International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 2144-2153

Received: 21-11-2020
Accepted: 30-12-2020

Rajendra Hegde
ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre Hebbal, Bangalore, Karnataka, India

MB Mahendra Kumar
ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre Hebbal, Bangalore, Karnataka, India

KV Niranjana
ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre Hebbal, Bangalore, Karnataka, India

KV Seema
ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre Hebbal, Bangalore, Karnataka, India

BA Dhanorkar
ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre Hebbal, Bangalore, Karnataka, India

Corresponding Author:
MB Mahendra Kumar
ICAR-National Bureau of Soil Survey and Land Use Planning, Regional Centre Hebbal, Bangalore, Karnataka, India

Land suitability evaluation in yaadhalli-1 microwatershed of Yadgir taluk and District of Karnataka, India, using remote sensing and geographical information system (GIS) tools

Rajendra Hegde, MB Mahendra Kumar, KV Niranjana, KV Seema and BA Dhanorkar

DOI: https://doi.org/10.22271/chemi.2021.v9.i1ad.11539

Abstract
In present investigation, five soil series were identified and mapped into eleven mapping units using GIS technique in Yaadahalli-1 microwatershed of Yadgir Taluk and District of Karnataka, India. The soils were varied from deep to very deep in depth, sandy clay loam to sandy clay in texture, very gently sloping, moderate erosion and non gravelly in nature. These soils were grouped into land capability class II (87%) and IV (2%) with limitations of soil characteristics and erosion. Land suitability evaluation showed a maximum area under highly suitable (S1) land for growing agricultural (sorghum, sunflower, Bengal gram and cotton) and horticultural (brinjal, onion, Bhendi, musambi, lime and custard apple) crops followed by moderately suitable (Class S2) land with minor limitations of texture, rooting depth, drainage and calcareousness. The marginally suitable (Class S3) land covers a minimum area with major limitations of rooting depth, gravelliness, texture and calcareousness. Currently not suitable (Class N1) land covers a negligible area with severe limitations of rooting depth and gravelliness. The results of this study could be used to provide the baseline information needed for mapping specific soil resource constraints for sustainable production of these crops in the study area. Therefore, the integration of remote sensing & GIS techniques could be envisaged as a laudable resource sustainable approach to model the growth of these crops in order to enhance profitable land use planning decision support for sustainable crop production in the study area.

Keywords: Soil series, mapping units, land capability class, land suitability evaluation, crops

Introduction
Land evaluation is defined as "the process of assessment of land performance when used for specific purposes". The FAO, land evaluation framework has been the primary method practiced worldwide to address local, regional and national land use planning (FAO, 1976) [3]. The increased necessity for food production and the limited resources stimulate a need for sophisticated methods of land evaluation to aid decision-makers in their role to both preserve highly suitable lands and satisfy producers demands for enhanced profits (Ali Bagherzadeh and Daneshvar, 2011) [1]. The soil and land resource units (soil phases) were assessed for their suitability for growing food, fodder, fibre and other horticulture crops by following the procedure as outlined in FAO, 1976 and 1983 [3, 4]. Crop requirements were developed for each of the crop from the available research data and also by referring to Naidu *et al.* (2006) [9] and Natarajan *et al.* (2015) [10]. The soil and land characteristics were matched with the crop requirement to arrive at the crop suitability. Soil site characteristics identifies the degree of suitability for land use which aids in planning expansion of area under a suitable site specific crop (Singh *et al*., 1998 and Sharma *et al*., 2001) [16, 15]. Knowledge of soil resources with respect to their spatial distribution; characteristics, potentials, limitations and their suitability for alternate land uses helps in formulating strategies to obtain higher productivity on sustained basis. Rapid evolution of satellite remote sensing and Geographical Information Systems (GIS) has made possible the development of new techniques for facilitating mapping of natural resources. Remote sensing and GIS application in soil resource mapping enables the study of soils in spatial domain, in time and in a cost effective manner.

For deriving crop suitability of a particular area detailed soil information is essential. By using detailed soil survey data we have arrived with soil mapping units. Assigning soil site suitability criteria to particular mapping units, soil suitability maps have been generated in the GIS environment (Chandrakala *et al*., 2019) [2]. The sustainable crop production system depends on developing and adaptation of ideal land use plan based on soil quality and its constraints for plant growth. Using the above criteria, the soil map units of the microwatershed were evaluated and land suitability maps for crops were generated. Hence, the detailed study was carried out with the objective of land suitability evaluation in Yaadhalli-1 microwatershed of Yadgir Taluk and District of Karnataka, India by using remote sensing and GIS tools.

Materials and Methods

Details of the study area

Yaadahalli-1 microwatershed is located in the northern part of Karnataka in Yadgir Taluk & District, Karnataka State (Fig.1). It comprises of Hatthakuni, Horunacha, Chamanahalli, Bandhalli and Yaddalli villages. It lies between 16^0 48' and 16^0 51' North latitudes and 77^0 8' and 77^0 10' East longitudes covering an area of about 702 ha. It is about 12 km from Yadgir town and is surrounded by Hatthakuni village on the north, Horunacha and Chamanahalli villages on the western side, Yaddalli village on the eastern side and Bandhalli village on the southern side. Geology of the area is granite gneiss of the Archaen age. Elevation ranges from 379-403 m above MSL. Climate is semiarid drought-prone type. Total annual rainfall of 866 mm and mean maximum and minimum temperature are 34 ^{0}C and 22 ^{0}C. In this microwatershed agriculture is the fundamental livelihood activity among the people. Study area is characterized by granite gneiss landscape. The detailed soil survey was conducted as per the guidelines given in Soil Survey Manual, 1993 [17]. Inceptisols, Alfisols and Vertisols form the major soil type. The physico-chemical (Table 1) properties (horizon-wise) were estimated by following the standard procedures outlined by Sarma *et al*., 1987 [13]. Five soil series were identified in the study area and mapped into 11 mapping units as phases of soil series. Weighted mean of each property was calculated and soil-site characteristics of different soil units were obtained as shown in Table 2. Land capability map and soil- site suitability maps were prepared from ArcGIS10.2.2 software.

Structure of the Classification for Soil suitability Evaluation

The land suitability classification is grouped into orders, classes, subclasses and units. At the order level, the land units are grouped into suitable or not suitable based on kinds of suitability for the selected land use. The orders are further divided into classes based on degrees of suitability and the classes are further divided into subclasses based on the kinds of limitations, subclasses are divided into land suitability units based on specific management requirements (Sys, 1993; NBSS&LUP, 1994 and Naidu *et al*., 2006) [18, 8, 9]. A brief description of the orders and classes used in the suitability assessment for major crops grown in the area is given below.

Order S (Suitable)

Class S1 (Highly suitable) - Land having no or slight limitations for sustainable use.

Class S2 (Moderately suitable) - Land with moderate limitations for sustained use.

Class S3 (Marginally suitable) Land with severe limitations for sustained use.

