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DIGITAL LAND RESOURCE INVENTORY FOR SUSTAINABLE AGRICULTURE - A CASE STUDY IN KORANAHALLI SUBWATERSHED

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Abstract

Digital land resource information at the micro-level has become vital for addressing current global issues of land degradation and food security. Hence, crop-land suitability analysis is essential to reach optimal utilisation of the available land resources for sustainable agricultural production. Land resource inventory using Remote Sensing (RS) & Geographical Information System (GIS) approach at the cadastral level on 1:7920 scale generated for Koranahalli subwatershed, Chikkamagaluru district. The soils were mapped as phases of soil series. A total of 14 soil series and 150 soil phases were identified after detailed soil survey. Soil phases were grouped into highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N). Soil site suitability evaluation for cultivating ragi, pigeon pea, groundnut, tomato and chilli revealed that about 3.49 per cent of the study area is highly suitable for cultivation of groundnut and tomato. About 55.94, 36.92 and 34.89 per cent of the area is moderately suitable for cultivating groundnut, chilli and ragi. However, about 37.44, 31.3 and 30.06 per cent of the area is not suitable for growing tomato, pigeon pea and ragi due to the limitations of gravelliness, texture, topography, drainage and rooting condition.

Key words: Digital land resource, Remote Sensing, GIS, Land suitability

Introduction

For agricultural planning and development, an inventory of natural resources is a prerequisite. The land resources in Karnataka state are under severe stress due to various forms of degradation. The challenge before us is to increase the productivity per unit area to meet out the food grain demand of the increased population, but also to reduce or conserve natural resources in the state. We are all aware that problems exist at the field level can be addressed only by formulating and adopting site-specific, viable and suitable land use options at the micro-level or watershed scale. The macro-level approach will not have the desired impact in addressing field-level issues faced by farmers. To solve the field level problems, we need a micro-level detailed site-specific spatial database. From the spatial database, viable and suitable land use options for sustainable agriculture can be formulated. Digital soil mapping aims to provide soil information for a broad range of studies. It has started from the cross-fertilization between soil surveyors, who involved in the use of RS and GIS software for improving their performances and soil scientist who applied geostatistical approaches for representing and predicting soil spatial variabilities (Webster, 1994; Dominique Arrouays *et al.*, 2017). RS and GIS techniques have emerged as useful and powerful tools for generating different spatial information on various natural resources. Therefore, detailed land resource inventory at the cadastral level (1:7920) by adopting RS and GIS techniques can only provide the required necessary information for effective utilisation of land resources.

With this objective in view, Koranahalli subwatershed, Tarikere taluk, Chikkamagaluru district, Karnataka has been selected to demonstrate the utility of digital land resource inventory at the cadastral level for sustainable agriculture.

Material and Methods

Study area: The location of Koranahalli subwatershed is situated in Chikkamagaluru district of Karnataka and lies between 13°36t50.16tt and 13°43t03.92tt N latitude and between 75°52t08.50tt and 75°57t21.80tt E longitude with a geographical area 5820.710 Ha (Fig.1). The mean annual rainfall for the last three decades in the study area was 750-900 mm.

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The region receives rainfall mainly from South-West monsoon and partly from North-East monsoon. The average relative humidity is about 65 per cent. Land resource mapping of Koranahalli subwatershed was carried out following a three-tier approach, *i.e.* Satellite image interpretation for physiographic unit's delineation, field survey and laboratory analysis and digital cartography using GIS platform.

Satellite image interpretation: Visual interpretation of Quick Bird False Colour Composite (FCC) satellite image with a spatial resolution of 0.65m pixel resolution was used in conjunction with all the available collateral data with local knowledge. The demarcated physiographic units were transferred on to a cadastral map and satellite imagery. Physiographically, study area dominated by Peninsular gneisses of Archean age. Based on the slope study area is divided into mounds, ridges, uplands and lowlands. They were further subdivided into physiographic units based on image characteristics.

Field survey and laboratory analysis: The cadastral map and Quick bird satellite image were used for the preparation of the base map for traversing the entire study area. Visual interpretation of FCC data on 1:7920 scale was carried out to identify the physiographic units in the subwatershed. The traversing of subwatershed as the whole was undertaken to check the physiographic groups. The transects were defined in such a way that each transect should cut across at least three or more physiographic units. In each physiographic unit, profiles were studied for morphological characteristics to establish a relation between physiography and soils depending on the length of slope (Natarajan *et al.*, 2015; Soil Survey Staff, 2017). Soil samples collected from the typifying pedons were analysed for physical and chemical properties as per the standard procedure.

Digital cartography using GIS platform: Based on the soil pedon characteristics the profiles were grouped into different soil series. The area under each soil series was further separated into soil phases, i.e., based on the observed variations in the surface soil texture, slope, erosion, gravelliness, stoniness etc. A soil phase is a subdivision of the soil series based on surface features that affect its use and management (Ravikumar and Govindaraju, 2019). The soil map finalised based on field and soil analysis data were scanned and digitised using GIS software to get the digital soil map.

Land Capability Classification (LCC): The LCC is an interpretative grouping of soil map units mainly based on inherent soil characteristics, external land features and

Table1: Morphological characteristics of Koranahalli subwatershed soils.

