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An assessment of the soil-site suitability for major cereal and pulse crops in the Shirur sub-watershed of Kundagol taluk, Dharwad district, Karnataka using RS and GIS

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Abstract
The present study assessed the soil-site suitability for major cereal and pulse crops in the Shirur sub-watershed of Kundagol taluk, Dharwad district, Karnataka, using remote sensing (RS) and geographic information system (GIS). The suitability evaluation was carried out for wheat, sorghum, maize, redgram, Bengal gram and green gram, based on FAO (1976) guidelines. The results indicated that the suitability of land was classified into suitable (S) and not suitable (N) categories, with further division into sub-classes based on various edaphic limitations such as erosion, texture, gravelliness, rooting conditions and nutrient availability. For wheat 5682 ha of the study was moderately suitable (S_2), while 433 ha was marginally suitable (S_3). Sorghum exhibited a high suitability in 4466 ha (69.27%) of the area, with marginal limitations in 433 ha. Maize had 3479 ha highly suitable, while red gram was highly suitable in 4453 ha. Bengal gram and green gram showed moderately to marginally suitable lands, with key constraints related to soil texture, nutrient availability and rooting conditions. The findings highlighted the importance of integrating RS and GIS for effective land use planning and optimizing crop productivity in the region.

Keywords: Redgram, Shirur, soil-site, wheat, cereal, maize

Introduction
Soil is a fundamental natural resource crucial for crop production, sustaining life and driving socio-economic progress. As a cornerstone of terrestrial ecosystems, soil plays a pivotal role in producing food to meet the demands of the world's growing population. Cereal and pulse crops, being staples of the local diet and economy, requires specific soil and environmental conditions for optimal growth. Understanding the suitability of soils for the cultivation of these crops can significantly enhance productivity and resource use efficiency. Soil-site suitability evaluation is a systematic approach that matches soil characteristics, including physical, chemical and topographical properties, with the requirements of specific crops. It prioritizes key soil properties, such as texture, nutrient availability, pH, organic carbon content, electrical conductivity (EC) and available nutrients, due to their significant influence on agricultural productivity. These edaphic factors are often more influential than other ecological variables in determining the success of crop cultivation (Balpande *et al*., 1996; Bai *et al*., 2017; Biradar *et al*., 2024; D'Souza A and Patil P L, 2024) [3, 2, 4, 6]. By evaluating these soil characteristics, the analysis helps to identify the most appropriate crops for a given location, optimizing land use and enhancing crop yields (Naidu *et al*., 2006) [13]. The accurate and timely information regarding the identification of the potential soils for cultivation and also highlights on their limitations such as gravelliness, nutrient availability or poor drainage which may restrict crop performance is necessary. Modern tools like remote sensing (RS) and geographic information systems (GIS) have revolutionized land evaluation by enabling detailed spatial analysis, mapping and visualization of soil properties and land suitability.

Remote sensing technology has become an invaluable tool for assessing soil resources, providing a cost-effective and time-efficient method for studying soil characteristics across large areas.

This technology allows for the collection of spatial data, facilitating the mapping of soil types, distribution, and associated properties, as well as identifying potential constraints and opportunities for agricultural productivity (Gabhane, 2006) [8]. In combination with Geographic Information System, which is a powerful tool for storing, processing, and visualizing spatial data (Reddy *et al*., 2018) [23], RS plays a crucial role in soil-site suitability assessments. GIS supports the analysis of multiple data layers, enabling a comprehensive evaluation of soil properties, topography, and climate factors that influence crop suitability. Precision agriculture, utilizing RS and GIS, allows for more targeted and sustainable land management by providing detailed insights into soil health and fertility, helping farmers optimize inputs and improve crop yields. Through the creation of soil maps and the analysis of soil properties, this approach enables the development of effective land management strategies that improve agricultural productivity and sustainability (Singh *et al*., 2021) [28]. In this context, the current study was planned with the objective of evaluating the soils of the Shirur sub-watershed for their suitability for major cereal and pulse crops grown in the area, such as wheat, sorghum, maize, redgram, Bengal gram and green gram. The study integrates remote sensing and geographic information systems to identify the most suitable locations for cultivation, ensuring optimal land use and resource management.

Materials and Methods

The present study was conducted in 2022–2024, in the Shirur sub-watershed of Kundagol taluk, Dharwad district in Karnataka (Fig. 1), situated between 15° 10’ 30” N -15° 14' 0” North latitudes and 75° 12' 30” -75° 19' 30” E longitudes. The total geographical area (TGA) of the sub-watershed is about 6446.14 ha. The climate of the area is semi-arid type with mean maximum and minimum temperatures are on the range of 28-38 °C and 16-23 °C and the average rainfall of 737.80 mm. The average potential evapotranspiration (PET) is 160 mm and varied from 120 to 225 mm. The length of crop growing period (LGP) varied from 180 to 196 days and starts from 3rd week of April to 4th week of October. After preliminary traversing of the entire study area using a 1:7,920 scale base map and satellite imagery, based on geology, drainage pattern, surface features, landforms, physiographic divisions, slope characteristics and land use, nineteen (19) soil profiles were selected and studied their morphologic characteristics. The physical and chemical properties were analysed using standard analytical procedures. A detailed soil survey of the Shirur sub-watershed was carried out and 19 series were mapped into sixty-seven (67) mapping units based on surface soil properties. After a detailed soil survey, crop suitability maps for major cereal and pulse crops growing in the study area at phase level were prepared by using ArcGIS software. Based on the optimum growth requirement of crop in relation to climate and soil-site parameters, *i.e*. drainage, surface stoniness, texture, depth, slope and other soil properties like organic carbon, $CaCO_3$, CEC, base saturation, pH, ESP and EC, soil-site suitability classifications for cereal and pulse crops were worked out. The soil properties of Shirur sub-watershed of Kundagol taluk (Table 1) were matched with the soil-site suitability criteria (Sehgal, 1996, NBSS and LUP, 1994 and Naidu *et al*., 2006) [26, 15, 13] for cereal and pulse crops and further soil-site suitability sub-classes were recorded.