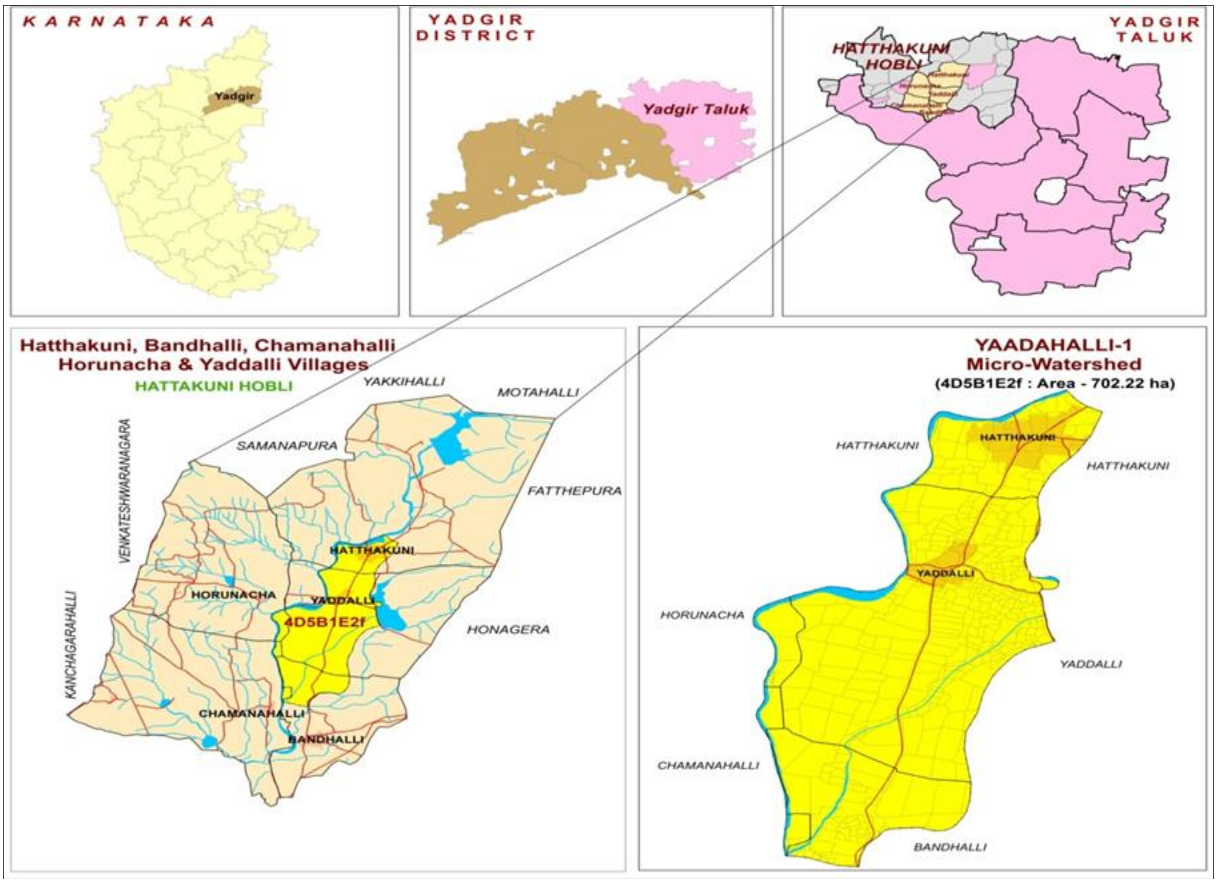

Fig 1: Location map of Yaadahalli-1 Microwatershed

Order N (Not Suitable)
Class N1 (Currently not suitable) - Land with severe or very severe limitations that may be overcome in time but cannot be corrected with existing knowledge at current acceptable cost.
Class N2 (Permanently not suitable) - Land having limitations that appear so severe as to prelude any possibility of use of the land.
Classes S2 and S3 were further divided into sub classes based on the specific limitations encountered in the area. There are no subclasses within suitability class S1. The specific limitations affecting crop production in the area are indicated below with their symbols.

Climate: temperature, rainfall total and distribution, dry months and growing period	**c**
Topography	l
Erosion	e
Soil depth or rooting condition	r
Soil texture (sandy or heavy clay)	t
Coarse fragments	g
Soil fertility (calcareousness)	s
Nutrient status (CEC/BS)	n
Drainage	w
Flood	f
Depth to water table	d

Limitations are indicated in lower case letters after the class symbol. For example moderately suitable land with texture as a limitation is designated as S2t. Normally two and sometimes three limitations are indicated at sub class level. The Arabic numbers, wherever used, indicates land suitability units, after the limitation symbol.

Land suitability assessment for major crops adopted to the area
Using the soil site suitability criteria (NBSS&LUP, 1994 & Naidu *et al*., 2006) [8, 9] land resource of the Yaadhalli-1 Microwatershed was assessed for their suitability for the following crops.

Agricultural crops:	Sorghum, Sunflower, Bengal gram & Cotton
Horticultural crops:	Brinjal, Onion, Bhendi, Musambi, Lime & Custard apple

Results and Discussion
Land capability classification: Land capability classification is an interpretative grouping of soil map units (soil phases) mainly based on inherent soil characteristics, external land features and environmental factors that limit the use of land for agriculture, pasture, forestry, or other uses on a sustained basis (IARI, 1971) [6]. The land and soil characteristics used to group the land resources in an area into various land capability classes, subclasses and units. Based on soil properties, the soils of Yaadahalli-1 microwatershed are grouped under 2 land capability classes (II & IV) and 4 land capability subclasses. An entire area of 626 ha (89%) in the microwatershed is suitable for agriculture. About 76 ha (11%) area is covered by others (water body & habitation) (Fig. 2). Good cultivable lands (Class II) cover an area of about 87 per cent and are distributed in the major part of the microwatershed with minor problems of soil and erosion. Fairly good cultivable lands (Class IV) cover an area of about 2 per cent of the microwatershed with severe problems of soil and erosion. Similar findings were also reported by Patil *et al*. (2011) [11] and Mahesh Kumar *et al*. (2019) [7].

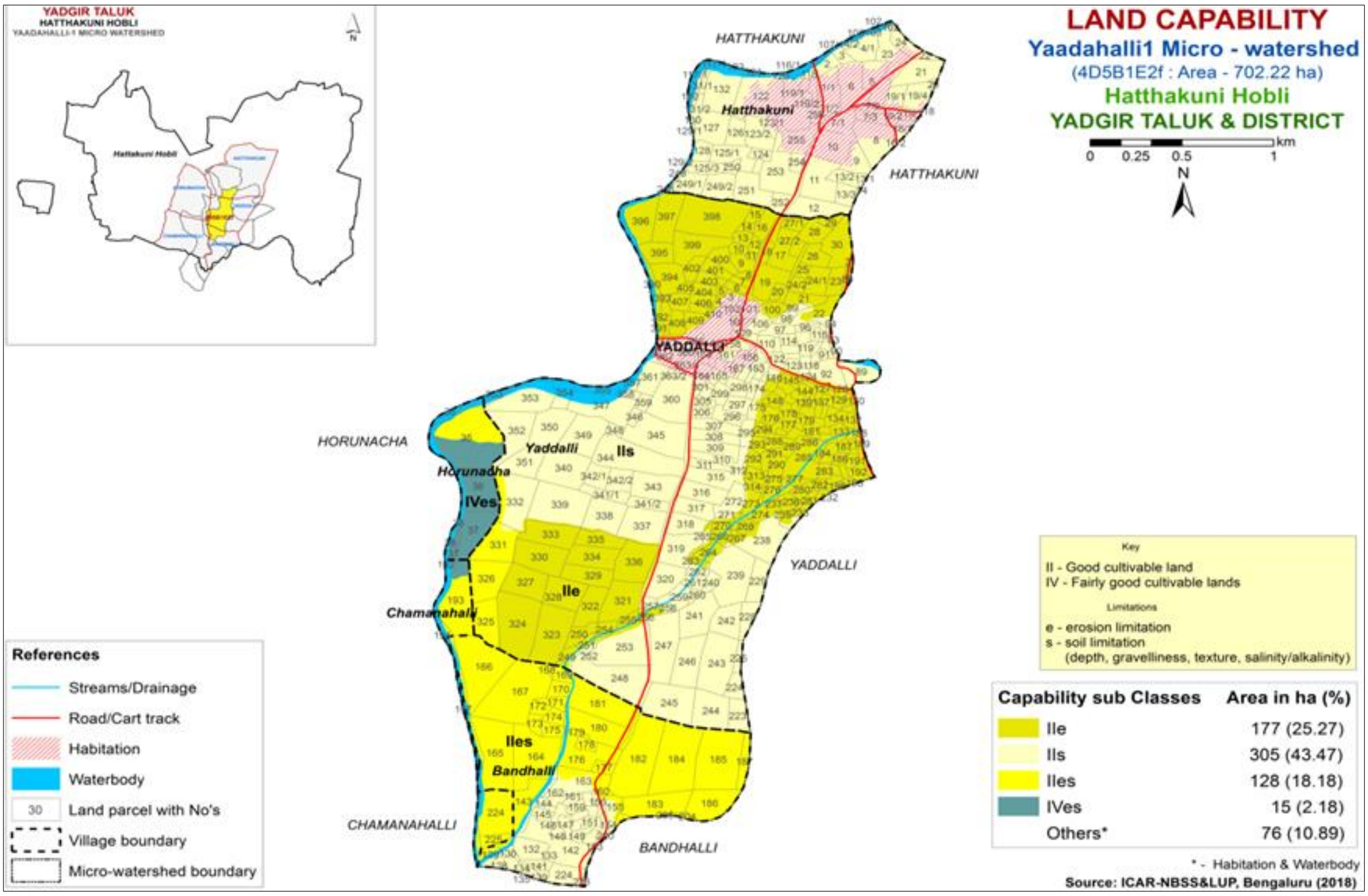

Fig 2: Land Capability map of Yaadahalli-1 Microwatershed

Table 1: Physico-chemical properties of the soils of Yaadhalli-1 Microwatershed of Yadgir Taluk and District of Karnataka, India