Name of Soil series	Soil depth (cm)	Moist Colour		Texture		Gravel (%)	Calcareousness	Horizon sequence
		Surface	Sub surface	Surface	Sub surface			
A K colony	100-150	10YR3/2	10YR3/1, 3/2, 5/6	SL	C-SC	—	Non calcareous	Ap-Bw-CR
B Kodihalli	>150	7.5YR2.5/3	7.5YR2.5/3, 3/3	C	C	—	Non calcareous	Ap-Bw-CR
Baggavali kaval	50-75	10YR2/2	7.5YR2.5/3, 3/3	SCL	CL-C	<15	Non calcareous	Ap-Bt-BC
Hanumapura	25-50	5YR4/6	5YR4/6	SCL	SC,C	35-60	Non calcareous	Ap-Bt-CR
Hebburu	50-75	10YR3/4	10YR3/3, 3/1	C	C	—	Non calcareous	Ap-Bw-BC
Hortithimmanahalli	25-50	10YR5/4	10YR5/5	SCL	SCL	15-35	Non calcareous	Ap-Bw-CR
Kedihalli	50-75	5YR3/3	5YR3/4, 2.5YR4/6	SL	SC-C	35-60	Non calcareous	Ap-Bt-BC
Kere basavanahalli	75-100	2.5YR3/4	2.5YR3/4, 3/6	SCL	SCL-C	15-35	Non calcareous	Ap-Bt-BC
Kornahalli	100-150	5YR3/4	7.5YR4/3, 2.5/4, 3/3, 3/4	SCL	SCL- SC-C	15-35	Non calcareous	Ap-Bt-BC
Santhaemaradi Kaval	75-100	7.5YR3/4	7.5YR3/3, 4/3	SCL	SC-C	<15	Non calcareous	Ap-Bt-CR
Siddarahalli	100-150	7.5YR3/6	7.5YR3/3,3/4,	SL	C	—	Non calcareous	Ap-Bt-BC
Sigehadlu	75-100	5YR3/4	2.5YR4/6	SL	SC	35-60	Non calcareous	AP-Bt-BC
Tadaga	50-75	5YR4/4	5YR3/4	SL	C	35-60	Non calcareous	Ap-Bt-BC-CR
Timmapura	75-100	7.5YR3/3	7.5YR3/2, 5YR4/4	SL	SCL-SC	35-60	Non calcareous	Ap-Bt-CR

Note: SCL- Sand Clay Loam, SL-Sandy Loam, SC- Sandy Clay, C-Clay, environmental factors that limit the use of land for agriculture, pasture, forestry or other purposes on a sustained basis (Beek,1981; Ravikumar *et al.*, 2018). The land capability classes provide clues to the management and improvement of soil units for sustainable agriculture. The land and soil characteristics used to group the land resources in an area into various land capability classes, subclasses and units. The land capability subclasses are recognised based on the dominant limitations observed within a given land capability class viz., e-erosion and runoff, w-excess water or wetness, s-soil rooting zone limitations and c-climatic limitations. The land capability subclasses have been further subdivided into land capability units based on the kinds of constraints present in each subclass. The capability units thus identified have similar soil and land characteristics that respond similarly to a given level of management (Prabhuraj *et al.*, 2012; Ravikumar and Govindaraju, 2019).

Land evaluation: The different soil phases of Koranahalli subwatershed were assessed for their suitability for growing major crops like Ragi *(Eleusine coracana)*, Pigeon pea or redgram (*Cajanus cajan*), Groundnut (*Arachis hypogaea*), Tomato (*Solanum lycopersicum*) and Chilli (*Capsicum annuum*) by following the procedure as outlined in FAO, 1976 and Naidu *et al.*, (2017). The FAO framework recognises two orders viz., suitable (S) and not suitable (N). The suitable (S) order comprises three different classes, namely S1-highly suitable, S2- moderately suitable and S3- marginally suitable. The not suitable (N) order consists of two classes, namely N1-currently not suitable and N2-permanently not suitable.

The classes are divided into subclasses based on the type of limitation and guide required land improvements. The subclasses are designated by suffixing lower case letters namely c-climate, e-erosion hazard, r-rooting condition, t-lighter or heavy texture, g-gravelly or stoniness, l-topography, w-drainage, m-moisture availability and n-

Table 2: Soil-site suitability criteria for Ragi, Pigeon pea, Groundnut, Chilli and Tomato crops.

Soil site characteristics Ragi (*Eleusine coracana*)	Unit	Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Mean temperature	ºC	28-34	25-27 ; 35-38	39-40 ; 20-40	>40 ; <20
Total rainfall	mm	750-900	600-750	450-600	<450
Length of Growing period	Days	>110	90-110	60-90	<60
Effective soil depth	cm	>75	51-75	25-50	<25
Slope	%	<3	3-5	5-10	>10
Pigeon pea (*Cajanus cajan*)					
Mean temperature	ºC	25-28	22-24	20-21	<20
Total rainfall	mm	800-1000	600-800	400-600	<400
Length of Growing period	Days	>180	100-120	80-100	<80
Effective soil depth	cm	>100	85-100	40-85	<40
Slope	%	<3	5-10	10-15	>15
Groundnut (*Arachis hypogaea*)					
Mean temperature	ºC	24-30	22-23 ; 31-33	20-21; 34-40	<20 ; >40
Total rainfall	mm	700-1000	500-700	350-500	<350
Length of Growing period	Days	100-125	90-105	75-90	100-125
Effective soil depth	cm	>75	50-75	25-50	<25
Slope	%	<3	3-5	5-10	>10
Chilli (*Capsicum annuum*)					
Mean temperature	ºC	25-32	33-35 ; 20-24	36-38 ; <20	>38
Total rainfall	mm	750-900	900-1200	500-600 ; >1200	—
Length of Growing period	Days	>150	120-150	90-120	<90
Effective soil depth	cm	>75	50-75	25-50	<25
Slope	%	<3	3-5	5-10	—
Tomato (*Solanum lycopersicum*)					
Mean temperature	ºC	25-28	29-32 ; 20-24	15-19 ; 33-36	<15 ; >36
Total rainfall	mm	600-750	500-600 ; 750-1000	400-500 ; >1 000	—
Length of Growing period	Days	>150	120-150	90-120	—
Effective soil depth	cm	>75	50-75	25-50	<25
Slope	%	1-3	3-5	5-10	>10