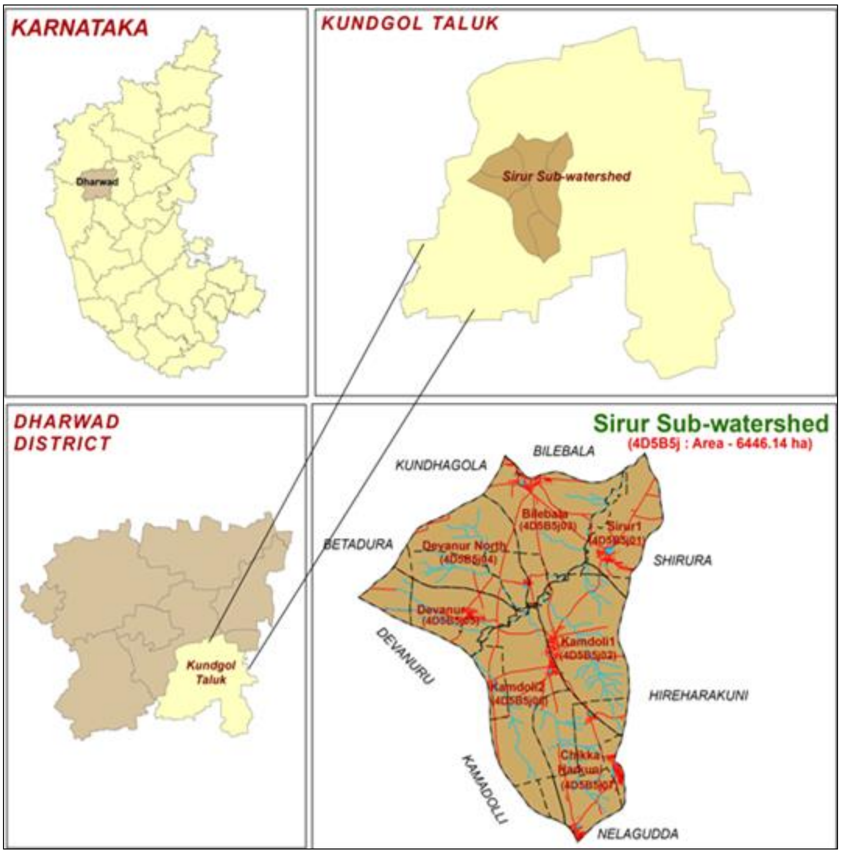

Fig 1: Location of the study area

Results and Discussion

The soil-site suitability is categorized into two main orders: suitable (S) and not suitable (N). The suitable order includes three classes: highly suitable (S1), moderately suitable (S2) and marginally suitable (S3), while the not suitable order has two classes: currently not suitable (N1) and permanently not suitable

(N2). Classes S2 and S3 are further divided into sub-classes based on limitations such as erosion (e), soil texture (t), gravelliness (g), rooting condition (r) and nutrient availability (n) according to the FAO (1976) guidelines. The details pertaining to the soil-site suitability for cereal and pulse crops grown in the Shirur sub-watershed are enlisted in Table 2.

Soil-site suitability evaluation for wheat

Wheat production requires specific environmental and soil conditions for optimal yield and quality. An ideal temperatures range from 12°C to 25°C, with cooler conditions at germination and mild warmth at maturity. A well-drained loamy or clay loam soils with a pH between 6.0 and 7.5, which retain moisture and nutrients well while providing good root anchorage is also necessary. The crop requires a moderate water supply, with about 400-600 mm of well-distributed rainfall or irrigation, particularly during critical growth stages such as tillering, heading and grain filling. The soil- site suitability of Shirur sub-watershed for growing wheat indicated that about 5682 ha of the study area was classified as moderately suitable (S2) with only 433 ha area marginally suitable (S3) for wheat cultivation (Fig. 2). The constraints such as gravelliness (g), nutrient availability (n) and texture (r) were the reason for the moderate and marginal suitability for wheat crop. The moderate, marginal and permanent non-suitability for wheat cultivation was due to moderate, severe and very severe limitations of slope, erosion, depth, texture, coarse fragments, pH, organic carbon and base saturation in Singhanhalli-Bogur micro-watershed, Karnataka were investigated by Amara *et al.* (2021) [1]. The dominant factors affecting soil suitability for wheat includes soil texture, depth, drainage, soil fertility, soil salinity and sodicity beside climatic limitations made it moderately marginally suitable in Chhata tehsil of Uttar Pradesh (Kumar *et al*., 2022) [11]. Similar findings were recorded by Patil *et al*. (2021) [16], Narsaiah *et al*. (2020) [14], Surya *et al*. (2020) [29] and Biradar *et al*. (2024) [4].

Soil-site suitability evaluation for sorghum

Sorghum crop production requires warm temperatures, thriving best between 25°C and 30°C, with an optimal growing range from 20°C to 35°C, as it is a heat-tolerant and drought-resilient crop. It performs well in semi-arid climates with an annual rainfall of 400-600 mm, although it can withstand lower rainfall due to its deep root system and efficient water use. Sorghum prefers well-drained, fertile loamy or sandy loam soils with a pH of 5.5 to 8.0, making it adaptable to a range of soil types, including those with moderate salinity. The soil- site suitability evaluation depicted that a total of 4466 ha (69.27%) study area was highly suitable with no limitations for sorghum cultivation. Whereas, 1216 ha and 433 ha area were classified as moderately suitable and marginally suitable, respectively for sorghum cultivation with the limitations of gravelliness, nutrient availability and texture (Figure 3). The soil-site suitability for sorghum was highly suitable in Chincholi Khurd-1 micro-watershed, Gulbarga district (Hegde *et al*., 2019) [10]. Sashikala *et al*. (2020) [24] recorded marginal suitability for sorghum cultivation due to the constraints of wetness, soil fertility characteristics like organic carbon, pH and sodicity from Tatrakallu village of Anantapuramu district Andhra Pradesh. Similar results were obtained from Patil *et al*. (2011) [18], Venkatesan and Dhanasekararan, (2019) [30] and D'Souza and Patil, (2024) [6].

Soil-site suitability evaluation for maize

Maize commonly known as corn is one of the world's most widely grown cereal crops due to its versatility, high yield potential and adaptability to different climates. It thrives in warm conditions, with ideal temperatures between 18°C and 27°C and grows best under well-distributed rainfall of 500-800 mm throughout its growing season. However, maize is sensitive to water logging, so it requires well-drained soils, preferably loamy with good organic content and a pH range of 5.5 and 7.5 for optimum nutrient availability. The suitability analysis for maize crop indicated that the majority of the study area were highly suitable (3479 ha; 53.97% of TGA) with no limitations. About 2203 ha (34.18%) and 433 ha (6.71%) area were moderately and marginally suitable for maize with specific constraints related to gravelliness, nutrient availability and rooting condition (r) (Fig.4). Soil-site suitability evaluation for maize found highly suitable in the soils under 48A Distibutary of Malaprabha Right Bank Command (Ravikumar *et al.*, 2009b) [21, 22]. The land suitability criteria indicated maize was less suitable due to gravelliness and shallow depth in the Hosakere micro-watershed of Davanagere district (Gowda *et al*., 2018) [9]. Related studies were conducted by Patil *et al*. (2023) [17] and D'Souza and Patil, (2024) [6].

Soil-site suitability evaluation for redgram

Redgram, also known as pigeon pea, is a key pulse crop known for its high protein content and adaptability to semi-arid and tropical climates. It is a drought-tolerant legume that grows best in temperatures between 20°C and 30°C and requires minimal rainfall, typically 600-800 mm annually, making it ideal for rain-fed agriculture. It thrives in well-drained sandy loam to clay loam soils with a pH range of 6.0 to 7.5. Based on the soil-site suitability evaluation about 4453 ha (69.07%) of the study area belonged to highly suitable class of soil-site suitability for growing redgram without any constraints. In the Shirur sub-watershed, 826 ha (14.98%) and 697 ha (10.81%) area belonged to moderately and marginally suitable with limitations of gravelliness, nutrient availability and rooting condition (Fig.5). Soil-site suitability evaluation showed that red soils of Bhanapur micro-watershed (Koppal district) were marginally suitable for redgram (D'Souza and Patil, 2024) [6]. Soil depth, topography, effective rooting depth and gravelliness found to be major limitations for pigeon pea production in Basavanagiri of Mysore district (Ramamurthy *et al*., 2021) [20]. Similar results were also found by Chandrakala *et al*. (2022) [5] and Yadav and Patil, (2024) [31].