Depth cm	Horizon	Particle size distribution (% of <2 mm)			pH (1:2.5)	EC (1:2.5) dS m^{-1}	OC (%)	Exchangeable bases [Cmol (p^+) kg^{-1}]				CEC [Cmol (p^+) kg^{-1}]	CEC/clay	Base saturation (%)
		Sand (2.0-0.05 mm)	Silt (0.05-0.002 mm)	Clay (<0.002 mm)				Ca	Mg	K	Na			
Dastharabad (DSB) Clayey-skeletal, mixed, isohyperthermic Paralithic Haplustalfs														
0-6	Ap	90.51	4.84	4.64	5.93	0.04	0.67	2.00	0.54	0.07	0.01	3.60	0.78	73
6-17	Bt1	49.11	8.08	42.81	7.31	0.110	0.91	11.19	3.37	0.12	0.49	15.20	0.36	100
17-43	Bt2	39.54	2.84	57.63	6.64	0.048	0.76	18.81	5.57	0.23	0.09	24.90	0.43	99
Hosalli (HSL) Fine, mixed, isohyperthermic Typic Haplustepts														
0-10	Ap	88.43	5.15	6.42	7.16	0.117	0.48	2.83	1.50	0.15	0.29	4.90	0.76	97
10-30	Bw1	58.47	7.24	34.29	6.91	0.040	0.36	10.64	5.43	0.10	0.26	17.80	0.52	92
30-50	Bw2	51.43	12.67	35.90	8.17	0.182	0.24	-	-	0.12	0.22	19.90	0.55	100
50-90	Bw3	49.89	13.64	36.47	8.60	0.148	0.20	-	-	0.13	0.16	19.70	0.54	100
Mundargi (MDG) Fine-loamy, mixed, isohyperthermic Fluventic Haplustepts														
0-9	Ap	81.23	12.97	5.80	8.20	0.399	0.44	-	-	0.16	0.38	4.90	0.84	100
9-20	A2	76.82	16.19	6.98	8.44	0.075	0.29	-	-	0.05	0.35	4.90	0.70	100
20-46	Bw1	42.43	17.43	40.15	9.39	0.451	0.32	-	-	0.12	5.22	20.77	0.52	100
46-90	Bw2	54.51	16.56	28.93	9.75	0.616	0.24	-	-	0.12	5.72	16.56	0.57	100
90-110	Bw3	53.69	11.00	35.30	9.72	0.725	0.24	-	-	0.14	6.84	19.76	0.56	100
Madhawara (MDR) Fine-loamy, mixed, isohyperthermic Fluventic Haplustepts														
0-11	Ap	58.94	20.74	20.32	8.31	0.33	0.46	-	-	0.45	0.47	20.57	1.01	100
11-30	Bw1	55.52	19.32	25.16	9.25	0.20	0.31	-	-	0.19	1.40	23.98	0.95	100
30-53	Bw2	53.95	19.15	26.90	9.78	0.40	0.19	-	-	0.16	1.53	24.53	0.91	100
53-117	Bw3	52.68	19.51	27.81	9.94	0.88	0.23	-	-	0.18	9.09	24.31	0.87	100
117-160	Bw4	49.95	17.27	32.79	9.98	0.93	0.15	-	-	0.24	11.09	28.27	0.86	100
Bhimanahalli (BMN) Fine, smectitic (calc), isohyperthermic Typic Haplusterts														
0-8	Ap	20.34	19.94	59.72	8.20	0.284	0.72	-	-	1.20	0.34	52.70	0.88	100
8-40	Bss1	19.61	22.76	57.62	8.44	0.139	0.40	-	-	0.30	0.48	52.06	0.90	100
40-70	Bss2	21.25	17.65	61.10	8.32	0.202	0.40	-	-	0.18	0.40	52.52	0.86	100
70-120	Bss3	19.08	22.29	58.63	9.30	0.282	0.36	-	-	0.27	0.38	50.97	0.87	100
120-170	Bss4	11.11	20.44	68.45	8.47	0.305	0.37	-	-	0.28	0.91	58.19	0.85	100

Land Suitability for Agricultural crops

The crop requirements for growing sorghum, sunflower, bengalgram and cotton were matched with the soil-site characteristics (Table 2) of the soils of the microwatershed and a land suitability map for growing sorghum, sunflower, bengalgram and cotton was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Fig. 3, 4, 5 and 6.

The suitable assessment for agricultural crops in Yaadahalli-1 microwatershed showed a maximum area under highly suitable (S1) land for growing sorghum (586 ha), sunflower (409 ha), bengalgram (586 ha) and cotton (409 ha) followed by moderately suitable (Class S2) land. They have minor limitations of texture, rooting depth, drainage and calcareousness. Sehgal (1996) [14] reported that, the factors that influence sorghum yield are rainfall, temperature, slope, base saturation, $CaCO_3$, cation exchange capacity and texture. For Cotton the yield was significantly influenced by rainfall and soil depth, an ideal depth of 100 to 200 cm soil depth and moisture storage capacity of 220 mm (Patil *et al.*, 2011) [11]. The marginally suitable (Class S3) land covers a minimum area with major limitations of rooting depth, gravelliness, texture and calcareousness. Currently not suitable (Class N1) land covers a negligible area with severe limitations of rooting depth and gravelliness. Similar findings were also reported by Mahesh Kumar *et al*. (2019) [7] and Geetha *et al*. (2017) [5]. The agricultural crops were well suitable for growing because of deep to very deep in depth, sandy clay loam to sandy clay texture with less gravelliness, very gently sloping land and moderate erosion.

Land Suitability for Horticultural crops

The crop requirements for growing brinjal, onion, bhendi, musambi, lime and custard apple were matched with the soil-site characteristics (Table 2) of the soils of the microwatershed and a land suitability map for growing brinjal, onion, bhendi, musambi, lime and custard apple was generated. The area extent and their geographic distribution of different suitability subclasses in the microwatershed are given in Fig. 7, 8, 9, 10, 11 and 12.

Whiley (1984) [19] reported that, the soil depth and soil reactions influence on growth and development of horticultural crops. The land Suitability for horticultural crops in Yaadahalli-1 microwatershed showed that maximum area comes under highly suitable (S1) land for growing brinjal (204 ha), onion (222 ha), bhendi (600 ha), musambi (409 ha), lime (409 ha) and custard apple (605 ha) followed by moderately suitable (Class S2) land with minor limitations of texture, rooting depth and calcareousness. The marginally suitable (Class S3) land covers a minimum area with major limitations of rooting depth, gravelliness and texture. Currently not suitable (Class N1) land covers a negligible area with severe limitations of rooting depth and gravelliness. Similar findings were also reported by Mahesh Kumar *et al*. (2019) [7] and Geetha *et al*. (2017) [5]. Majority of the soils in the microwatershed is suitable for horticultural crops due to deep to very deep in depth, sandy clay loam to sandy clay in texture, less gravelliness, maximum available water content, very gently sloping land with moderate erosion enhance for growing of this crops.

Remote sensing and GIS based cadastral level detailed LRI help to derive land suitability and land capability at parcel level for improved agricultural and horticultural planning and management (Rajesh *et al*., 2016) [12].

