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Soil-Site Suitability Assessment of Horticultural Crops Grown in the Ganjigatti Sub-watershed of Karnataka

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Abstract: The initial step in planning future agricultural land use is to establish a connection between soil characteristics and crop requirements. The objective of this study is to assess the limitations and potential of soils within the Ganjigatti sub-watershed in Karnataka and to determine their suitability for major horticultural crops grown in that sub-watershed. During the land resource inventory of the study area, twenty-one soil series were identified and mapped.Using criteria such as texture, depth, slope, erosion, gravel content and stoniness, twenty-one soil series were categorized into sixty-one mapping units. These soils were evaluated for their suitability for major horticultural crops, including chilli, tomato, rose and jasmine, in the Ganjigatti sub-watershed, located in the hilly zone (Zone 9) of Karnataka, with a focus on sustainable land use planning. The sub-watershed had predominantly moderate (S2) and marginally (S3) suitability for various crops. For chilli production, 2181 ha (50.46%) and 1571 ha (36.33%) were moderately and marginally suitable, respectively, but faced limitations such as length of the growing period, soil drainage, texture, depth, gravel content and slope. Similarly, for tomato production, 1294 ha (29.92%) and 2460 ha (56.88%) were moderately and marginally suitable, respectively, with similar limitations. For rose production, 899 ha (20.79%) and 1337 ha (30.92%) were moderately and marginally suitable, respectively, with issues related to soil drainage, texture, depth, gravel content and calcium carbonate ($CaCO_3$) levels. Approximately 36.43% of TGA were not suitable for rose production due to severe depth limitations. For jasmine production, 30.30% and 56.64% of TGA were moderately and marginally suitable, respectively, but faced limitations concerning average annual temperature, soil drainage, texture, depth, gravel content, $CaCO_3$ levels and slope.

Keywords: Soil-site suitability, *Arc*GIS, Ganjigatti sub-watershed, Horticultural crops

The majority of India's agriculture is rain-fed and highly erratic rains, poor soils, low yields and inadequate infrastructure development characterize it. The fragile ecologies of these rain-fed regions are likewise severely degraded. Population growth has resulted in the overexploitation of land, water and other natural resources, leading to water scarcity, soil degradation and the rapid depletion of groundwater tables (Srinivasarao et al., 2015). As a result, the agricultural growth rate is stagnant and food price inflation is soaring. In order to restore the declining trend of the qualities of different soils in India, there has been an emerging need for soil as well as land evaluation and land use planning (Ramamurthy et al., 2012, Naidu et al., 2015). The concept of soil-site suitability for crop production is central to sustainable agriculture and plays a pivotal role in ensuring global food security. Soil-site suitability analysis involves a comprehensive assessment of soil properties, environmental factors and crop requirements to determine the appropriateness of a specific location for successful crop cultivation. This multifaceted evaluation is indispensable for maximizing crop yields, minimizing resource inputs and sustaining the long-term health of agricultural ecosystems. For rationalizing land use, the soil-site suitability for different crops needs to be determined (Ramamurthy et al., 2020). These suitability models provide guidelines to decide the policy of growing the most suitable crops depending on the suitability and capability of each soil unit. There is need to identify land-specific suitability criteria for different annual crops through a land evaluation approach with the help of soil parameters and yield data.

Remote sensing (RS) data offers the capability to identify and characterize various physiographic features, along with providing supplementary data regarding site attributes such as slope, aspect, and orientation within the study area. However, when it comes to assessing crop suitability, a more comprehensive understanding of soil profile properties becomes imperative. Therefore, soil survey data plays an indispensable role in creating a detailed soil map specific to the region under consideration. This map, in turn, serves as a crucial tool for determining the suitability of the area for different crops and for conducting an analysis of suitable cropping systems. By integrating RS data with information derived from soil surveys, it is possible to harness the power of Geographic Information Systems (GIS) to assess crop suitability across a range of soil types and biophysical conditions. This integrated approach, as demonstrated in previous studies (Hegde et al., 2019, Tuyen et al., 2019, Chikkaramappa et al., 2020), offers significant potential for quantitative land evaluation. The research presented here focuses on showcasing the synergistic use of remote sensing (RS) and Geographic Information System (GIS) data to evaluate the suitability of sites for cultivating specific horticultural crops in the Ganjigatti sub-watershed of Karnataka. The crops examined in this study include chili, tomato, rose and jasmine.

MATERIAL AND METHODS

Site location: The study was conducted in 2021–2023, in the Ganjigatti sub-watershed (5B1A4F) of Dharwad district in Karnataka, situated between 15° 10' 10.114″ to 15° 17' 1.147″ N latitudes and 75° 0' 57.672″ to 75° 4' 50.525″ E longitudes, with the highest elevation of 610 m above mean sea level. The total geographical area of the watershed is about 4323.84 ha. The annual temperature ranges from 24.68 to 26.67 °C. The average rainfall in the watershed was 917.00 mm (Fig. 1). Relative humidity varies from 28% in summer to 70% in winter. The average potential evapotranspiration (PET) is 150 mm and varies from 115 to 232 mm. The PET is always higher than precipitation in all the months except August and October. Generally, the length of crop growing period (LGP) is 150 days and starts from 3rd week of June to third week of November. After preliminary traversing of the entire watershed using a 1:7,920 scale base map and satellite imagery, based on geology, drainage pattern, surface features, slope characteristics, land use, landforms and physiographic divisions, twenty-seven (27) soil profiles were selected and studied and their morphometric characteristics were recorded.