Soil-site suitability evaluation for Bengal gram

Bengal gram, commonly known as chickpea, is a widely cultivated pulse crop known for its high protein content and nutritional value. It thrives in warm climates with optimal temperatures ranging from 20°C to 30°C. Bengal gram requires about 400-600 mm of rainfall during its growing season, making it suitable for regions with well-distributed rainfall or as a rain-fed crop. It performs best in well-drained, fertile loamy soils with a pH of 6.0 to 8.0, which allows for good root development and nutrient availability. About 3479 ha of the study area was highly suitable for Bengal gram cultivation with no limitations. Whereas, 2203 ha (34.18%) were moderately suitable and 433 ha (6.71%) were marginally suitable with gravelliness, nutrient availability and rooting condition constraints (Fig. 6). The limitations of shallow soil depth, wetness, organic carbon, pH and $CaCO_3$ content reasoned for the marginal suitability of bengalgram in soils of Prakasam district, Andhra Pradesh (Sekhar *et al*., 2017) [27]. The mapping units of Kanamadi South sub-watershed were moderately suitable (S2) to marginally suitable (S3) for chickpea with moderate to severe limitation of temperature, rainfall, depth and pH (D'Souza and Patil, 2024) [6]. Ravikumar, (2019) [21, 22], Sashikala *et al*. (2023) [25] and Yadav and Patil, (2024) [31] also supported the similar results in their investigations.

Soil-site suitability evaluation for green gram

Greengram crop thrives in warm climates, with optimal temperatures between 25°C and 35°C. It is a drought-resistant crop that requires approximately 300-600 mm of rainfall, making it conducive to rain-fed agriculture. These crops prefer well-drained, sandy loam to clay loam soils with a pH of 6.0 to 7.5. The study area was moderately (88.15% of TGA) to marginally (6.71% of TGA) suitable for the cultivation of green gram crop (Fig. 7). Gravelliness, nutrient availability, texture and rooting condition were the major limitations found in the study area for the crop production. According to D'Souza and Patil, (2024) [6] 19 mapping units from Kanamadi South sub-watershed were moderately (S2) to marginally suitable (S3) greengram having marginal to severe limitations of rainfall and soil physico-chemical properties. Similar results were recorded by Rajesh *et al*. (2019) [19].

Table 1: Soil-site characteristics of soil mapping units of Shirur sub-watershed for evaluation of crop suitability

Sl. No.	Soil Phases	Physical Condition Of Soil				Nutrient Availability				Salinity/Alkalinity	
		Texture	Depth (cm)	Gravelliness (%)	$CaCO_3$ (%)	pH (1:2.5)	OC (g kg^{-1})	CEC [cmol (p+) kg^{-1}]	BS (%)	EC (1:2.5) (dS m^{-1})	ESP
1	AMTmB2g1Ca	Clay	51	15-35	5.17	8.34	3.47	55.30	74.08	0.03	2.92
2	ATTmB2	Clay	65	<15	1.57	7.14	3.60	32.31	88.84	0.17	1.75
3	ATTmB2g2Ca	Clay	65	35-60	1.57	7.14	3.60	32.31	88.84	0.17	1.75
4	BLBmA2	Clay	135	<15	2.12	8.33	5.28	58.93	83.41	0.35	4.49
5	BLBmA2g1Ca	Clay	135	15-35	2.12	8.33	5.28	58.93	83.41	0.35	4.49
6	BLBmA2g2Ca	Clay	135	35-60	2.12	8.33	5.28	58.93	83.41	0.35	4.49
7	BTPiB2	Sandy clay	172	<15	5.48	8.05	8.08	58.21	91.76	0.37	3.03
8	BTPiB2g2	Sandy clay	172	35-60	5.48	8.05	8.08	58.21	91.76	0.37	3.03
9	BTPmA1	Clay	172	<15	5.48	8.05	8.08	58.21	91.76	0.37	3.03
10	BTPmA2	Clay	172	<15	5.48	8.05	8.08	58.21	91.76	0.37	3.03
11	BTPmA2g1Ca	Clay	172	15-35	5.48	8.05	8.08	58.21	91.76	0.37	3.03
12	BTPmB2	Clay	172	<15	5.48	8.05	8.08	58.21	91.76	0.37	3.03
13	BTPmB2g1Ca	Clay	172	15-35	5.48	8.05	8.08	58.21	91.76	0.37	3.03
14	BTPmB2g2Ca	Clay	172	60-80	5.48	8.05	8.08	58.21	91.76	0.37	3.03
15	BVPiA2	Sandy clay	60	<15	2.63	8.05	8.08	58.21	91.76	0.29	0.92
16	CKRiA2	Sandy clay	60	<15	1.17	6.40	8.08	58.21	91.76	0.15	4.77
17	CKRmA2	Clay	60	<15	1.17	6.40	8.08	58.21	91.76	0.15	4.77
18	CKRmA2g2Ca	clay	60	35-60	1.17	6.40	2.53	25.71	83.32	0.15	4.77
19	CKRmB2g2Ca	Clay	60	35-60	1.17	6.40	5.20	22.84	82.44	0.15	4.77
20	JLGmA1	Clay	89	<15	0.42	6.47	5.20	22.84	82.44	0.18	1.98
21	JLGmA2	Clay	89	<15	0.42	6.47	5.20	22.84	82.44	0.18	1.98
22	JLGmA2g1Ca	Clay	89	15-35	0.42	6.47	5.20	22.84	82.44	0.18	1.98
23	JLGmB2g1Ca	Clay	89	15-35	0.42	8.08	5.77	44.13	91.29	0.18	1.98
24	KNLmA2	Clay	182	<15	1.17	8.08	5.77	44.13	91.29	0.41	5.13
25	KPRmA1	Clay	128	<15	15.90	8.32	5.77	44.13	91.29	0.10	1.05
26	KPRmA2	Clay	128	<15	15.90	8.32	5.77	44.13	91.29	0.10	1.05
27	KPRmA2g1Ca	Clay	128	15-35	15.90	8.32	5.05	51.82	84.28	0.10	1.05
28	KPRmB2	Clay	128	<15	15.90	8.32	6.93	36.46	87.66	0.10	1.05
29	KPRmB2g1Ca	Clay	128	15-35	15.90	8.32	6.93	36.46	87.66	0.10	1.05
30	MGDmA1	Clay	200	<15	6.55	7.64	6.93	36.46	87.66	0.19	2.71
31	MGDmA2	Clay	200	<15	6.55	7.64	6.93	36.46	87.66	0.19	2.71
32	MGDmA2g1Ca	Clay	200	15-35	6.55	7.64	6.93	36.46	87.66	0.19	2.71
33	MGDmA2g2Ca	Clay	200	35-60	6.55	7.64	6.93	36.46	87.66	0.19	2.71
34	MGDmB2g1Ca	Clay	200	15-35	6.55	8.35	2.13	37.61	89.17	0.19	2.71