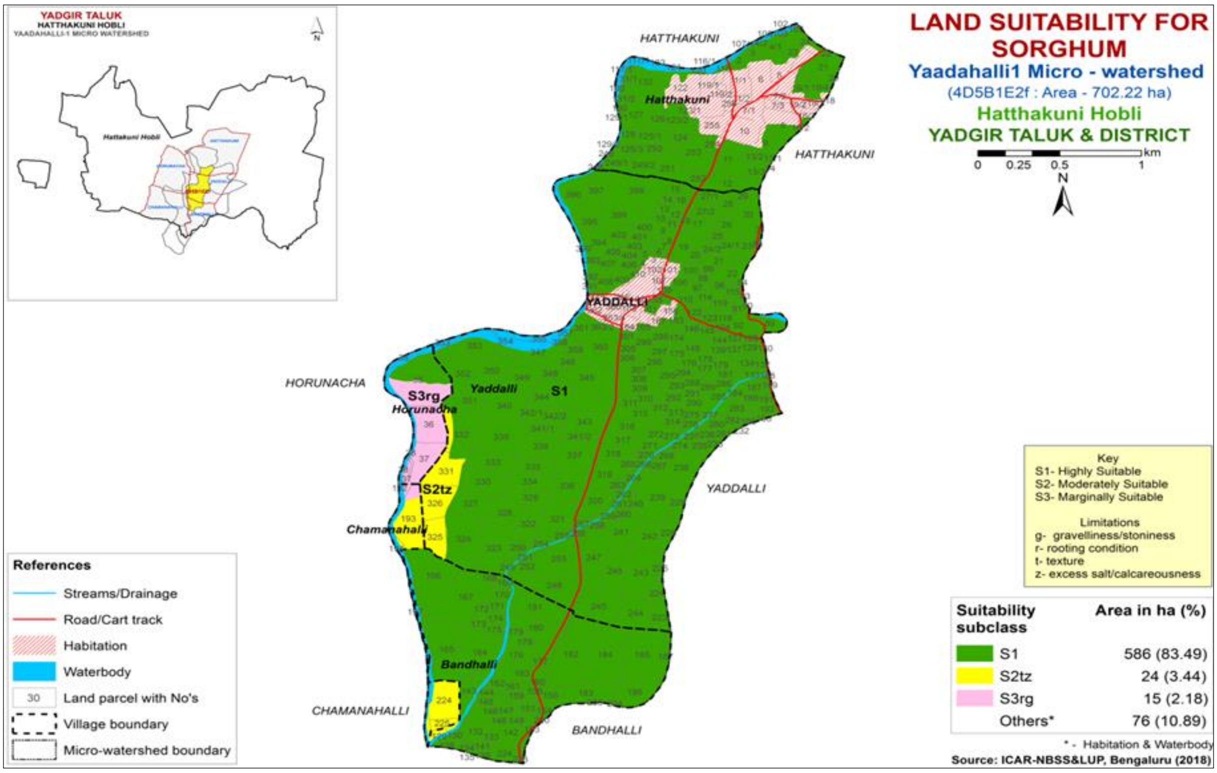

Fig 3: Land Suitability map of Sorghum

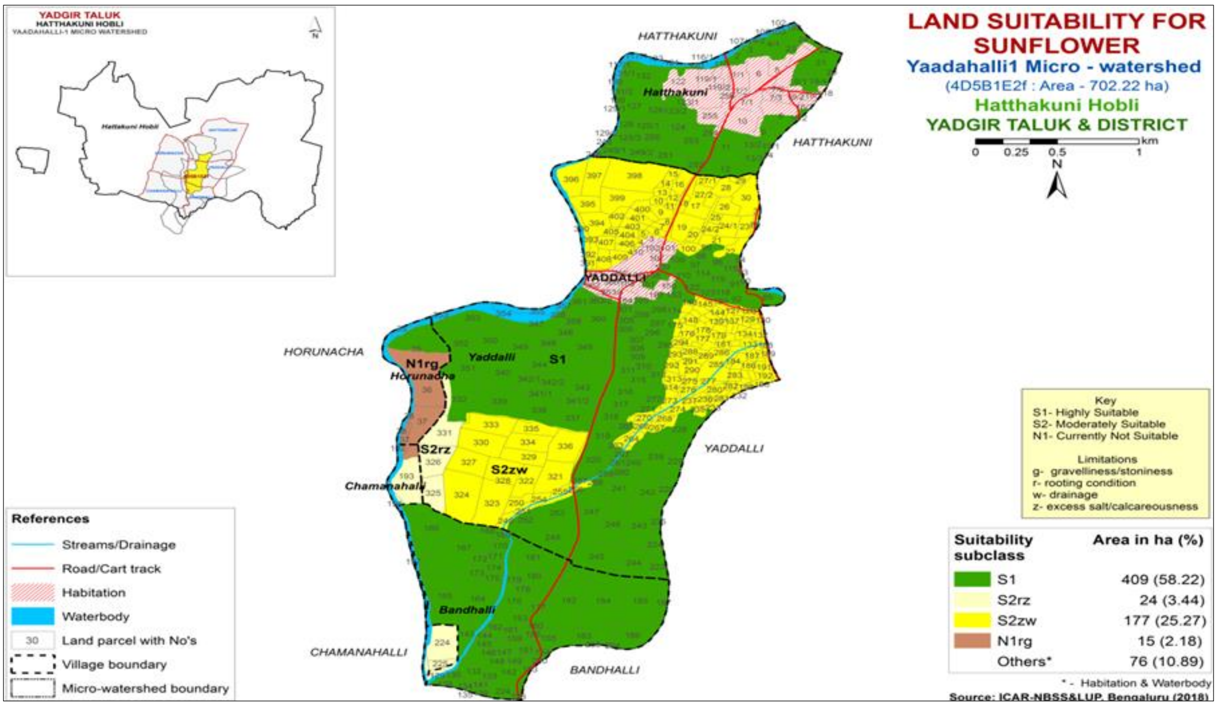

Fig 4: Land Suitability map of Sunflower

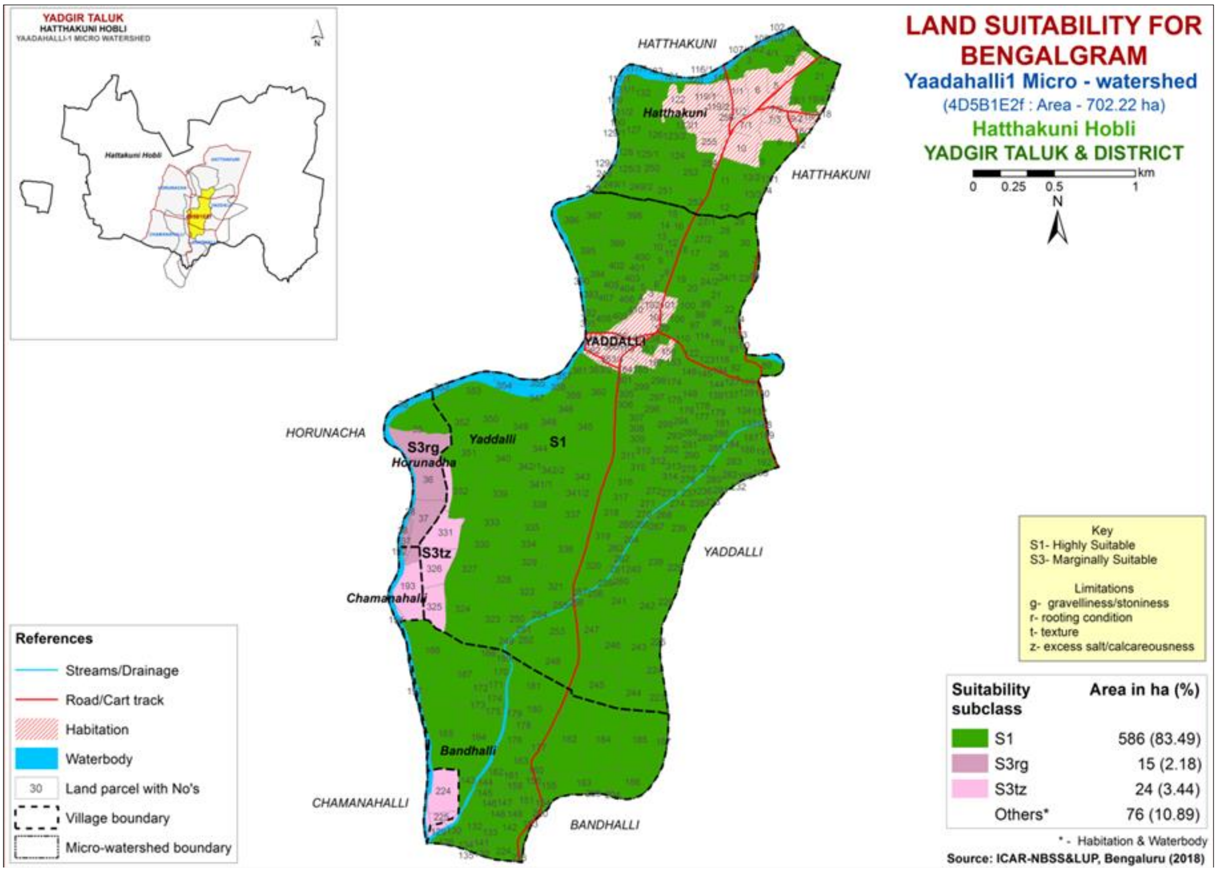

Fig 5: Land Suitability map of Bengal gram

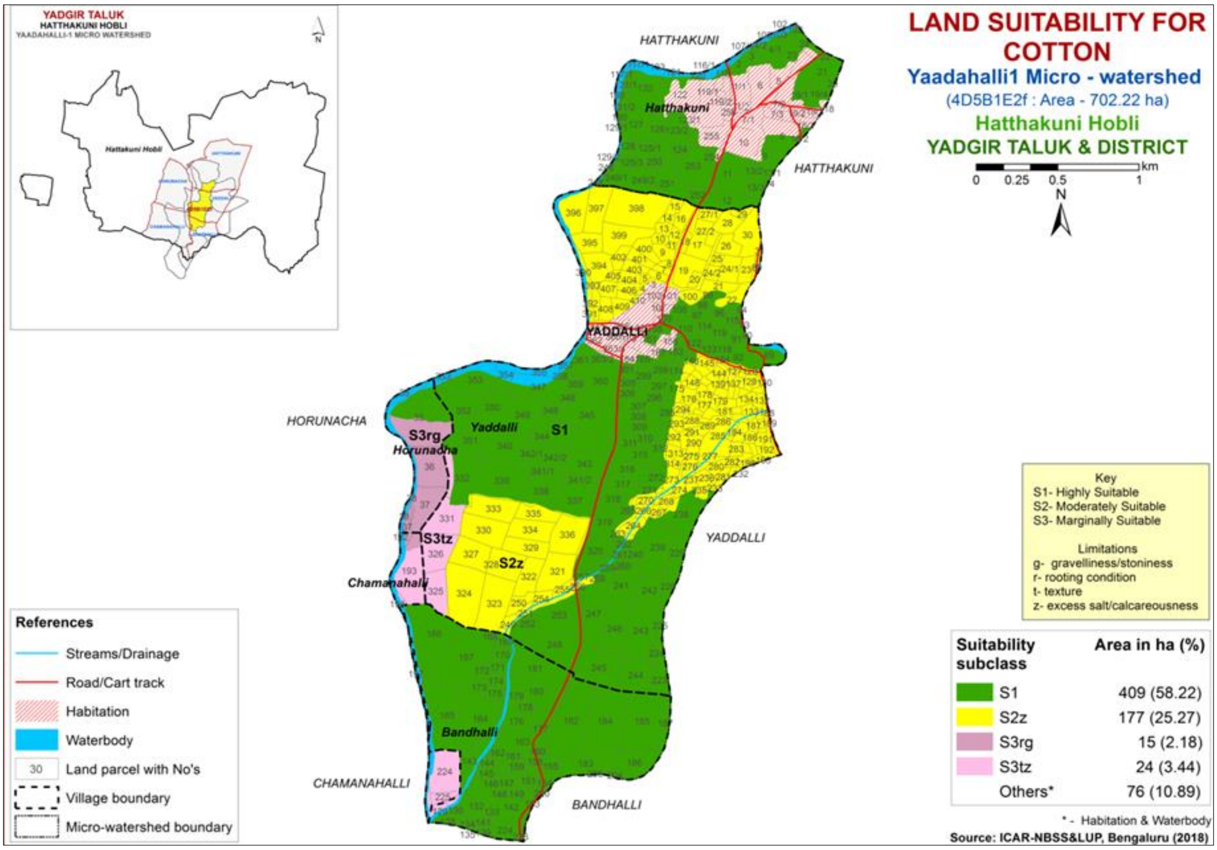

Fig 6: Land Suitability map of Cotton

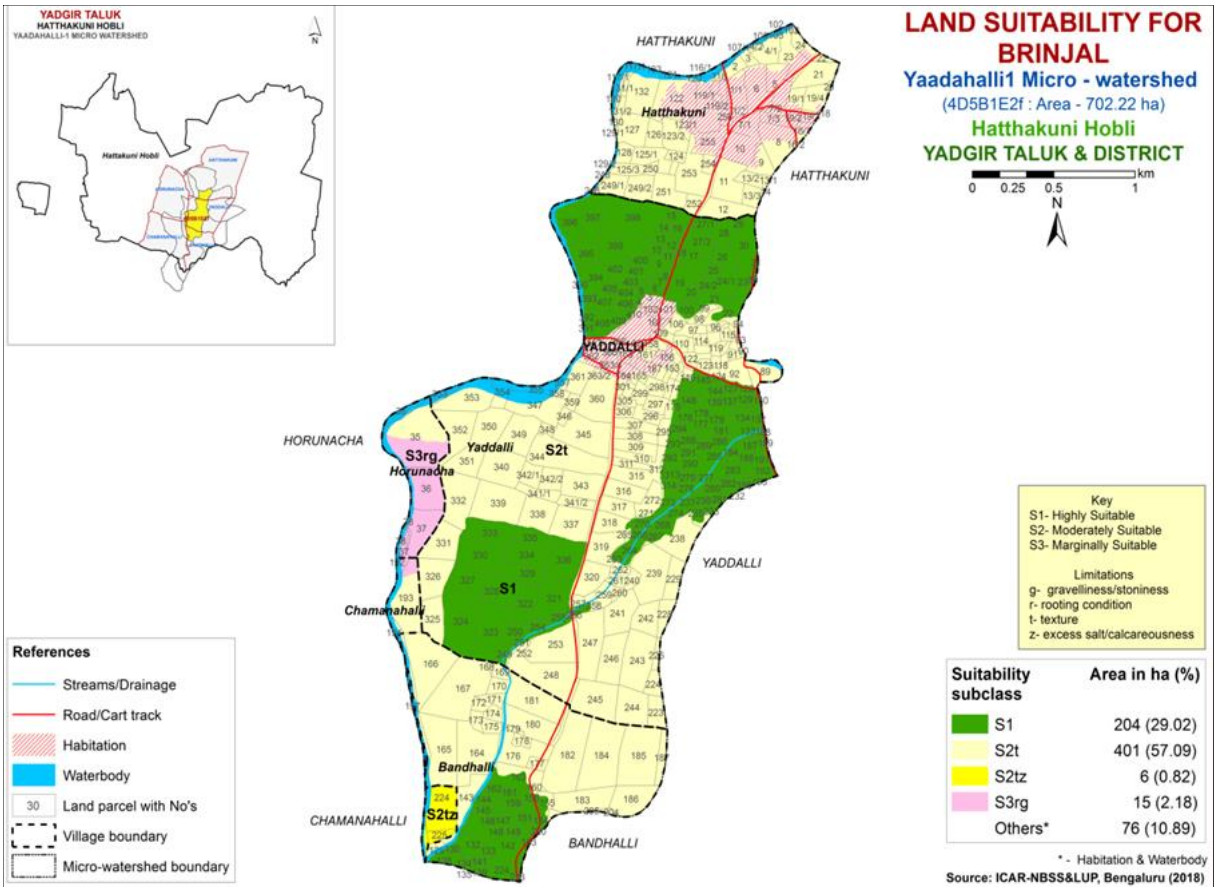

Fig 7: Land Suitability map of Brinjal

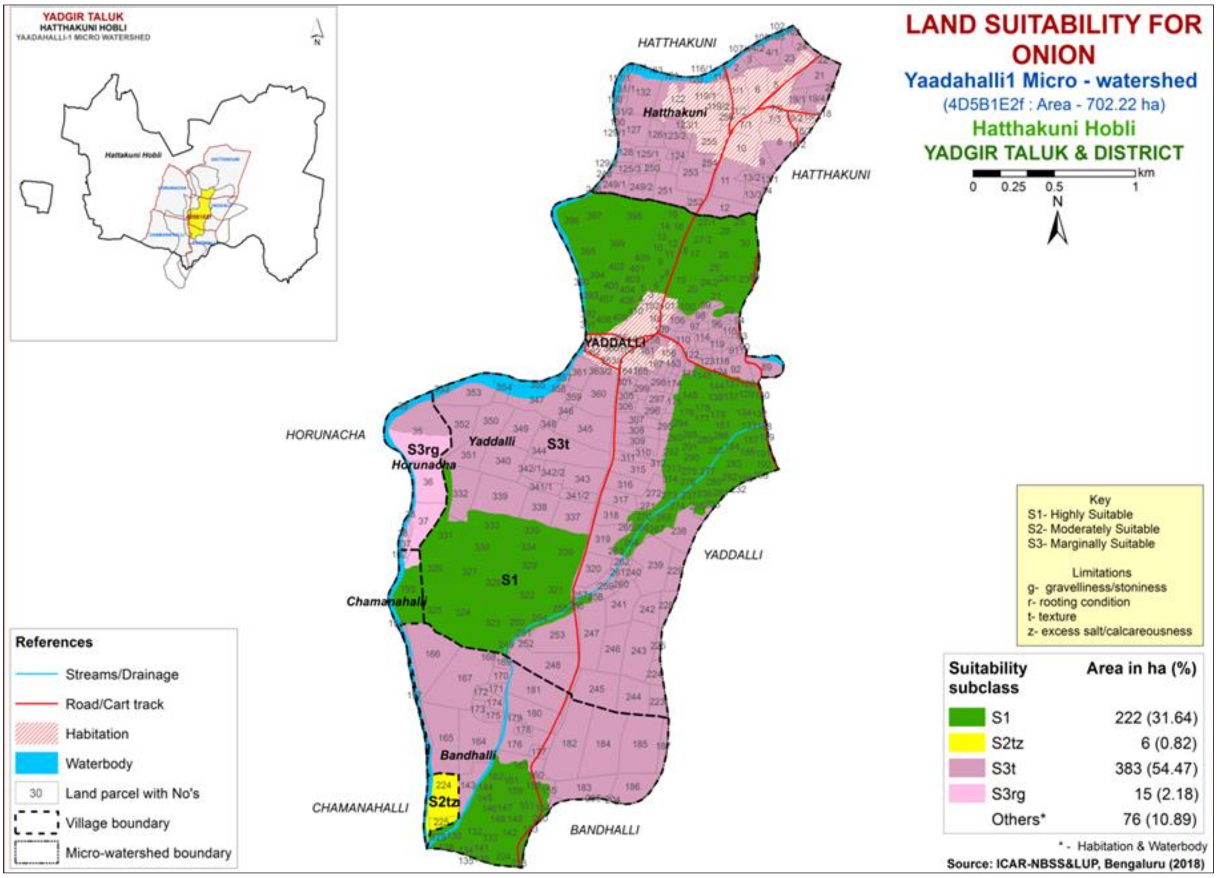

Fig 8: Land Suitability map of Onion

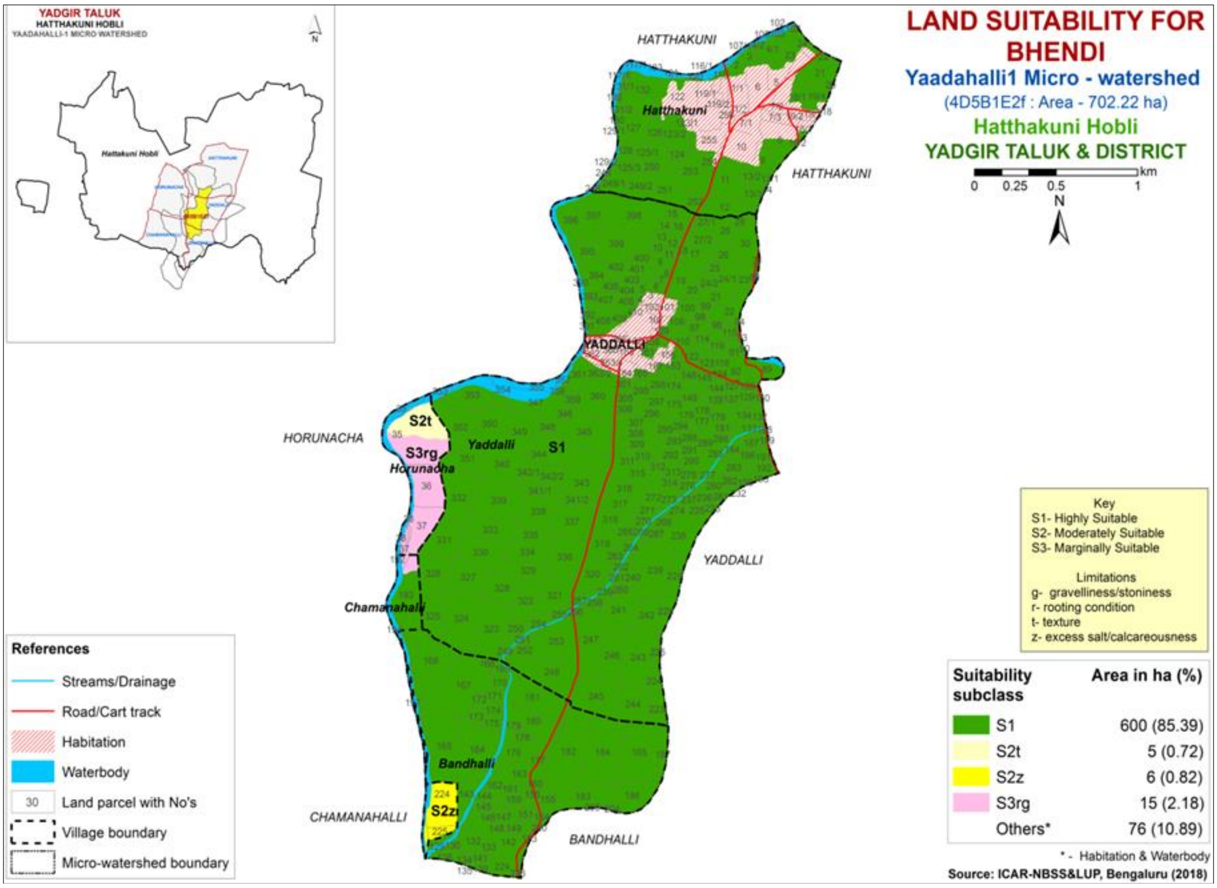

Fig 9: Land Suitability map of Bhendi

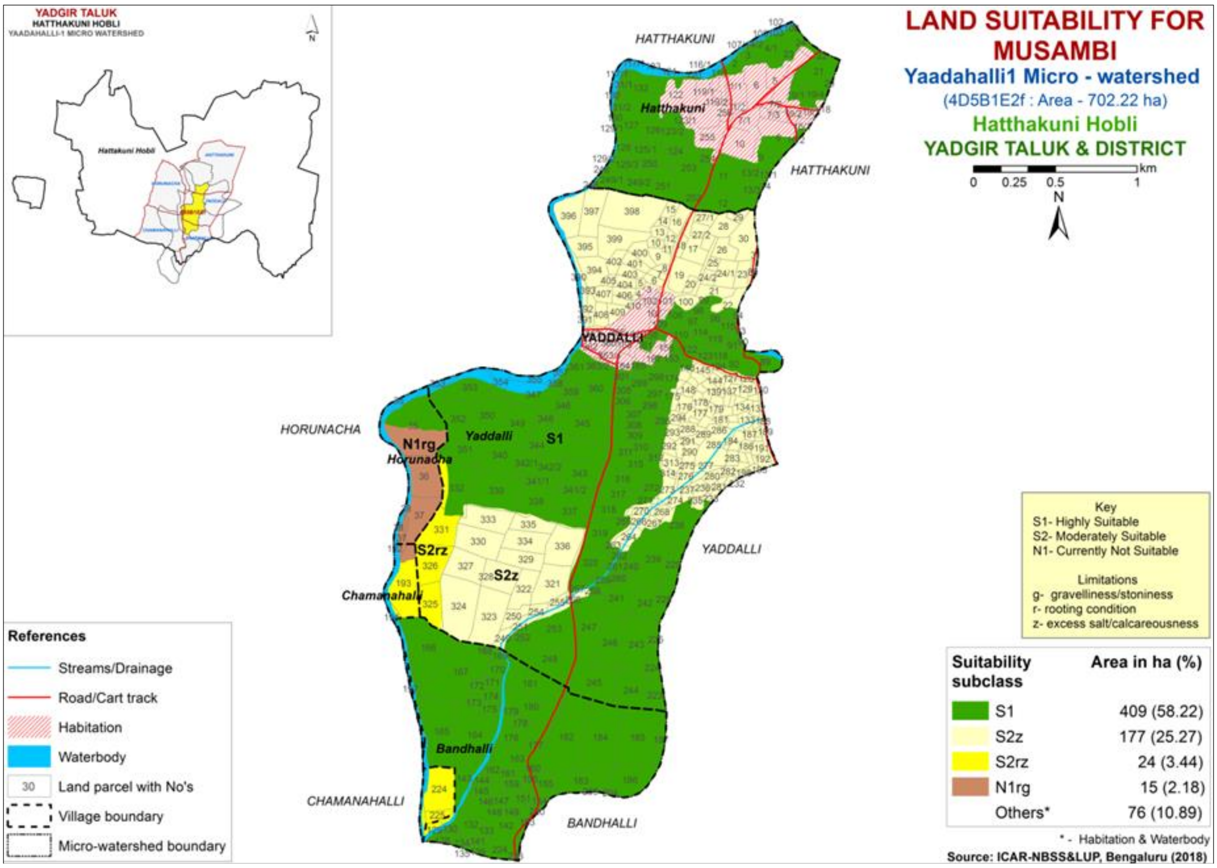

Fig 10: Land Suitability map of Musambi

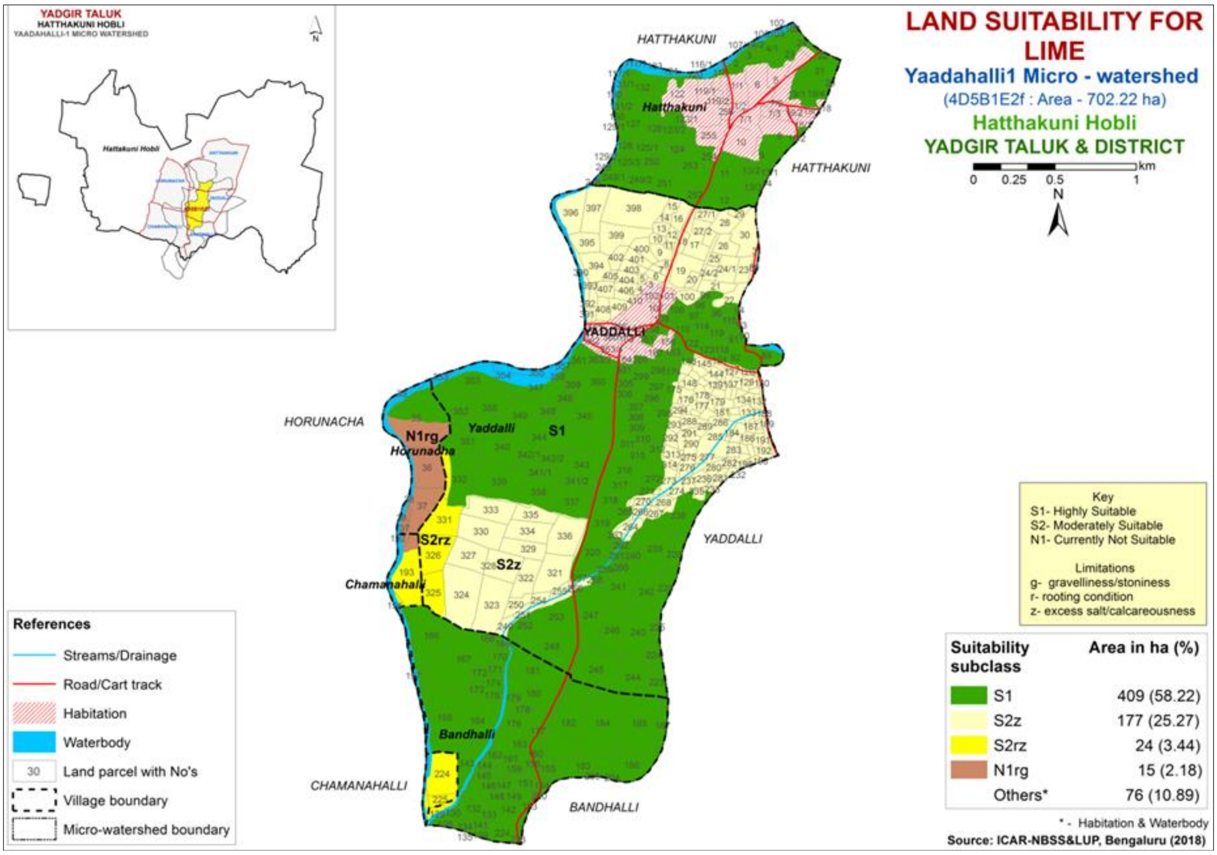

Fig 11: Land Suitability map of Lime

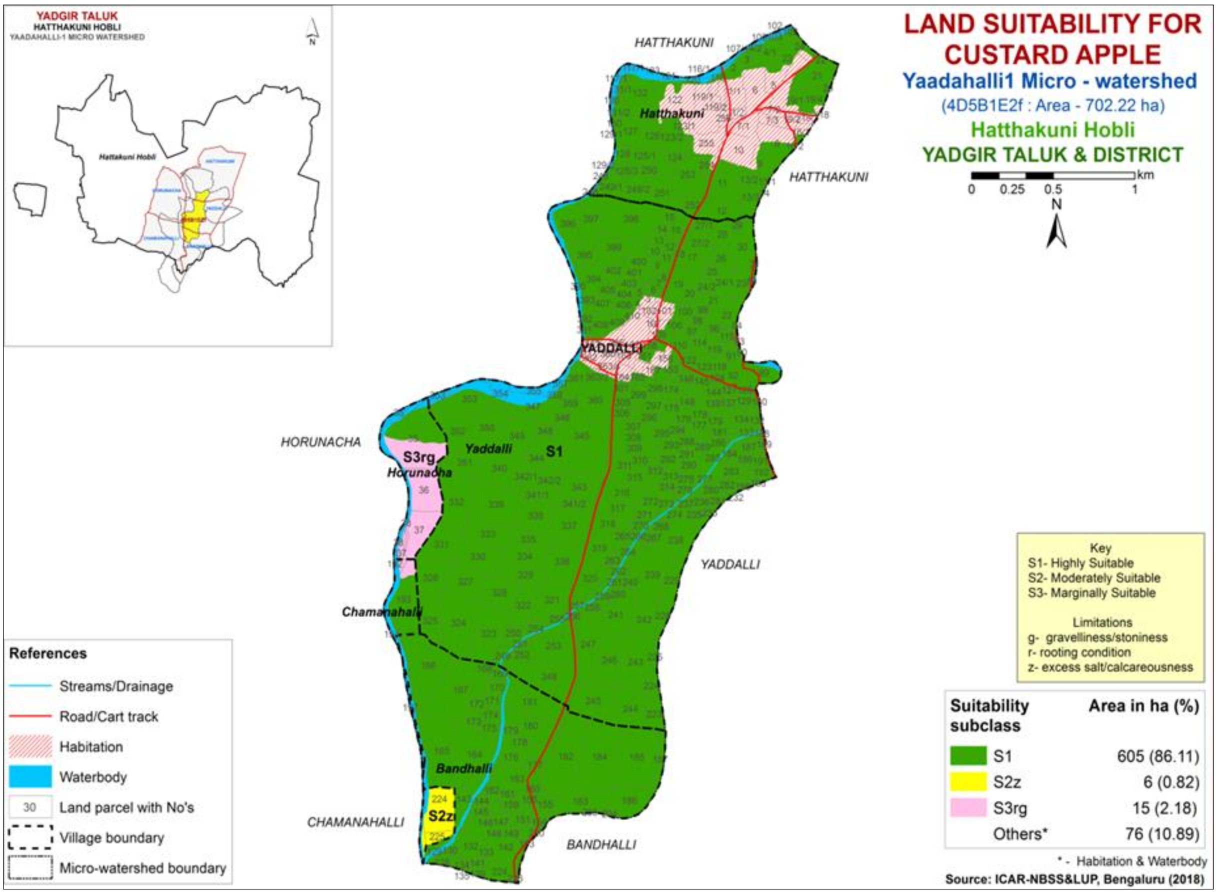

Fig 12: Land Suitability map of Custard Apple

Table 2: Soil-Site Characteristics of Yaadahalli-1 Microwatershed

Soil Map Units	Climate (P) (mm)	Growing period (Days)	Drain-age Class	Soil depth (cm)	Soil texture		Gravelliness		AWC (mm/m)	Slope (%)	Erosion	pH	EC (dSm^{-1})	ESP (%)	CEC [Cmol (p$^+$)kg^{-1}]	BS (%)
					Sur-face	Sub-surface	Surface (%)	Sub-surface (%)								
DSBiB2	866	150	WD	25-50	sc	gc	<15	35-60	<50	1-3	moderate	5.93	0.04	0.14	3.60	73