Soil properties: Physical and chemical properties were

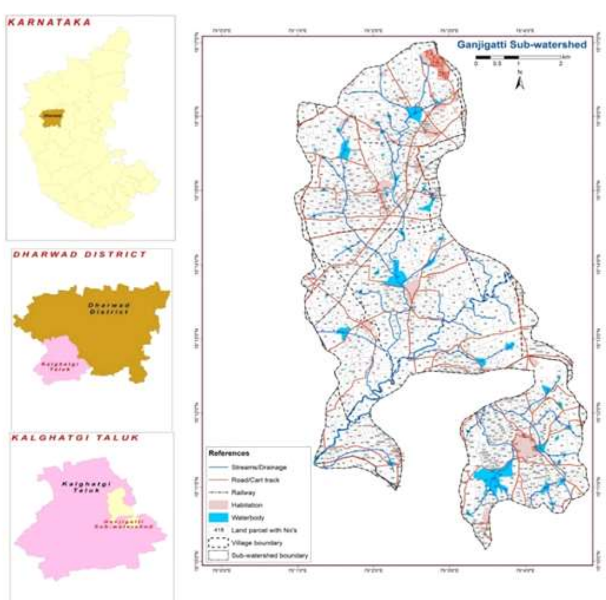

Fig. 1. Location of the study area

estimated using standard procedures. The detailed soil resource inventory of the Ganjigatti sub-watershed was carried out and 21 series mapped into sixty-one (61) mapping units based on surface soil properties. After a detailed soil survey, crop suitability maps for major fruit crops growing in the Ganjigatti sub-watershed area at soil phase level were prepared by using the platform of *Arc*GIS 10.8.2. Their suitability was assessed using the limitation method regarding the number and intensity of limitations (Naidu et al., 2006). This evaluation procedure consists of three phases. In phase I, the data was collected in terms of characteristics (Table 1). The landscape and soil characteristics used to evaluate soil suitability: topography (slope %), wetness (flooding and drainage), physical soil characteristics (texture/structure, % coarse fragments by volume, soil depth in cm, $CaCO_3$ per cent), salinity (EC, dSm^{-1}) and alkalinity (ESP). The study locations were nearly level to moderately steep sloping and had never been flooded (F0). The drainage conditions were moderately well to well and sandy loam to clay in texture, as per the guidelines given by FAO (1976). Weighted mean of each property was calculated and soil-site characteristics of different soil units were obtained. These weighted average data have been used to evaluate and soil site suitability (FAO 1976). In phase II, the landscape and soil requirements for these five crops were taken from Naidu et al (2006) as described by Sehgal (2005). In phase III, the land suitability under rainfed conditions has been assessed by comparing the landscape and soil characteristics with crop requirements at different limitations levels: no (0), slight (1), moderate (2), severe (3), and very severe (4). Limitations are deviations from the optimal conditions of a land characteristic, such as land quality, that adversely affect the kind of land use. If a land characteristic is optimal for plant growth, it has no limitation. On the other hand, when the same characteristic is unfavourable for plant growth, it has severe limitations for land evaluation types. Thus, the evaluation was done by comparing the land characteristics with the limitation levels of the crop requirement given by Naidu et al. (2006), as described by Seghal (2005). The number and degrees of limitations suggested the suitability class of each soil series for a particular crop, as given by FAO (1976).

RESULTS AND DISCUSSION

Soil-site suitability evaluation consider the topography (t) of the land (slope% and erosion), soil physical conditions (s) (surface texture, stoniness, gravelines, $CaCO_3$ content and depth), wetness (w) (drainage) and fertility parameters (f) (CEC, BS, OC and EC) (Sehgal 2005). Fertility limitations (f) were not considered for soil-site suitability evaluation of sub-

Table 1. Soil-site characteristics of soil mapping units of Ganjigattisub-watershed