Contd…

Sl.No	Soil Phases	Physical condition of soil				Nutrient availability				Salinity/alkalinity	
		Texture	Depth (cm)	Gravelliness (%)	$CaCO_3$ (%)	pH (1:2.5)	OC (g kg^{-1})	CEC [cmol (p+) kg^{-1}]	BS (%)	EC (1:2.5) (dS m^{-1})	ESP
35	Mgdmb2g2	Clay	200	35-60	6.55	8.35	2.13	37.61	89.17	0.19	2.71
36	MGDmB2g2Ca	Clay	200	35-60	6.55	8.35	2.13	37.61	89.17	0.19	2.71
37	MTPmA2	Clay	142	<15	4.98	8.35	2.13	37.61	89.17	0.27	8.30
38	MTPmA2g1Ca	Clay	142	15-35	4.98	8.35	2.13	37.61	89.17	0.27	8.30
39	MUKmA1	Clay	50	<15	7.27	8.35	2.13	37.61	89.17	0.21	5.93
40	MUKmA2	Clay	50	<15	7.27	8.35	2.13	37.61	89.17	0.21	5.93
41	MUKmA2g1Ca	Clay	50	15-35	7.27	7.40	5.75	35.37	81.84	0.21	5.93
42	MUKmB2g1Ca	Clay	50	15-35	7.27	7.40	5.75	35.37	81.84	0.21	5.93
43	MVDmA1	Clay	109	<15	15.22	8.07	7.00	60.88	89.04	0.24	0.92
44	MVDmA2	Clay	109	<15	15.22	8.07	7.00	60.88	89.04	0.24	0.92
45	MVDmA2g1Ca	Clay	109	15-35	15.22	8.07	7.00	60.88	89.04	0.24	0.92

46	MVDmA2g2Ca	Clay	109	35-60	15.22	8.07	7.00	60.88	89.04	0.24	0.92
47	MVDmB2g2Ca	Clay	109	35-60	15.22	8.07	6.08	48.60	88.14	0.24	0.92
48	NGTiB2g1	Sandy clay	154	15-35	15.78	8.39	6.08	48.60	88.14	0.10	0.70
49	NGTmA1	Clay	154	<15	15.78	8.39	6.08	48.60	88.14	0.10	0.70
50	NGTmA2	Clay	154	<15	15.78	8.39	6.08	48.60	88.14	0.10	0.70
51	NGTmA2g1Ca	Clay	154	15-35	15.78	8.39	6.08	48.60	88.14	0.10	0.70
52	NGTmA2g2Ca	Clay	154	35-60	15.78	8.39	5.88	43.12	86.52	0.10	0.70
53	NGTmB2	Clay	154	<15	15.78	8.39	5.88	43.12	86.52	0.10	0.70
54	NGTmB2g1Ca	Clay	154	15-35	15.78	8.39	5.88	43.12	86.52	0.10	0.70
55	NGVmA2g1Ca	Clay	52	15-35	7.35	8.01	5.88	43.12	86.52	0.14	1.62
56	SKBmB2g1Ca	Clay	85	15-35	1.83	7.72	5.88	43.12	86.52	0.05	0.67
57	VKPmA2	Clay	72	<15	14.07	7.72	5.88	43.12	86.52	0.12	0.58
58	VKPmA2g1Ca	Clay	72	15-35	14.07	7.72	5.88	43.12	86.52	0.12	0.58
59	VKPmA2g2Ca	Clay	72	35-60	14.07	7.51	6.25	24.92	83.44	0.12	0.58
60	VRViB2g1	Sandy clay	83	15-35	14.97	6.62	6.20	26.37	84.13	0.51	0.77
61	VRVmA2	Clay	83	<15	14.97	6.62	6.20	26.37	84.13	0.51	0.77
62	VRVmA2g1Ca	Clay	83	15-35	14.97	7.68	6.87	52.08	90.65	0.51	0.77
63	VRVmA2g2Ca	Clay	83	35-60	14.97	7.68	6.87	52.08	90.65	0.51	0.77
64	VRVmB2g1Ca	Clay	83	15-35	14.97	7.68	6.87	52.08	90.65	0.51	0.77
65	YVHmA2g1Ca	Clay	79	15-35	1.50	7.89	6.10	51.83	90.08	0.14	2.87
66	YVHmB2	Clay	79	<15	1.50	7.89	6.10	51.83	90.08	0.14	2.87
67	YVHmB2g1Ca	Clay	79	15-35	1.50	7.89	6.10	51.83	90.08	0.14	2.87

Table 2: Soil-site suitability classification of soil mapping units of Shirur sub-watershed for major field crops

SL. No	Soil Phases	Wheat	Sorghum	Maize	Red Gram	Bengal Gram	Greengram
1	AMTmB2g1Ca	S3gnt	S3gnt	S3gn	S3gn	S3gn	S3gnt
2	ATTmB2	S2t	S2t	S2r	S2r	S3r	S2rt
3	ATTmB2g2Ca	S2gt	S2gt	S2gr	S2gr	S2gr	S2gr
4	BLBmA2	S2gn	S2gn	S2gn	S2gn	S2gn	S2gnt
5	BLBmA2g1Ca	S2gn	S2gn	S2gn	S2gn	S2gn	S2gnt
6	BLBmA2g2Ca	S2gn	S2gn	S2gn	S2gn	S2gn	S2gnt
7	BTPiB2	S2nt	S1	S2n	S1	S2n	S2t
8	BTPiB2g2	S2gnt	S2g	S2g	S2g	S2g	S2t
9	BTPmA1	S2nt	S1	S2n	S1	S2n	S2t
10	BTPmA2	S2nt	S1	S2n	S1	S2n	S2t
11	BTPmA2g1Ca	S2nt	S1	S2n	S1	S2n	S2t
12	BTPmB2	S2nt	S1	S2n	S1	S2n	S2t
13	BTPmB2g1Ca	S2nt	S1	S2n	S1	S2n	S2t
14	BTPmB2g2Ca	S2gnt	S1	S2n	S1	S2n	S2t
15	BVPiA2	S2t	S2r	S2r	S3r	S2r	S2rt
16	CKRiA2	S2gt	S2gn	S2gn	S3gn	S2gn	S2gnt
17	CKRmA2	S2gt	S2gn	S2gn	S3gn	S2gn	S2gnt
18	CKRmA2g2Ca	S2gt	S2gn	S2gn	S3gn	S2gn	S2gnt
19	CKRmB2g2Ca	S2gt	S2gn	S2gn	S3gn	S2gn	S2gnt
20	JLGmA1	S2nt	S2n	S2n	S2nr	S2n	S2nt
21	JLGmA2	S2nt	S2n	S2n	S2nr	S2n	S2nt
22	JLGmA2g1Ca	S2nt	S2n	S2n	S2nr	S2n	S2nt
23	JLGmB2g1Ca	S2t	S1	S1	S2r	S1	S2t
24	KNLmA2	S2t	S1	S1	S1	S1	S2t
25	KPRmA1	S2t	S1	S1	S1	S1	S2t
26	KPRmA2	S2t	S1	S1	S1	S1	S2t
27	KPRmA2g1Ca	S2t	S1	S1	S1	S1	S2t
28	KPRmB2	S2t	S1	S1	S1	S1	S2t
29	KPRmB2g1Ca	S2t	S1	S1	S1	S1	S2t
30	MGDmA1	S2nt	S1	S1	S1	S1	S2t
31	MGDmA2	S2nt	S1	S1	S1	S1	S2t
32	MGDmA2g1Ca	S2nt	S1	S1	S1	S1	S2t
33	MGDmA2g2Ca	S2gnt	S2g	S2g	S2g	S2g	S2t
34	MGDmB2g1Ca	S2nt	S1	S1	S1	S1	S2t
35	MGDmB2g2	S2gnt	S2g	S2g	S2g	S2g	S2t