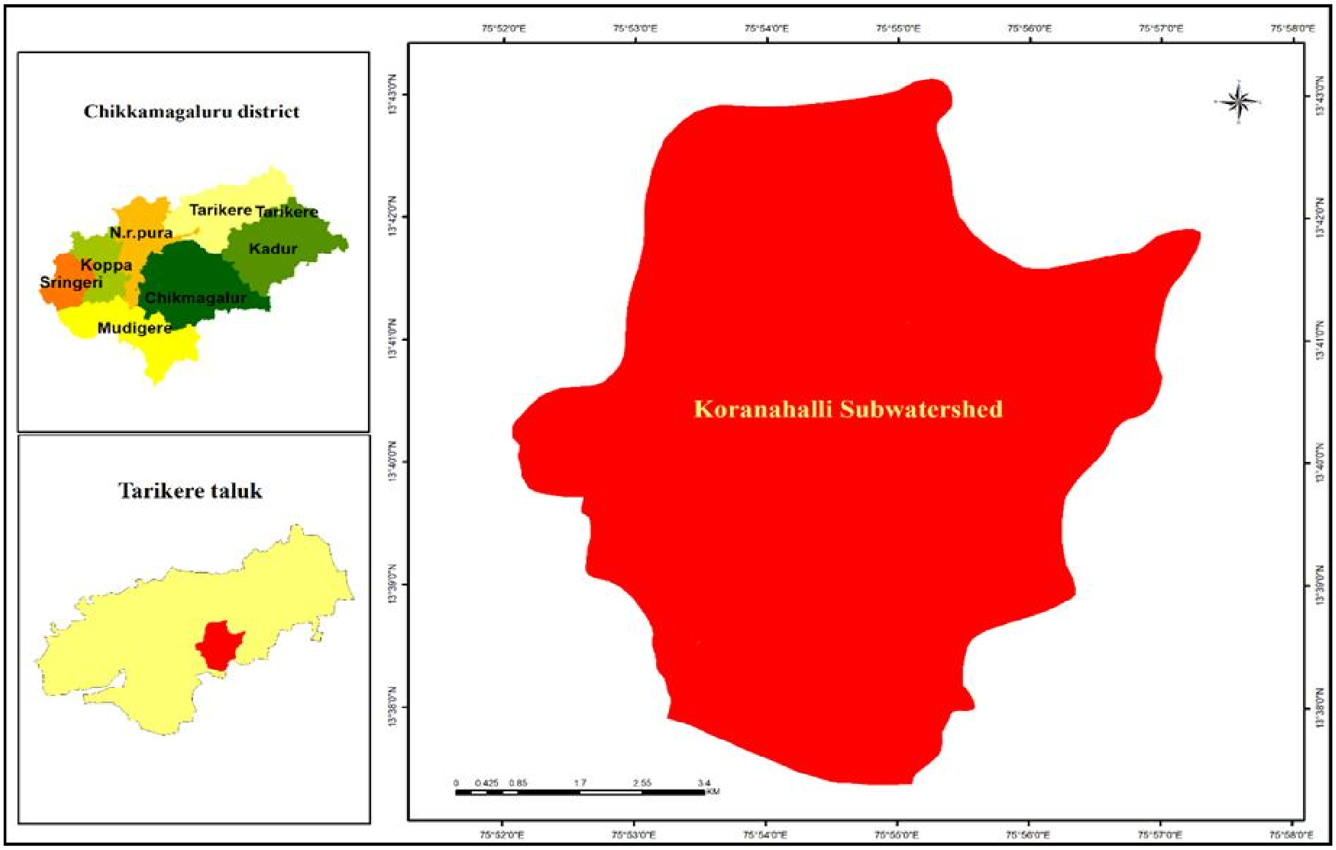

Fig. 1: Location map of Koranahalli subwatershed.