Soil phases	Wetness (w)	Physical condition of soil (s)					Fertility (f)				Salinity/ Alkalinity (n)		Erosion (e)
	Drainage	Texture	Depth (cm)	Stoniness	Gravel (%)	$CaCO_3$ (%)	pH	OC (%)	CEC	BS (%)	EC (dS m^{-1})	ESP (%)	Slope %
AKTmB2R2	Moderately well	Clay	79	Nil	<15	3.21	7.18	0.48	59.33	72.52	0.28	1.48	1-3
ASRfB2	Well drained	Clay loam	130	Nil	<15	15.96	8.68	0.33	48.70	87.46	0.36	1.00	1-3
ASRfB2g1	Well drained	Clay loam	130	Nil	15-35	15.96	8.68	0.33	48.70	87.46	0.36	1.00	1-3
ASRmB2	Well drained	Clay	130	Nil	<15	15.96	8.68	0.33	48.70	87.46	0.36	1.00	1-3
ASRmC3	Well drained	Clay	130	Nil	<15	15.96	8.68	0.33	48.70	87.46	0.36	1.00	3-5
BGDhB2g1	Well drained	Sandy clay loam	20	Nil	15-35	1.5	5.91	1.19	16.55	60.76	0.49	1.94	1-3
BGDhC3g2	Well drained	Sandy clay loam	20	Nil	35-60	1.5	5.91	1.19	16.55	60.76	0.49	1.94	3-5
BGHfB2	Moderately well	Clay loam	90	Nil	<15	7.35	7.33	0.6	23.64	85.7	0.3	2.19	1-3
BGHfB2g1	Moderately well	Clay loam	90	Nil	15-35	7.35	7.33	0.6	23.64	85.7	0.3	2.19	1-3
BGHfB2g2	Moderately well	Clay loam	90	Nil	35-60	7.35	7.33	0.6	23.64	85.7	0.3	2.19	1-3
BGHfC3	Moderately well	Clay loam	90	Nil	<15	7.35	7.33	0.6	23.64	85.7	0.3	2.19	3-5
BGHfC3g1	Moderately well	Clay loam	90	Nil	15-35	2.99	7.08	0.58	23.48	83.88	0.12	1.72	3-5
BGHfD3g2	Moderately well	Clay loam	90	Nil	35-60	2.99	7.08	0.58	23.48	83.88	0.12	1.72	5-10
BGHhB2	Moderately well	Sandy clay loam	90	Nil	<15	7.35	7.33	0.6	23.64	85.7	0.3	2.19	1-3
BGHhB2g1	Moderately well	Sandy clay loam	90	Nil	15-35	7.35	7.33	0.6	23.64	85.7	0.3	2.19	1-3
BGHmB1g1St2	Moderately well	Clay	80	1-3	15-35	3.5	6.83	0.83	43.84	77.7	0.18	0.53	1-3
BNKmB1	Well drained	Clay	35	Nil	<15	2.81	7.23	0.53	28.34	69.91	0.22	2.42	1-3
BNKmB1g1	Well drained	Clay	35	Nil	15-35	2.81	7.23	0.53	28.34	69.91	0.22	2.42	1-3
BNKmB2g1	Well drained	Clay	35	Nil	15-35	2.81	7.23	0.53	28.34	69.91	0.22	2.42	1-3
BNKmC2g2	Well drained	Clay	35	Nil	35-60	2.81	7.23	0.53	28.34	69.91	0.22	2.42	3-5
BTPmA1	Well drained	Clay	200	Nil	<15	12.02	8.3	0.75	58.22	90.28	0.16	2.67	0-1
BTPmB2	Well drained	Clay	200	Nil	<15	12.02	8.3	0.75	58.22	90.28	0.16	2.67	1-3
BTPmB2g1	Well drained	Clay	180	Nil	15-35	13.28	7.82	0.45	37.39	89.51	0.36	2.63	1-3
GJGiB2	Moderately well	Sandy clay	55	Nil	<15	3.76	7.22	0.66	22.68	71.53	0.22	1.48	1-3
GJGiB2g1	Moderately well	Sandy clay	55	Nil	15-35	3.76	7.22	0.66	22.68	71.53	0.22	1.48	1-3
GJGiC3g1	Moderately well	Sandy clay	55	Nil	15-35	3.76	7.22	0.66	22.68	71.53	0.22	1.48	3-5
HNLiC2g1	Moderately well	Sandy clay	67	Nil	15-35	3.06	5.92	0.66	19.82	50.72	0.26	2.03	3-5
HNLiC2g2	Moderately well	Sandy clay	67	Nil	35-60	3.06	5.92	0.66	19.82	50.72	0.26	2.03	3-5
HRGmB2	Moderately well	Clay	130	Nil	<15	15.9	8.1	0.49	49.58	90.85	0.34	0.86	1-3
HRGmB2Ca	Moderately well	Clay	130	Nil	<15	15.9	8.1	0.49	49.58	90.85	0.34	0.86	1-3
HRGmC3g1	Moderately well	Clay	130	Nil	15-35	15.9	8.1	0.49	49.58	90.85	0.34	0.86	3-5
KDKhB2g1	Moderately well	Sandy clay loam	49	Nil	15-35	2.89	6.42	0.53	59.33	72.52	0.16	0.84	1-3
KDKhC3g2	Moderately well	Sandy Clay loam	49	Nil	35-60	2.89	6.42	0.53	59.33	72.52	0.16	0.84	3-5
KDKhC3g2	Moderately well	Sandy Clay loam	49	Nil	35-60	2.89	6.42	0.53	59.33	72.52	0.16	0.84	3-5
KDKhC3g3	Moderately well	Sandy Clay loam	49	Nil	60-80	2.89	6.42	0.53	59.33	72.52	0.16	0.84	3-5
KDKiB2	Well drained	Clay loam	35	Nil	<15	2.53	6.84	0.76	23.00	69.1	0.22	1.87	1-3
KMDhC3g2	Well drained	Sandy Clay loam	35	Nil	35-60	0.91	5.36	0.73	11.15	49.67	0.1	1.82	3-5
KMDmB2	Well drained	Clay	35	Nil	<15	0.91	5.36	0.73	11.15	49.67	0.1	1.82	1-3
KDKiB2	Well drained	Clay loam	35	Nil	<15	2.53	6.84	0.76	23	69.1	0.22	1.87	1-3
KMDhC3g2	Well drained	Sandy Clay loam	35	Nil	35-60	0.91	5.36	0.73	11.15	49.67	0.1	1.82	3-5
KMDmB2	Well drained	Clay	35	Nil	<15	0.91	5.36	0.73	11.15	49.67	0.1	1.82	1-3
KMDmB2g1	Well drained	Clay	35	Nil	15-35	0.91	5.36	0.73	11.15	49.67	0.1	1.82	1-3
KRKfC2g1	Well drained	Clay loam	30	Nil	15-35	2.65	5.61	0.58	20.03	68.16	0.09	2.07	3-5