HSLiB2	866	150	MWD	75-100	sc	sc	<15	<15	101-150	1-3	moderate	7.16	0.11	5.94	4.90	97
HSLhB2	866	150	MWD	75-100	scl	sc	<15	<15	101-150	1-3	moderate	7.16	0.11	5.94	4.90	97
HSLcB2g2	866	150	MWD	75-100	sl	sc	35-60	<15	101-150	1-3	moderate	7.16	0.11	5.94	4.90	97
MDGmB1	866	150	WD	100-150	c	scl	<15	<15	>200	1-3	slight	8.20	0.40	3.08	4.90	100
MDRiA1	866	150	WD	>150	sc	scl	<15	<15	>200	0-1	slight	8.31	0.33	0.90	20.57	100
MDRmB2	866	150	WD	>150	c	scl	<15	<15	>200	1-3	moderate	8.31	0.33	0.90	20.57	100
MDRhB2	866	150	WD	>150	scl	scl	<15	<15	>200	1-3	moderate	8.31	0.33	0.90	20.57	100
MDRiB2	866	150	WD	>150	sc	scl	<15	<15	>200	1-3	moderate	8.31	0.33	0.90	20.57	100
MDRcA1	866	150	WD	>150	sl	scl	<15	<15	>200	0-1	slight	8.31	0.33	0.90	20.57	100
BMNmB2	866	150	MWD	>150	c	c	<15	<15	>200	1-3	moderate	8.20	0.28	0.65	52.70	100

Conclusion

It can be concluded that, the soils were deep to very deep in depth, sandy clay loam to sandy clay in texture, less gravelliness, maximum available water content, very gently sloping with moderate erosion. The GIS tool was effectively utilized at the study area for land capability and crop suitability classifications. The land capability classification