Contd…

Sl. No	Soil Phases	Wheat	Sorghum	Maize	Red gram	Bengal gram	Greengram
36	Mgdmb2g2ca	S2gnt	S2g	S2g	S2g	S2g	S2t
37	MTPmA2	S2t	S1	S1	S1	S1	S2t
38	MTPmA2g1Ca	S2t	S1	S1	S1	S1	S2t

39	MUKmA1	S3nt	S3nr	S3nr	S3nr	S3nr	S3nr
40	MUKmA2	S3nt	S3nr	S3nr	S3nr	S3nr	S3nr
41	MUKmA2g1Ca	S3nt	S3nr	S3nr	S3nr	S3nr	S3nr
42	MUKmB2g1Ca	S3nt	S3nr	S3nr	S3nr	S3nr	S3nr
43	MVDmA1	S2nt	S2n	S2n	S2n	S2n	S2nt
44	MVDmA2	S2nt	S2n	S2n	S2n	S2n	S2nt
45	MVDmA2g1Ca	S2nt	S2n	S2n	S2n	S2n	S2nt
46	MVDmA2g2Ca	S2nt	S2gn	S2gn	S2gn	S2gn	S2gnt
47	MVDmB2g2Ca	S2nt	S2gn	S2gn	S2gn	S2gn	S2gnt
48	NGTiB2g1	S2t	S1	S1	S1	S1	S2t
49	NGTmA1	S2t	S1	S1	S1	S1	S2t
50	NGTmA2	S2t	S1	S1	S1	S1	S2t
51	NGTmA2g1Ca	S2t	S1	S1	S1	S1	S2t
52	NGTmA2g2Ca	S2gt	S2g	S2g	S2g	S2g	S2gt
53	NGTmB2	S2t	S1	S1	S1	S1	S2t
54	NGTmB2g1Ca	S2t	S1	S1	S1	S1	S2t
55	NGVmA2g1Ca	S2gnt	S2gn	S2gn	S3gn	S2gn	S2gn
56	SKBmB2g1Ca	S2t	S2n	S2n	S2nr	S2n	S2gn
57	VKPmA2	S2gnt	S2gr	S2gr	S3gr	S2gr	S2gr
58	VKPmA2g1Ca	S2gnt	S2gr	S2gr	S3gr	S2gr	S2gr
59	VKPmA2g2Ca	S2gnt	S2gr	S2gr	S3gr	S2gr	S2gr
60	VRViB2g1	S2gnt	S2gn	S2gn	S2gn	S2gn	S2gn
61	VRVmA2	S2nt	S2n	S2n	S2nr	S2n	S2nt
62	VRVmA2g1Ca	S2gnt	S2gn	S2gn	S2gn	S2gn	S2gn
63	VRVmA2g2Ca	S2gnt	S2gn	S2gn	S2gn	S2gn	S2gn
64	VRVmB2g1Ca	S2gnt	S2gn	S2gn	S2gn	S2gn	S2gn
65	YVHmA2g1Ca	S2gt	S2g	S2g	S2gr	S2g	S2g
66	YVHmB2	S2gt	S2g	S2g	S2gr	S2g	S2g
67	YVHmB2g1Ca	S2gt	S2g	S2g	S2gr	S2g	S2g