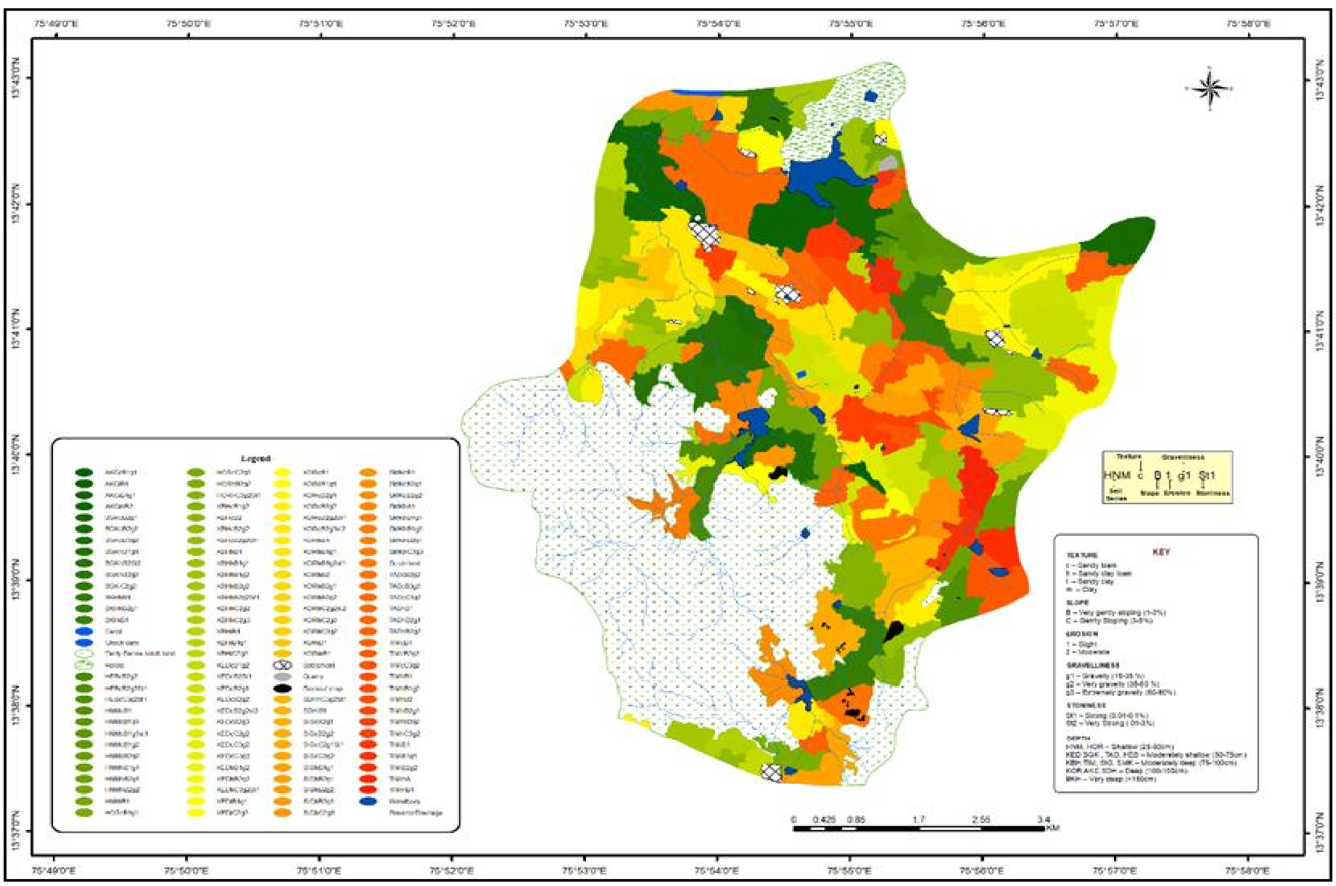

Fig. 2: Soil phase map of Koranahalli subwatershed.

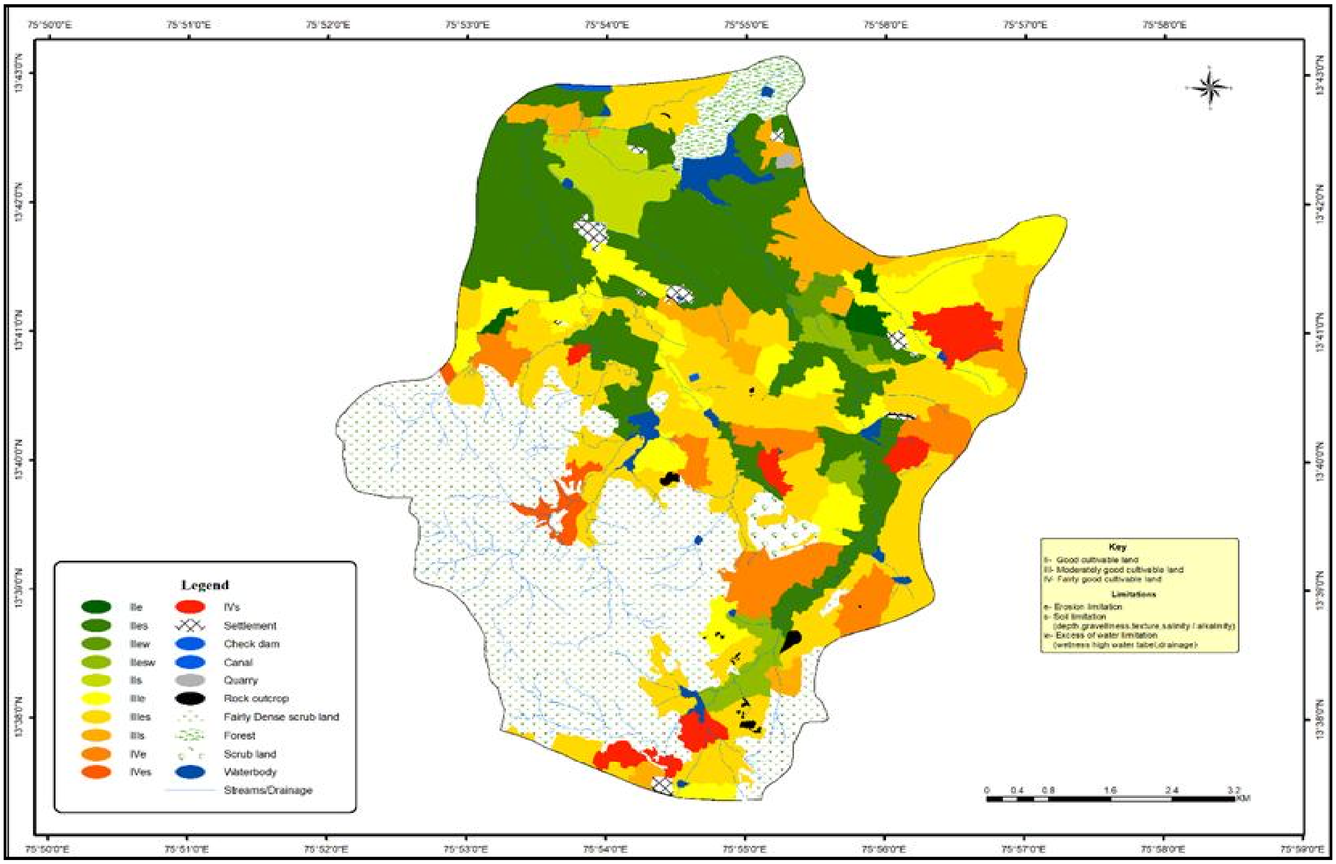

Fig. 3: Land Capability Classification (LCC) map of Koranahalli subwatershed.