Cont...

Table 1. Soil-site characteristics of soil mapping units of Ganjigattisub-watershed

Soil phases	Wetness (w)	Physical condition of soil (s)					Fertility (f)				Salinity/ Alkalinity (n)		Erosion (e)
	Drainage	Texture	Depth (cm)	Stoniness	Gravel (%)	$CaCO_3$ (%)	pH	OC (%)	CEC	BS (%)	EC (dS m^{-1})	ESP (%)	Slope %
KRKmC2g1	Well drained	Clay	40	Nil	15-35	3.33	6.02	1.02	21.16	70.31	0.06	0.79	3-5
MLPdB1g1	Moderately well	loam	20	Nil	15-35	1.35	5.83	0.58	23.62	49.72	0.11	2.22	1-3
MLPdC2g1	Moderately well	loam	20	Nil	15-35	1.35	5.83	0.58	23.62	49.72	0.11	2.22	3-5
MLPdC2g2	Moderately well	loam	20	Nil	35-60	1.35	5.83	0.58	23.62	49.72	0.11	2.22	3-5
MRKiB2	Moderately well	Sandy Clay	28	Nil	<15	3.21	7.18	0.48	26.49	64.29	0.28	1.48	1-3
MRKiB2g1	Moderately well	Sandy Clay	28	Nil	15-35	3.21	7.18	0.48	26.49	64.29	0.28	1.48	1-3
MVDfB2	Well drained	Clay loam	170	Nil	<15	4.66	6.62	0.52	23.96	84.18	0.2	2.07	1-3
MVDfB2g1	Well drained	Clay loam	170	Nil	15-35	4.66	6.62	0.52	23.96	84.18	0.2	2.07	1-3
MVDfD3	Well drained	Clay loam	170	Nil	<15	4.66	6.62	0.52	23.96	84.18	0.2	2.07	5-10
RMNiC3g2	Well drained	Sandy Clay	120	Nil	35-60	3.2	8.28	0.64	17.35	90.34	0.18	4.65	3-5
RMNiD3g2	Well drained	Sandy Clay	120	Nil	35-60	3.2	8.28	0.64	17.35	90.34	0.18	4.65	5-10
SDKhB2	Moderately well	Sandy clay loam	39	Nil	<15	3.81	6.45	0.56	27.41	69.55	0.16	0.81	1-3
SDKhB2g1	Moderately well	Sandy clay loam	39	Nil	15-35	3.81	6.45	0.56	27.41	69.55	0.16	0.81	1-3
SDKiB2g1	Moderately well	Sandy Clay	46	Nil	15-35	3.85	6.68	0.72	19.92	87.4	0.14	2.61	1-3
SDKiC3g1	Moderately well	Sandy Clay	46	Nil	15-35	3.85	6.68	0.72	19.92	87.4	0.14	2.61	3-5
SGLmB1	Moderately well	Clay	180	Nil	<15	15.05	8.13	0.45	53.97	92.99	0.21	1.36	1-3
SGLmB1g1	Moderately well	Clay	180	Nil	15-35	15.05	8.13	0.45	53.97	92.99	0.21	1.36	1-3
SSKcD3g2	Moderately well	Sandy loam	30	Nil	35-60	1.25	5.49	0.47	6.18	69.69	0.28	2.56	5-10
SSKcE3g2	Moderately well	Sandy loam	30	Nil	35-60	1.25	5.49	0.47	6.18	69.69	0.28	2.56	10-15
SSKhC3g1	Moderately well	Sandy clay loam	30	Nil	15-35	1.25	5.49	0.47	6.18	69.69	0.28	2.56	3-5
UGKmB2	Moderately well	Clay	65	Nil	<15	3.05	7.13	0.64	29.03	58.28	0.24	1.81	1-3
YSJhB2g2	Moderately well	Sandy clay loam	30	Nil	35-60	0.45	5.55	0.64	14.54	40.22	0.12	1.86	1-3