*Limitations- g: gravelliness; n: nutrient availability; t: texture; r: depth

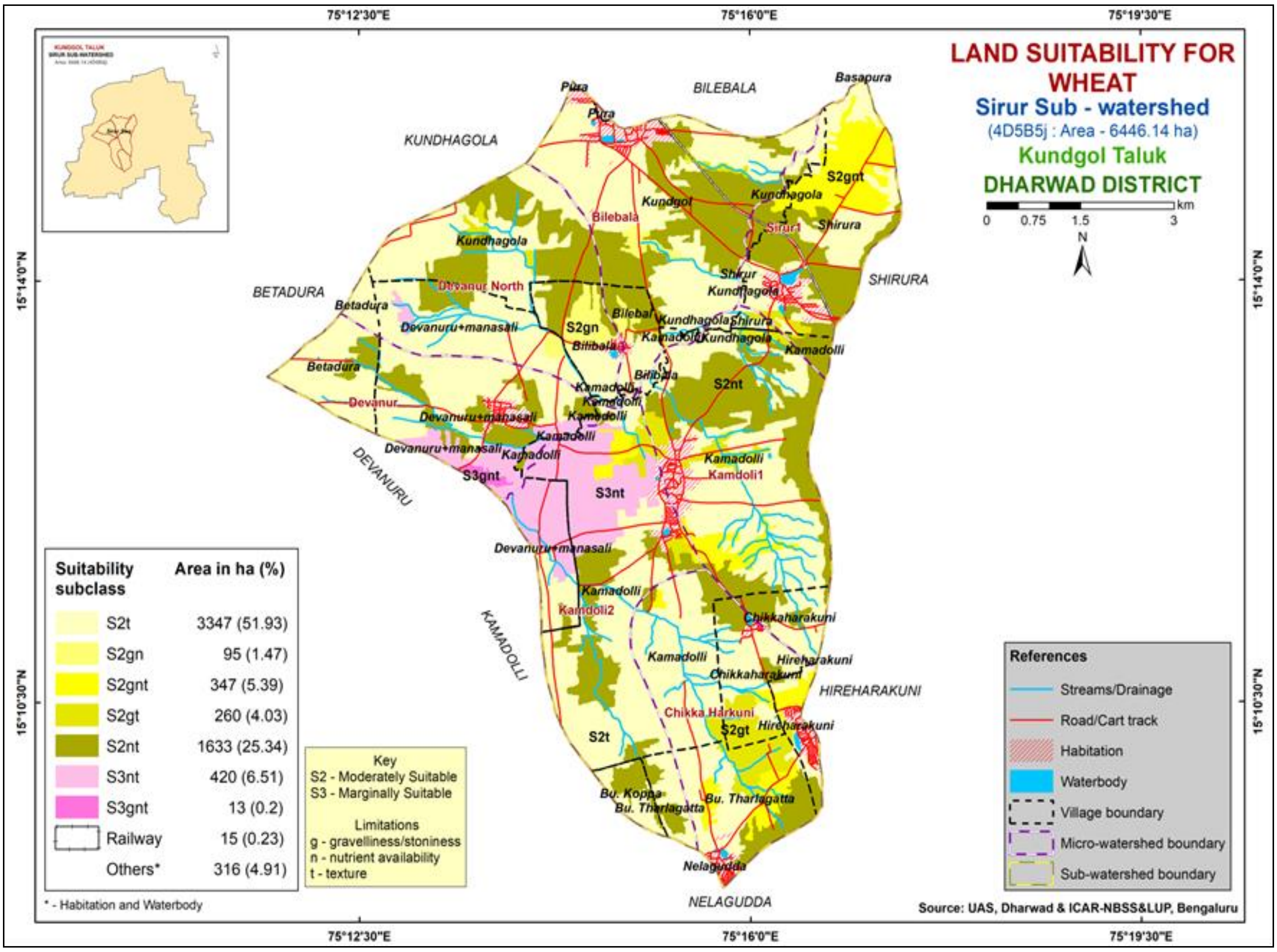

Fig 2: Soil site suitability map for wheat crop in Shirur Sub-watershed

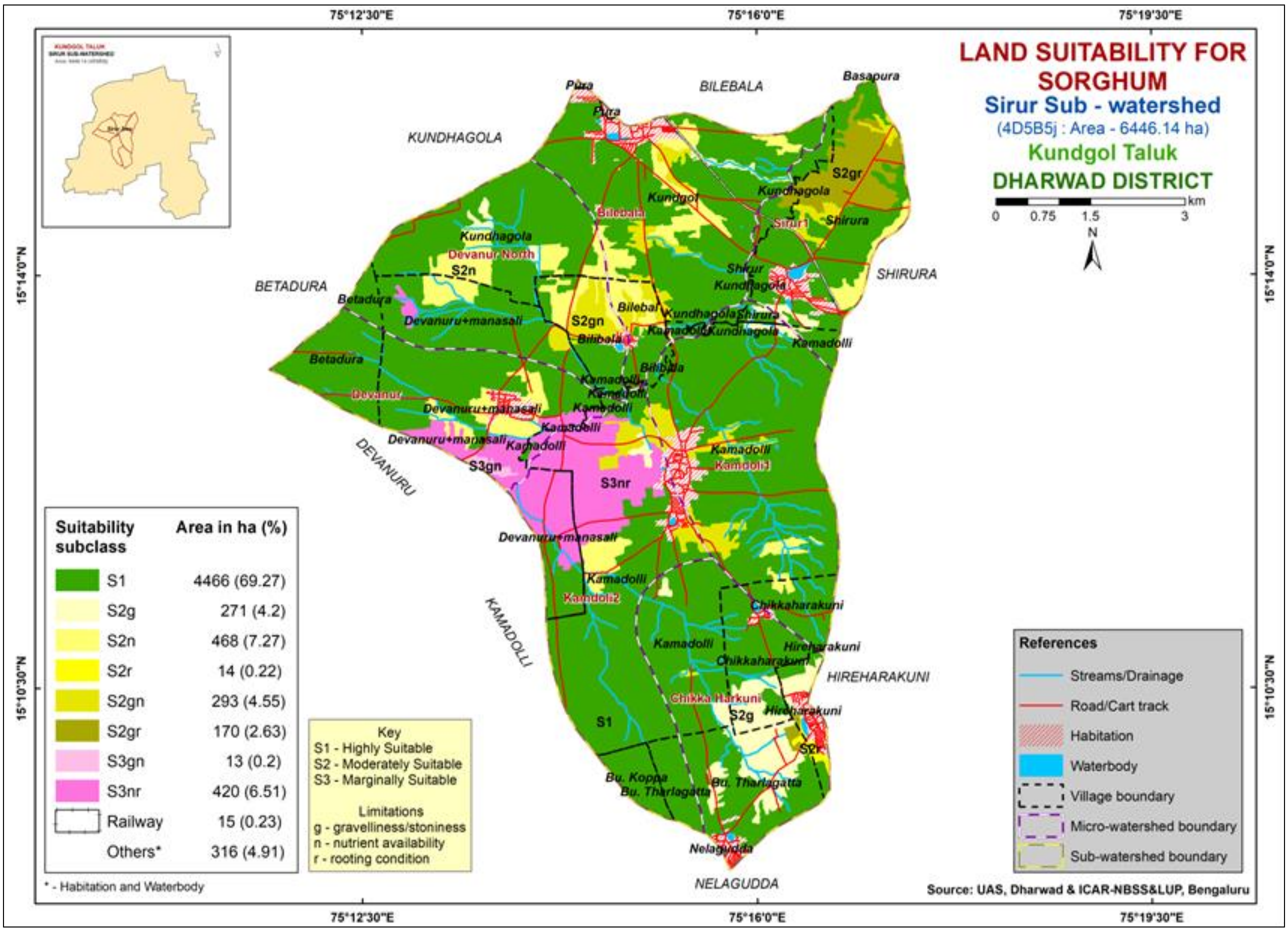

Fig 3: Soil site suitability map for sorghum crop in Sirur Sub-watershed

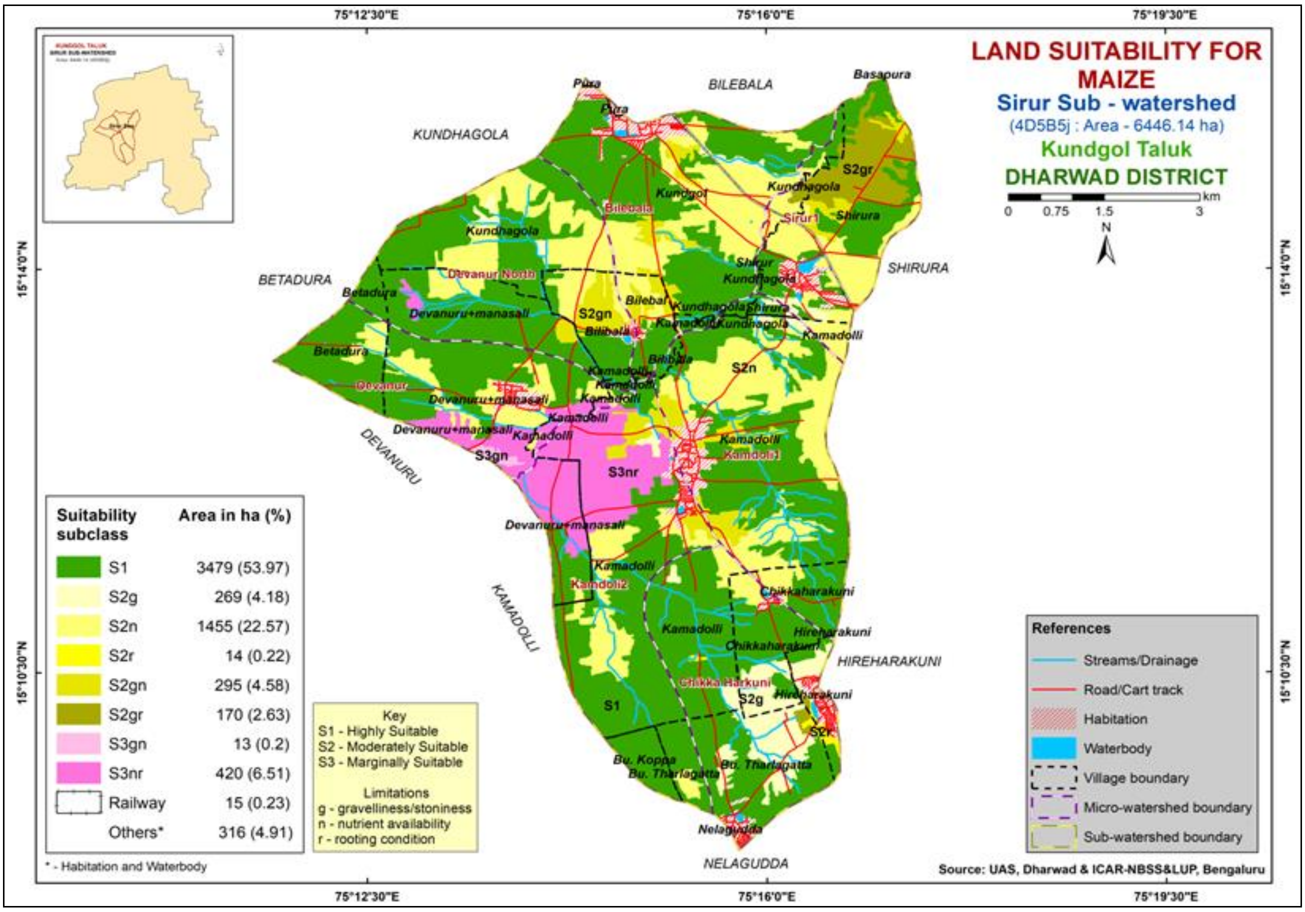

Fig 4: Soil site suitability map for maize crop in Shirur Sub-watershed

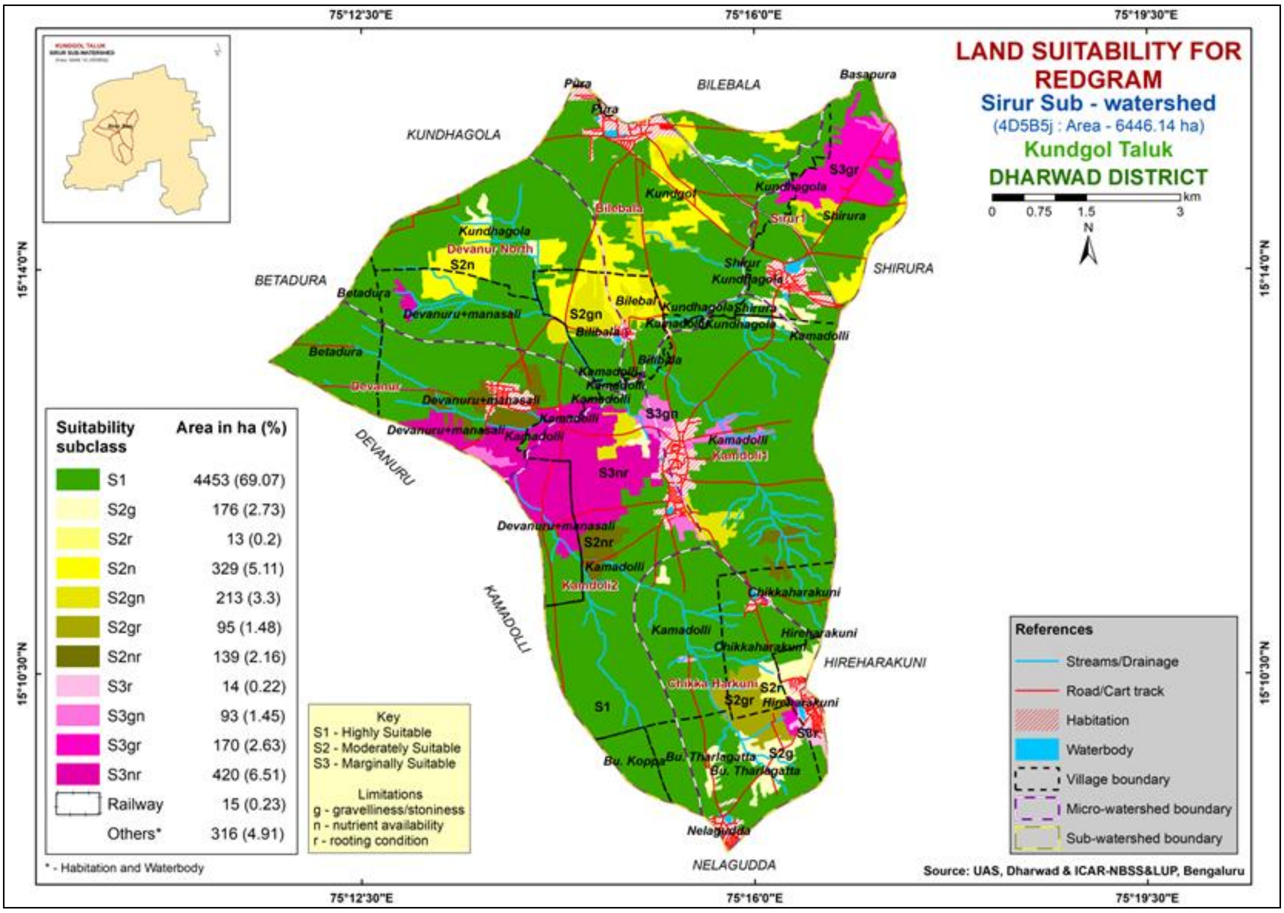

Fig 5: Soil site suitability map for redgram crop in Sirur Sub-watershed

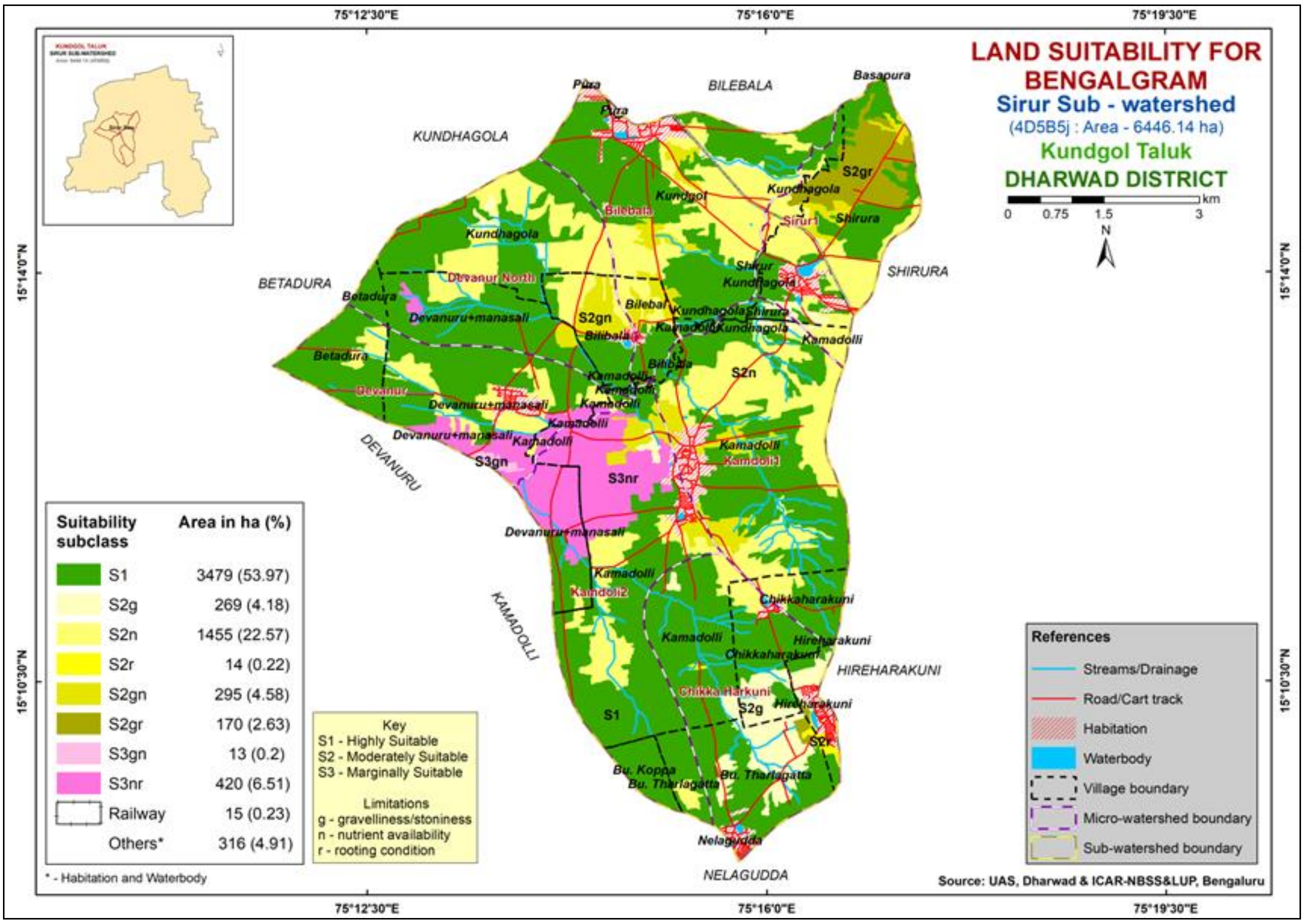

Fig 6: Soil site suitability map for bengalgram crop in Shirur Sub-watershed

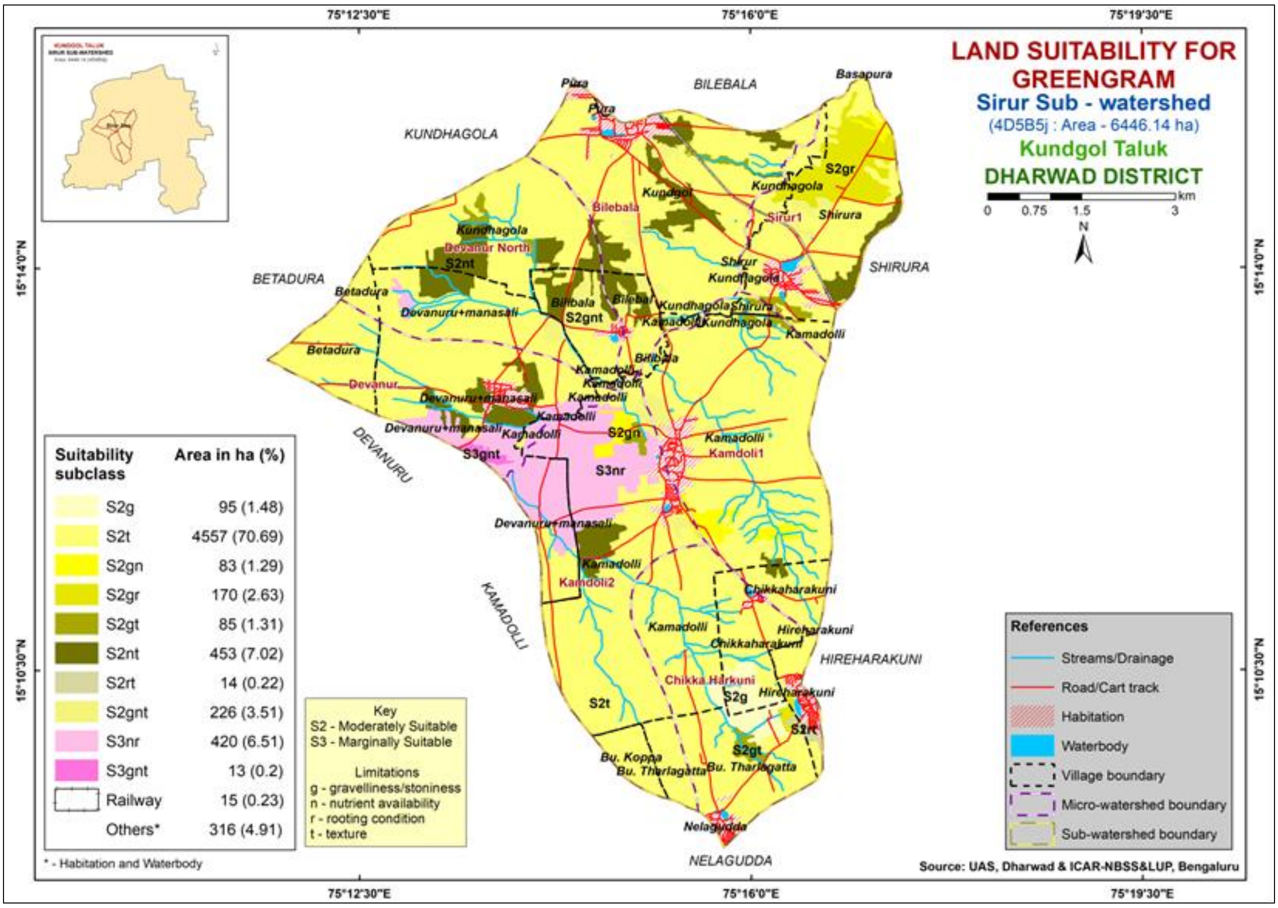

Fig 7: Soil site suitability map for greengram crop in Shirur Sub-watershed

Conclusion

The soil-site suitability assessment of the Shirur sub-watershed revealed varying levels of suitability for major cereal and pulse crops. Wheat was predominantly moderately suitable (S2) due to gravelliness, nutrient availability, and texture limitations, while sorghum and maize showed significant highly suitable areas (69.27% and 53.97%, respectively). Redgram and Bengal gram were mostly highly suitable, emphasizing their potential in semi-arid conditions, while green gram was moderately suitable with similar constraints. Overall, this study emphasized the importance of soil and crop-specific management strategies to overcome moderate to severe limitations. Addressing constraints such as soil fertility, texture and gravelliness through targeted amendments and sustainable practices can enhance the productivity of cereal and pulse crops in the region. Also, with the integration of RS and GIS for suitability evaluation provided valuable insights for efficient agricultural planning, supporting food security and resource conservation in the semi-arid landscapes of Karnataka.

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Conflict of interest

The authors declare that they have no conflict of interest.

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