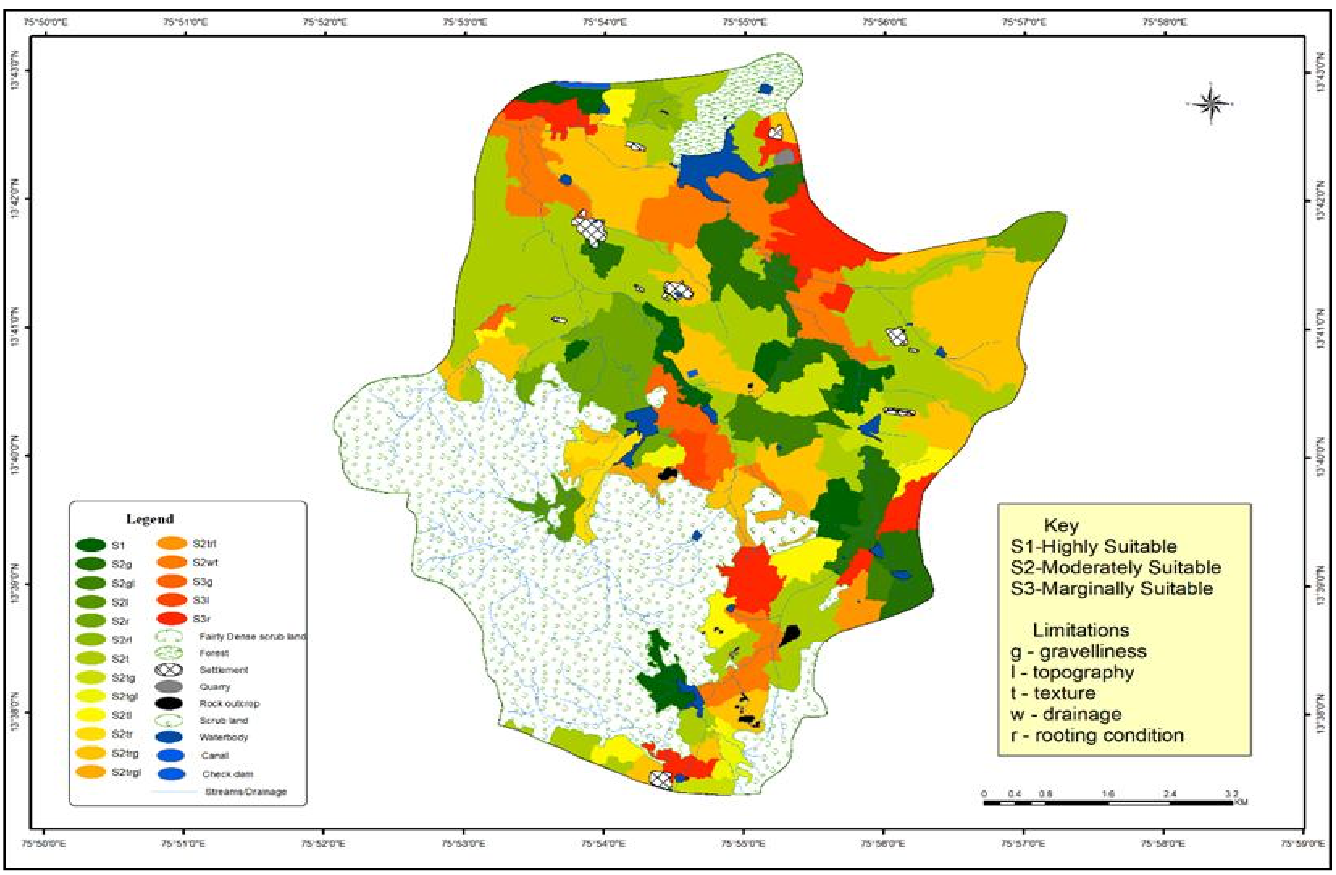

Fig. 4: Land suitability map of Groundnut in Koranahalli subwatershed.

