slight		S2z	S2z	S2z	S2z	S2z	S2tz
KUGiB1	>150	sc	1 - 3%	slight		S2z	S2z	S2z	S2z	S2z	S2tz
KUGmA1	>150	c	0 - 1%	slight		S2z	S2z	S2z	S2z	S2z	S2tz
KUGmB1	>150	c	1 - 3%	slight		S2z	S2z	S2z	S2z	S2z	S2tz
SMHmA1	>150	c	0 - 1%	slight		S2z	S2z	S2z	S2z	S2z	S2tz

Table 2: Land suitability assessment for agriculture and horticulture crops in Haradanahalli micro watershed.

Note: Suitability: S1 - Highly suitable S2 - moderately suitable S3 - marginally suitable N - not suitable g - gravelliness t –texturez - calcareousr - rooting depth

Texture: scl: sandy clay loam, sc: sandy clay, c: clay, sl: sandy loam, *SSG: Sub surface gravel

Sorghum

In general sorghum require an annual rainfall of 700-750 mm, soil depth (75-100 cm) with sandy clay loam to clayey texture with a good drainage system [14]. The crop suitability of the various physiographic units indicated that 45.5 ha is highly suitable (S1) and 514 ha is 'moderately suitable (S2) due to limitations of gravelliness, rooting depth and calcareousness (Figure 5). If this limitation is taken care, suitability of soils may be improved.

Redgram

The yield influencing factors on redgram are rainfall, soil depth and calcium carbonate [13]. In 680 ha study area 45.5 ha is highly suitable (S1), moderately (S2) suitable area exists in 510.4 ha due to gravelliness and rooting depth limitation and the remaining 3.8 ha is marginally suitable (S3) for redgram because it had severe limitations of texture and calcareousness (Figure 6). It is observed that most crops produced excellent yields with an effective root zone depth of 90 to 100 cm. Field studies of Sehgal., *et al.* [3] suggested that a depth of 100-120 cm was optimum and soils with 60-100 cm was critical for redgram.

Turmeric

Turmeric is a tropical herb and is grown in both tropics and sub tropics. It will grow luxuriantly in shade if not too dense, but it produces larger and better rhizomes in the open ground exposed to the sun. It can be grown in a wide range of soils from light black to

Figure 5: Land suitability for sorghum.

Figure 6: Land suitability for Redgram.

clay loam soils with low organic matter content. Considering the soil site characteristics of the study are, 49.7 ha out of 680 ha is highly suitable (S1), 203 ha is moderately (S2) and 307 ha is marginally suitable for turmeric cultivation due to limitation of texture and calcareousness (Figure 7).

Figure 7: Land suitability for turmeric.

Mango

Mango (*Mangifera indica* L) is one of the choicest and most ancient fruits known to mankind.Mango thrives well up to 600 m above mean sea level provided locality is frost free and there is no high humidity or rains during flowering. Mango has been found to grow on a wide range of soils. However, deep and well-drained loam to sandy loam soils are most suitable for cultivation. In this micro watershed 28.5 ha of the study is highly suitable (S1). Whereas 507.4 ha area was found to be moderately suitable due to limitation of texture and calcareousness. Marginally suitable soils exist in 15.3 ha of the area and 8.5 ha is not suitable for cultivation of mango due to shallow depth (Figure 8).

Figure 8: Land suitability for mango.

Custard apple

The fruits are low in saturated fat, cholesterol and sodium and high in vitamine-C, Manganese, Iron and potassium. Custard apple grow best in sandy loam soil, but well structured clay loams are highly suitable. In Haradanahalli micro watershed, 58.3 ha is found to be highly suitable (S1) and 501 ha is found to be moderately suitable (S2) due to gravelliness, rooting depth and calcareousness as limitation (Figure 9).

Guava

It tolerates a soil pH of 4.5-8.2. Maximum concentration of its feeding roots is present up to 25 cm soil depth. Thus, the top soil should be quite rich to provide enough nutrients for accelerating new growth which bears fruits. In 680 ha study area 238 ha is moderately (S2) suitable due to limited rooting depth an calcareousness whereas, 318 ha is marginally suitable (S3) for guava due to limitations of gravelliness and rooting depth and 3.6 ha is not suitable due to shallow rooting depth (Figure 10).