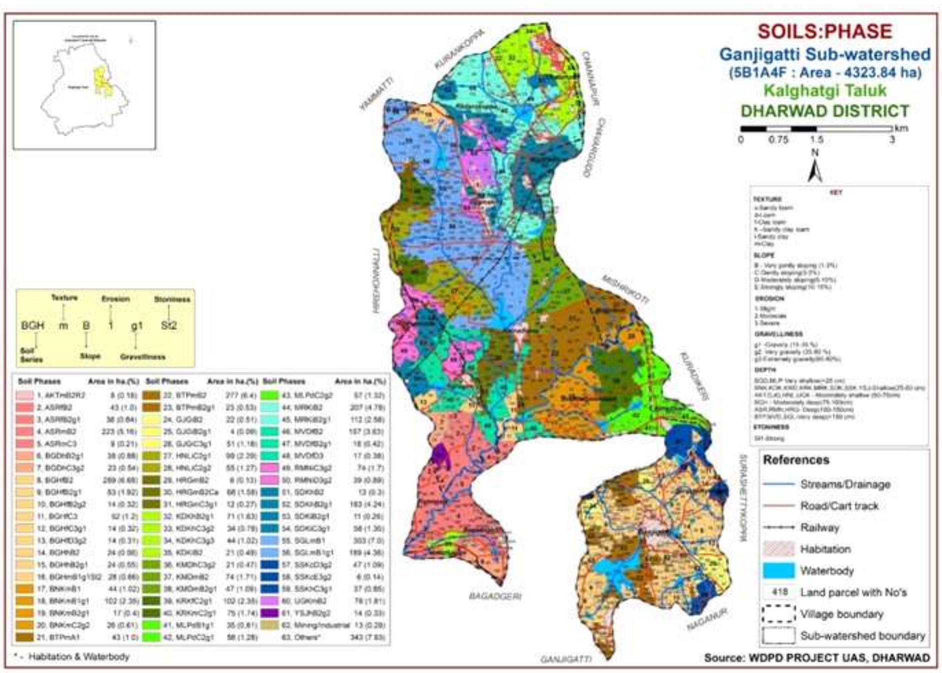

Fig. 2. Soil phases of series in Ganjigatti sub-watershed

watershed since they are manageable constraints. Hence, in this soil-site suitability evaluation, soil depth, extent of erosion, surface soil texture, stoniness, gravellines, $CaCO_3$ content and drainage account for more priority. Nasre et al. (2013), Naveen Kumar et al. (2018) and Yadav et al. (2023) also employed very similar parameters in the land evaluation of the respective study sites.

Slope is the basic element for analyzing and visualizing landform characteristics. The result of classified slope reveals that most of the area is gently sloping (3-5%) and very gently sloping (1-3%) in the sub-watershed (Fig. 3). Drainage is an important determining factor in plant growth. Moderate and well·drainage facilitate plant growth while poor and excess drainage inhibits plant growth. Because of this reason, drainage was also another important factor considered for evaluation of soil-site suitability in the sub-watershed. Most of the soils in the present study are well and moderately well drained. Soil depth plays a pivotal role in soil-site suitability evaluation and land use planning because it directly influences the land's suitability for various purposes, crop selection and the overall health of ecosystems. Understanding soil depth helps optimize land use while minimizing the risk of soil erosion and environmental degradation. Soil depth can be related with a number of associated factors such as low availability of soil, restricted rooting depth and inadequate nutrient uptake. The soil depth varies from very shallow (< 25 cm), shallow (25-50 cm), moderately shallow (50-75 cm), moderately deep (75-100 cm), deep (100-150 cm) and very deep (> 150 cm) (Fig. 4), accounting for 4.83, 31.6, 7.32, 14.5, 9.8 and 23.72%, respectively. Soil texture is the relative proportions of clay, silt and sand. The soil textures in the sub-watershed are sandy loam (1.23%), loam (3.41%), clay loam (19.38%), sandy clay loam (12.16%), sandy clay (17.4%) and clay (38.2%) (Fig. 5). The soil properties of the study area were compared with the soil suitability criteria for major horticultural crops grown in North Karnataka (Table 2).