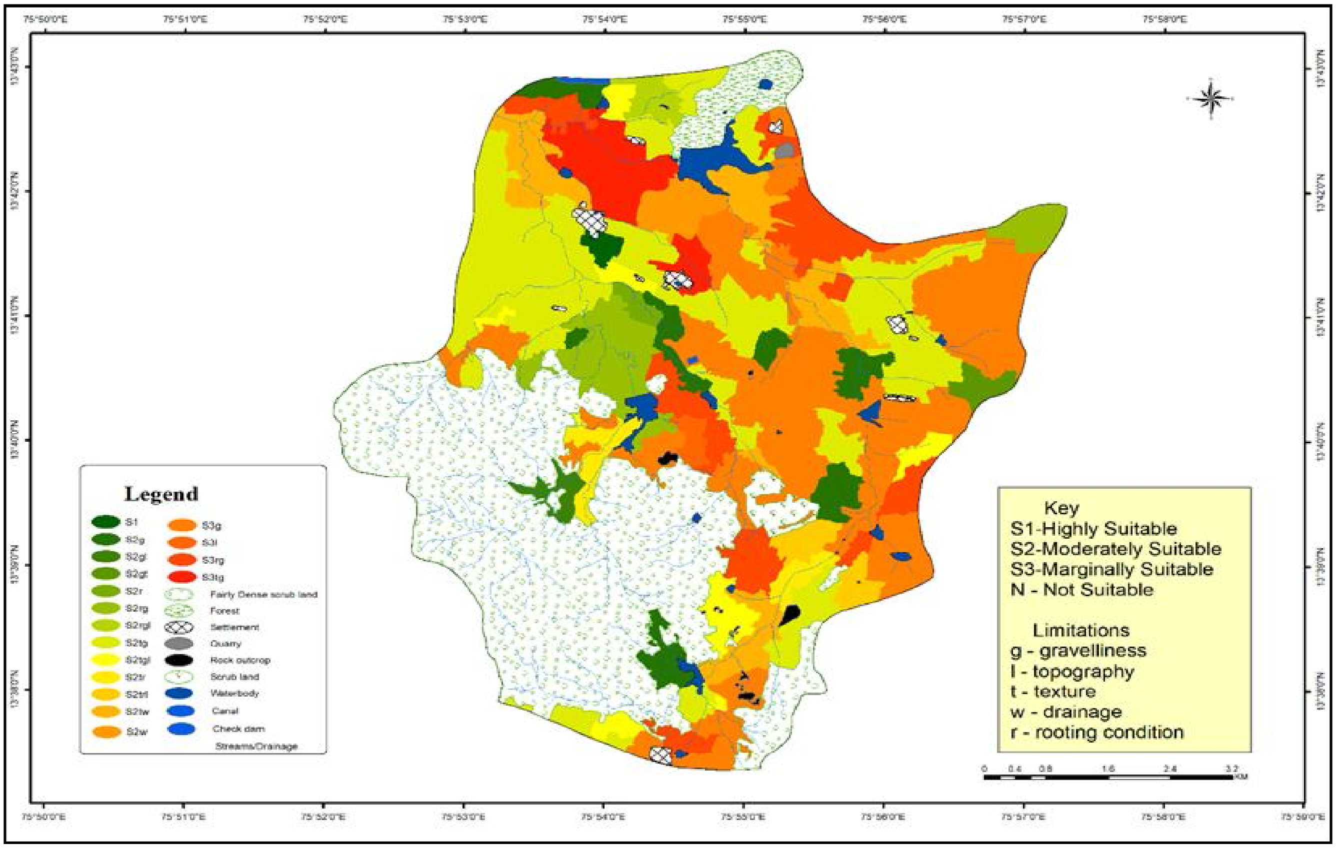

Fig. 5: Land suitability map of Chilli in Koranahalli subwatershed.