Figure 9: Land suitability for custard apple.

Figure 10: Land suitability for guava.

Conclusion

Major portion of the study area (82.0%) falls under class-II due to limitations of soil such as depth, gravelliness, slope, and texture. Hence, practices such as dead furrows between crops to arrest soil loss, summer ploughing for in situ moisture conservation and addition of organic matter (FYM, compost) to maintain soil aggregation should be followed.

Among land management units (LMU), LMU-6 occupies 39.2% of the study area followed by LMU-7 (26.3%) and LMU-4 (6.6%). Since depth is considered as important factor in distinguishing land to different management units shallow rooted crops such as pulses viz., cowpea, black gram, green gram is found to be appropriate in LMU-1. Whereas deep rooted crops such sorghum and redgram should be grown in LMU-3 LMU-4, LMU-5 and horticultural crops should be cultivated in LMU-4, LMU-5, LMU-6 and LMU-7 for harnessing maximum yield. Cultivation of turmeric is restricted to LMU-2 and LMU-3 due to limitation of texture.

In this micro watershed moderately suitable soils occupy major portion of the area compared to highly suitable soil. Wherein 514 ha area is moderately suitable for sorghum, 510 ha for redgram and 203 hain case of turmeric. For horticulture crop 507is moderately suitable for mango, 501 ha in case of custard apple and 238 ha for guava. Soil factors made the land moderately suitable for cultivation. Therefore, major limiting land characteristic for crop production in watershed is attributed to soil factors such as gravelliness, slope and texture. This indicates that such lands can be degraded and easily loose the productive potential with existing land use practicesand no well-timed appropriate measures are undertaken.

Bibliography

1. Edward CA., *et al*. “Sustainable Agriculture Systems”. *Soil and Water Conservation* (1990): 696.
2. Comerma J. “Land capability, suitability and vocation in Venezuela”. 19th World Congress of Soil Science, Soil Solutions for a Changing World 1 – 6 August 2010, Brisbane, Australia (2010): 129-131.
3. Sehgal JL., *et al*. “Suitability of swell shrink soils of India for crop growth”. In: Soil for Development. Ed. Van Cleemut. ITC Ghent Publication Series 1 (1989): 29-53.
4. Soil Survey Division Staff. Soil Survey Manual USDA, Handbook. No. 18 US Government printing office: Washington, D.C (1999).
5. Richards LA. “Diagnosis and improvement of saline and alkali soils”. USDA, Hand Book No 60 (1954): 101.
6. Sys C., *et al*. “Land evaluation, part III. Crop requirements”. Agriculture publication, no.7, General Administration for Development Cooperation. Brussels, Belgium, (1993): 166.
7. NBSS and LUP. “Proceedings National meet on soil site suitability criteria for different crops, NBSS and LUP, Nagpur”. (1994).
8. Soil Survey Staff, “Soil Survey Manual”. US Department of Agriculture Handbook No. 18 (1951).
9. Klingebiel AA and Montgomery PH. “Land capability classification, Soil conservation Services, USDA”. Agriculture hand book number 210 (1961): 6-11.
10. Naidu LGK., *et al*. “Manual soil site criteria for major crops”. NBSS publication no. 129, NBSS and LUP, Nagpur (2006): 118.

11. Naidu LGK., *et al*. "Mapping of agroecological zones of AP through soil resource data". *Indian Journal of Agricultural Sciences* 68 (1998): 661-665.

12. Suresh Kumar., *et al*. "Geospatial technology in soil resource inventory and land capability assessment for sustainable development- Wayanad District, Kerala". *Journal of Soil and Water Conservation* 15.3 (2016): 218-225.

13. Gahlod NS., *et al*. "Soil resource inventory for assessing soil quality and land capability using geospatial technology". *Journal of Soil and Water Conservation* 16 (2017): 1-9.

14. Sehgal JL and Gajbhiye KS. "Land resource for sustainable agriculture: the challenges and views". Agroped 6 (1996): 1-12.

Volume 3 Issue 3 March 2019
© All rights are reserved by Anilkumar SN*., et al.*