of the entire study area placed under class II (87%) of good cultivable land. The land suitability for different agriculture and horticulture crops were matched with the land characteristics, these soils were highly suitable for most of the crops. It is however to be noted that a given soil may be suitable for various crops but what specific crop to be grown may be decided by the farmer looking to his capacity to invest on various inputs, marketing infrastructure, market price and finally the demand and supply position.

References

1. Ali Bagherzadeh, Mohammad Reza, Mansouri Daneshvar. Physical land suitability evaluation for specific cereal crops using GIS at Mashhad Plain, Northeast of Iran. Front. Agric. China 2011;5(4):504-513.
2. Chandrakala M, Srinivasan R, Anil Kumar KS, Sujatha K, Rajendra Hegde, SK Singh. Land suitability evaluation for major crops adopted to tropical humid region of Kerala, India. International Journal of Chemical studies 2019;7(4):2446-2453.
3. FAO. A framework for land evaluation. FAO Soils Bulletin No. 32, Rome 1976.
4. FAO. Guidelines: Land evaluation for rainfed agriculture. FAO Soils Bulletin. No. 52, Rome 1983.
5. Geetha GP, Prabhudev Dhumgond, Shruti Y, Ramakrishna Parama VR, Sathish A. Study of Land Evaluation in Giddadapalya Microwatershed, Tumkur District, Journal of Pharmacognosy and Phytochemistry 2017;6(5):2123-2130.
6. IARI. Soil Survey Manual, All India Soil and Land Use Survey Organization, IARI, New Delhi 1971, 121.
7. Mahesh Kumar, Basavaraj K, Rajesh NL, Chittapur BM. Land evaluation of Bharatnur-3 microwatershed in north eastern dry zone of Karnataka for sustainable land use planning. International Journal of Chemical studies 2019;7(1):801-811.
8. NBSS LUP. Proceedings National meet on soil site suitability criteria for different crops, NBSS and LUP, Nagpur 1994, 30.
9. Naidu LGK, Ramamurthy V, Challa O, Rajendra Hegde, Krishnan P. Manual Soil Site Criteria for Major Crops NBSS Publication No. 129, NBSS&LUP, Nagpur 2006, 118.
10. Natarajan A, Rajendra Hegde, Raj JN, Shivananda Murthy HG. Implementation Manual for Sujala-III Project, Watershed Development Department, Bengaluru, Karnataka 2015.
11. Patil PL, Vinay L, Dasog GS. Land evaluation of Bhanapur micro-watershed in Northern Dry Zone of Karnataka. Agropedology 2011;21(2):10-16.