Soil-site Suitability Evaluation

Chilli: Chilli requires a warm, humid climate during the early stages and dry weather towards maturity. It can be successfully grown up to 2000 m above MSL. The chilli crop requires an annual rainfall of 750–900 mm, a soil depth of more than 75 cm, sandy loam, silt loam, clay loam, loam texture, soils free of salinity and alkalinity, and well-drained soils. The most suitable temperature for germination and growth is 25 °C to 32 °C. The length of the growing period for optimum crop production is more than 150 days (Naidu et al., 2006). The suitability of soil phases in the Ganjigatti sub-watershed for growing chilli indicated that all the mapping units were moderately suitable to currently not suitable (N), having moderate, severe and very severe limitations of climate, soil drainage, soil physical properties and land forms. Areas of moderately (S2), marginally (S3) and currently not suitable (N) classes for chilli were 2181 (50.46%), 1571 (36.33%) and 215 ha (4.97%), respectively (Fig. 7). Based on the specific type of limitations present in the mapping units, the S2 class has been subdivided into the following sub-classes: S2c, S2cs, S2cw, S2cse, S2cwe, S2cws, and S2cwse. These sub-classes cover 4.63, 14.34 7.23, 0.21, 1.20, 18.79 and 4.06% of the total geographical area, respectively (Tables 1, 2). Based on the type of limitations, the soil site suitability class S3 (marginally suitable) was subdivided into subclasses S3e (0.38% of TGA), S3s (33.66%) and S3se (2.29%). The sub-classes Ns (BGDhB2g1, BGDhC3g2, MLPdB1g1, MLPdC2g1 and MLPdC2g2) and Ne (SSKcE3g2) are currently not suitable for chilli cultivation due to limitations in soil physical factors such as depth, gravellines and slope percent, respectively. Patil et al. (2008) observed similar findings in a sub-watershed of the northern dry zone of Karnataka.

Tomato: Tomato is a warm season crop and it requires an annual rainfall of 600–750 mm, a soil depth of more than 75 cm, sandy loam, silt loam, clay loam, loam texture, soils free of salinity and alkalinity and well-drained soils. The most suitable temperature for germination and growth is 25°C to 32°C. The length of the growing period for optimum crop production is more than 150 days (Naidu et al., 2006). The majority area of the sub-watershed was moderately (S2) and marginally (S3) suitable for tomato production, at 1294 (29.92%) and 2460 (56.88%), respectively, with moderate to severe limitations in terms of length of the growing period, soil drainage, soil texture, depth, gravelines, $CaCO_3$ content and sloppiness. Only a small, significant area of 215 ha (4.97%) is currently not suitable class (N) due to the very severe limitations of soil depth and sloppiness (Fig. 8). Due to moderate limitations related to climatic factors (c), soil drainage (w), soil physical factors (s) and slope percentage (e), S2 class has been subdivided into the following sub-classes: S2c (3.63%), S2cs (8.35%), S2cws (12.95%), and S2cwse (4.99%) (Tables 1, 2). For areas with severe limitations, the soil suitability class S3 has been divided into the sub-classes: S3e (1.47%), S3s (54.21%), and S3se (1.20%). Similar constraints for tomato cultivation in the Koppal district were identified by Patil et al. (2008).

Rose: Rose garden requires a soil depth of more than 100 cm, sandy loam, silt loam, clay loam, loam texture, soils free of salinity and alkalinity and well-drained soils. The most suitable temperature for rose cultivation is 25 °C to 30 °C (Naidu et al., 2006). The suitability of soil phases in the Ganjigatti sub-watershed for growing rose indicated that all