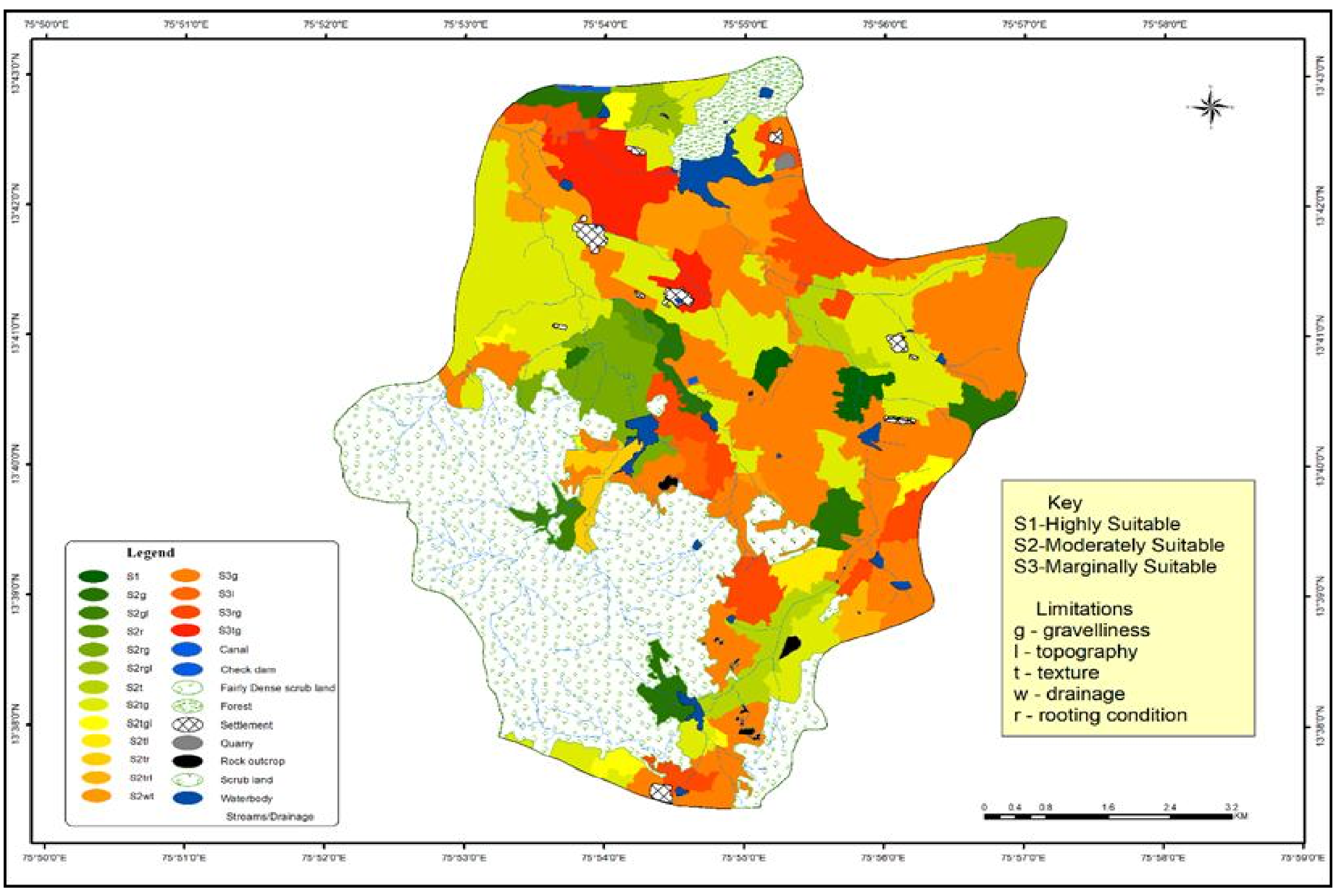

Fig. 6: Land suitability map of Ragi in Koranahalli subwatershed.

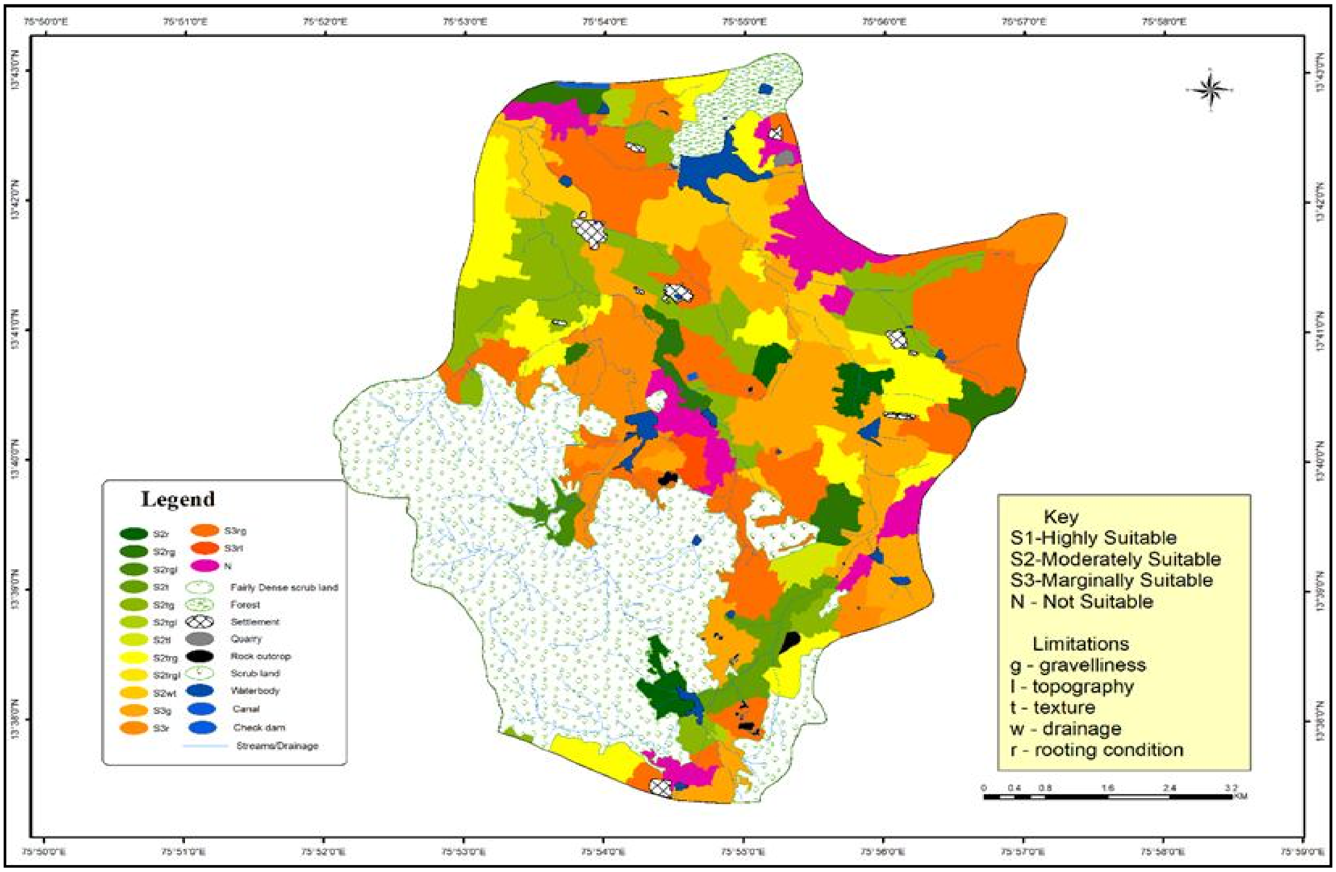

Fig. 7: Land suitability map of Pigeon pea in Koranahalli subwatershed.