12. Rajesh NL, Rudramurthy HV, Chittapur BM, Basavraj K, Vidyavathi GY, Satishkumar U *et al*. Detailed LRI for crop suitability and land capability clsiiification using RIS and GIS. Prog. Res. An Int. J 2016;11(1):61-65.
13. Sarma VAK, Krishnan P, Budihal SL. Laboratory Manual Technical Bulletin. NBSS &LUP, Nagpur 1987, 23.
14. Sehgal JL. Pedology - Concepts and applications, Kalyani Publishers, New Delhi 1996, 488.
15. Sharma RK, Swami BN, Giri JD, Singh SK, Shyampura RL. Soils of Haldi Ghati region of Rajasthan and their land suitability for different land uses. Agropedology 2001;11:23-28.
16. Singh K, Swami BN, Giri JD, Shyampura RL, Singh SK. Characteristics and soil suitability evaluation for maize. Paper presented at the 16th World Congress of Soil Science, Montpellier, France 1998.
17. Soil Survey Division Staff. Soil Survey Manual, Agriculture Handbook No.18. U.S. Department of Agriculture, Washington DC. USA 1993, 437.
18. Sys C, Van Ranst E, Debaveye J, Beernaert F. Land evaluation, Part III, Crop requirements, Agricultural publications- No. 7, General Administration for Development Cooperation Place du Champ de Mars 5 bte 57-1050 Brussels- Belgium 1993.
19. Whiley W. Tropical Tree fruits for Australia/compiled by PE page Qd. Dept. Of Prim. Indus. Inform. Series Q 183018, 2s. 1984.