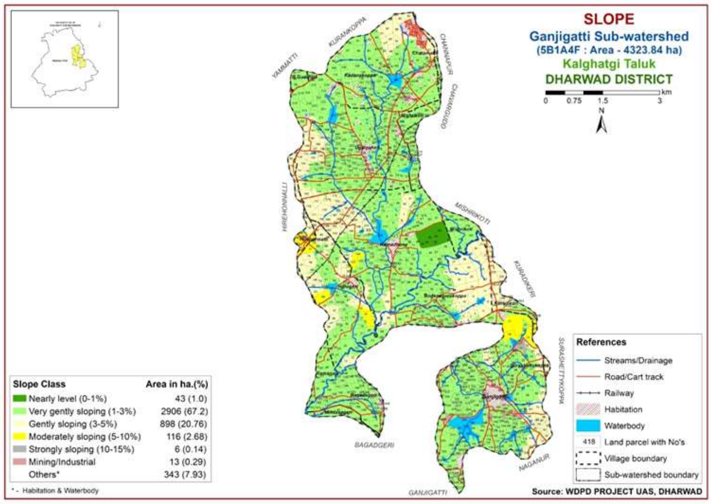

Fig. 3. Percent slope map of the Ganjigatti sub-watershed

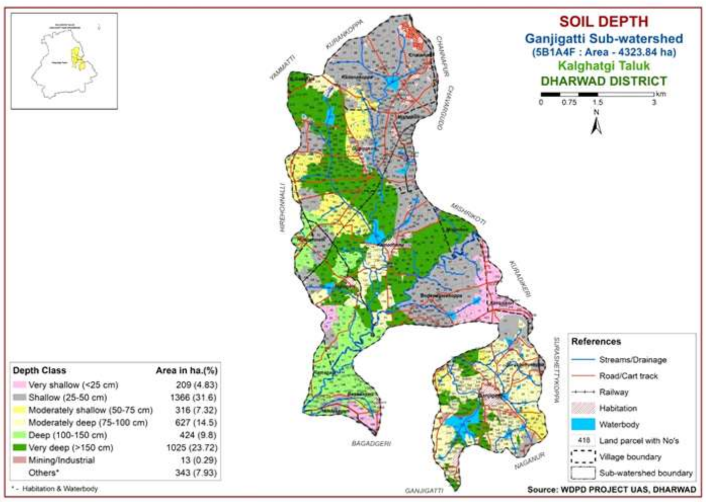

Fig. 4. Soil depth categories map of the Ganjigatti sub-watershed

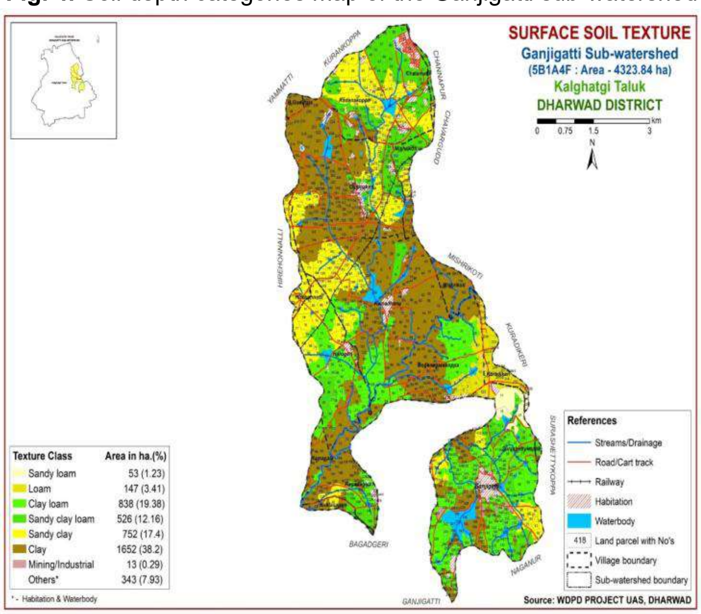

Fig. 5. Soil textural map of the Ganjigatti sub-watershed

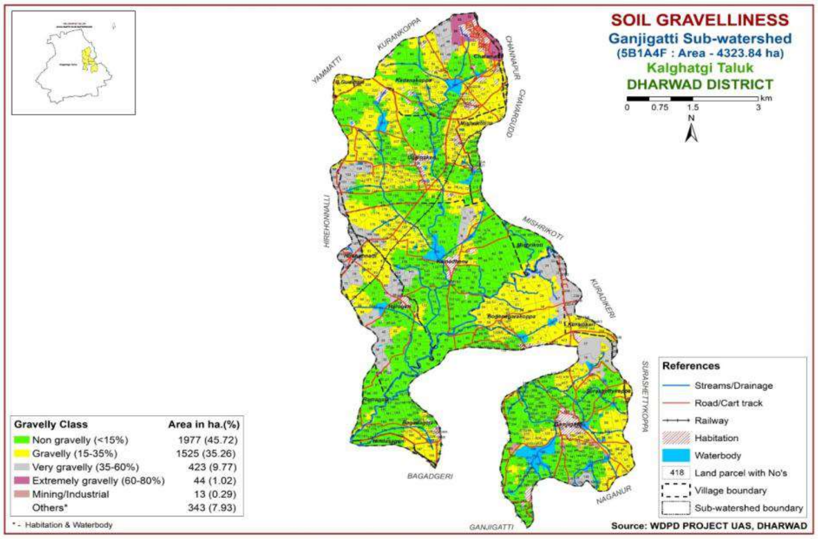

Fig. 6. Soil gravelliness map of Ganjigatti sub-watershed

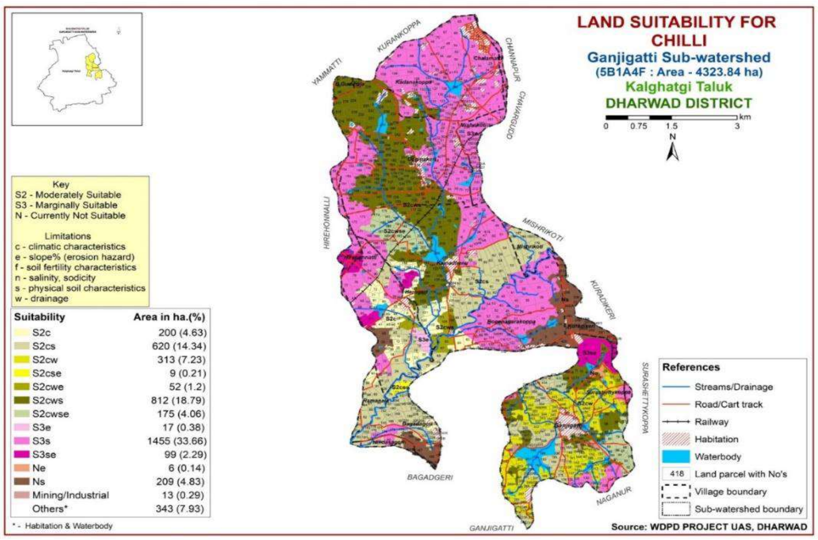

Fig. 7. Soil sitesuitability map for Chilli crop in Ganjigatti sub-watershed

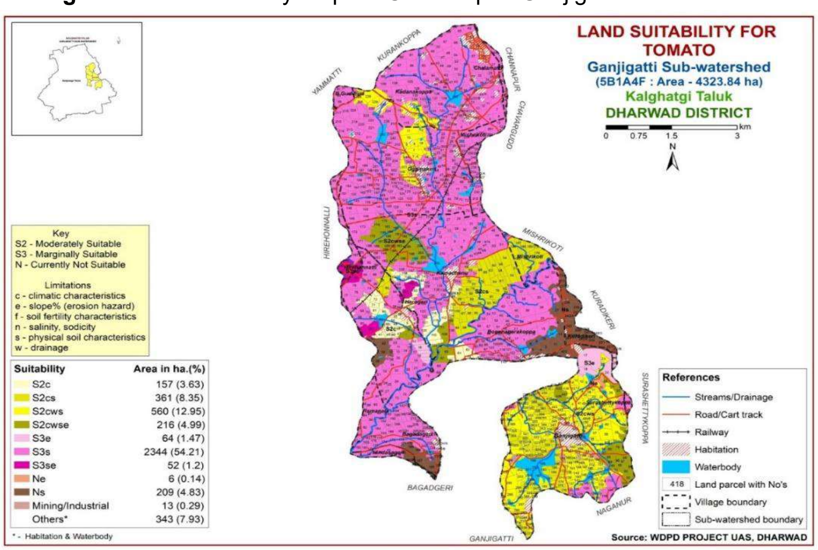

Fig. 8. Soil sitesuitability map for Tomato crop in Ganjigatti sub-watershed

Table 2. Soil-site suitability classification of mapping units for horticultural crops

Soil phases	Chilli	Tomato	Rose	Jasmine
AKTmB2R2	S2cws	S2cws	S2ws	S2cws
ASRfB2	S2c	S3s	S3s	S3s
ASRfB2g1	S2cs	S3s	S3s	S3s
ASRmB2	S2cs	S3s	S3s	S3s
ASRmC3	S2cse	S3s	S3s	S3s
BGDhB2g1	Ns	Ns	Ns	Ns
BGDhC3g2	Ns	Ns	Ns	Ns
BGHfB2	S2cw	S2cws	S2ws	S2cws
BGHfB2g1	S2cws	S2cws	S2ws	S2cws
BGHfB2g2	S3s	S3s	S3s	S3s