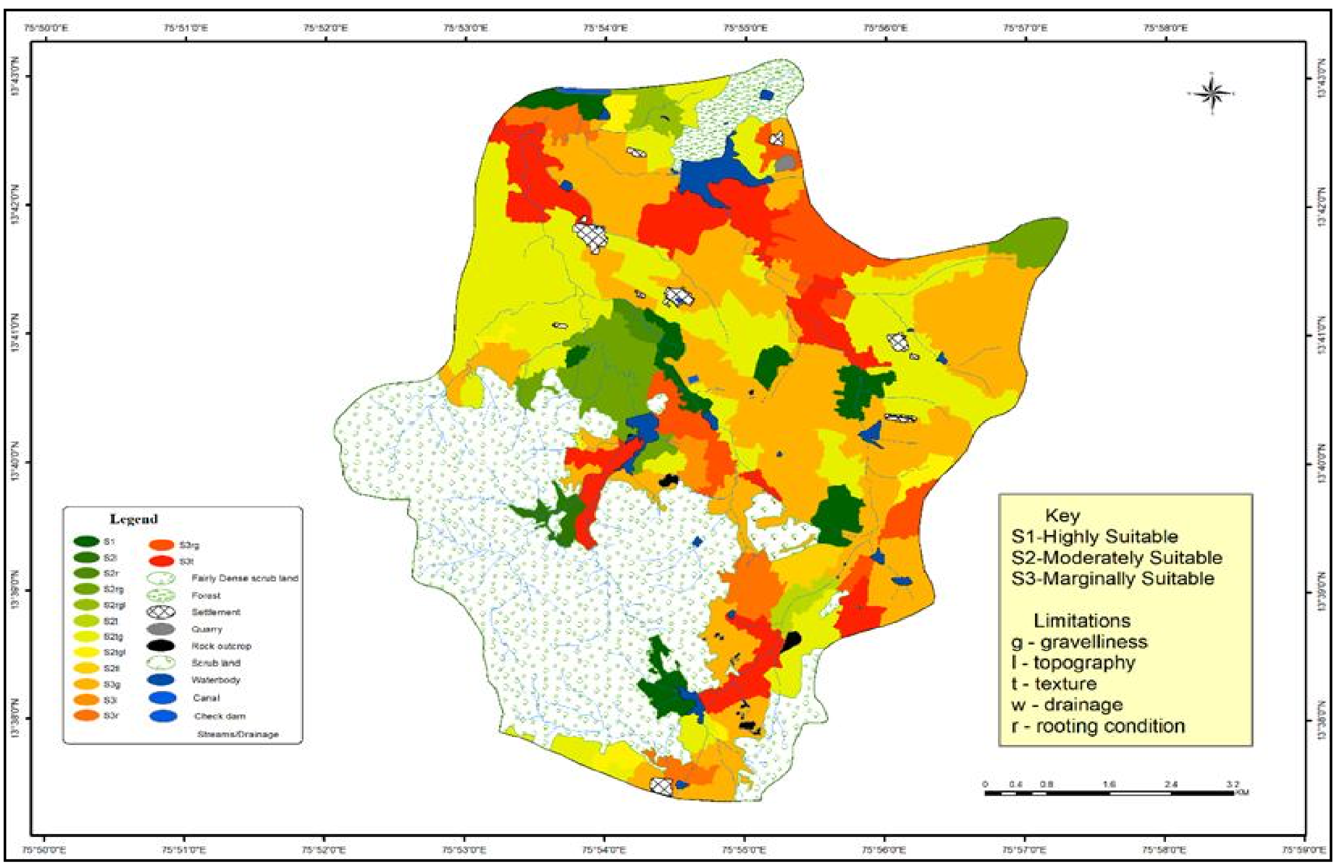

Fig. 8: Land suitability map of Tomato in Koranahalli subwatershed.

nutrient availability The soil phase map can be used for identifying the land capability units and suitability classes for growing specific crops or for other alternative uses.

Results and Discussion

Detailed information on different kinds of soils occurring in Koranahalli subwatershed is presented in Table 1. Based on geology, fourteen soil series were identified. The area under each soil series was further separated into soil phases. The depth of soils varying from very shallow to very deep, soil colour was ranged from 5 YR to 10YR, and sandy clay loam to clayey texture was recorded in subsurface horizons. About 108 soil phases, i.e., mapping units were delineated based on the soil site characteristics like soil depth, texture, slope, erosion and gravelliness. The soil map was representing different soil phases presented in Fig.2. The soil map units identified in the study area are grouped under three land capability classes, *i.e.*, class II and III and IV with three capability subclasses of ‘e’, ‘s’ and ‘w’ (Fig.3). About 1406.25 ha area is covered by good cultivable land with minor limitations of ‘s’, ‘e’ and ‘w’ (class II) followed by 1950.21 ha area is under moderately good cultivatable land with significant limitations of ‘e’, ‘s’ and ‘w’ which reduce the choice of crops or that require special conservation practices (class III) and about 477.13 ha area is under fairly good land with very severe limitations that reduce the choice of crops (class IV).

The land resource units (soil phases) of the study area were assessed for their site suitability for growing of major crops like ragi, pigeon pea, groundnut, tomato and chilli (Table. 2). About 3256 ha, 2149 ha, 2031 ha, 1734 ha and 1452 ha of the subwatershed area is found to be moderately suitable (S2) for the cultivation of groundnut, chilli, ragi, pigeon pea and tomato (Fig. 4, 5, 6, 7 and 8), followed by marginally suitable (S3) of 2179 ha, 1812 ha, 1750 ha, 1667 ha and 375 ha of land for the cultivation of tomato, pigeon pea, ragi, chilli and groundnut. However, for the cultivation of groundnut and tomato 203 ha of land found to be highly suitable (S1) followed by 53 ha of ragi and 18 ha of chilli respectively. About 288 ha of Koranahalli subwatershed area found to be not suitable (N) for the cultivation of pigeon pea.

Conclusion

The land resource units of Koranahalli subwatershed, Tarikere taluk of Chikkamagaluru district generated using large scale Quick Bird satellite data, and geographical information system was assessed for their suitability for growing major crops like ragi, pigeon pea, tomato and chilli. The study brings out the different limitations of the land and soil, which reduces the crop yield. Proper recommendations can be made to overcome these limitations and suggest a package of practices to increase crop yield on a sustainable basis.

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