BGHfC3	S2cwe	S2cwse	S2ws	S2cws
BGHfC3g1	S2cwse	S2cwse	S2ws	S2cws
BGHfD3g2	S3se	S3se	S3s	S3s
BGHhB2	S2cw	S2cws	S2ws	S2cws
BGHhB2g1	S2cws	S2cws	S2ws	S2cws
BGHmB1g1St2	S2cws	S2cws	S2ws	S2cws
BNKmB1	S3s	S3s	Ns	S3s
BNKmB1g1	S3s	S3s	Ns	S3s
BNKmB2g1	S3s	S3s	Ns	S3s
BNKmC2g2	S3s	S3s	Ns	S3s
BTPmA1	S2cs	S2cs	S2s	S2cs
BTPmB2	S2cs	S2cs	S2s	S2cs
BTPmB2g1	S2cs	S2cs	S2s	S2cs
GJGiB2	S2cws	S2cws	S3s	S2cws
GJGiB2g1	S2cws	S2cws	S3s	S2cws
GJGiC3g1	S2cwse	S2cwse	S3s	S2cws
HNLiC2g1	S2cwse	S2cwse	S3s	S2cws
HNLiC2g2	S3s	S3s	S3s	S3s
HRGmB2	S2cws	S3s	S3s	S3s
HRGmB2Ca	S2cws	S3s	S3s	S3s
HRGmC3g1	S2cwse	S3s	S3s	S3s
KDKhB2g1	S3s	S3s	Ns	S3s
KDKhC3g2	S3s	S3s	Ns	S3s
KDKhC3g3	S3s	S3s	Ns	S3s
KDKiB2	S3s	S3s	Ns	S3s
KMDhC3g2	S3s	S3s	Ns	S3s
KMDmB2	S3s	S3s	Ns	S3s
KMDmB2g1	S3s	S3s	Ns	S3s
KRKfC2g1	S3s	S3s	Ns	S3s
KRKmC2g1	S3s	S3s	Ns	S3s
MLPdB1g1	Ns	Ns	Ns	Ns
MLPdC2g1	Ns	Ns	Ns	Ns

Cont...

Table 2. Soil-site suitability classification of mapping units for horticultural crops

Soil phases	Chilli	Tomato	Rose	Jasmine
MRKiB2	S3s	S3s	Ns	S3s
MRKiB2g1	S3s	S3s	Ns	S3s
MVDfB2	S2c	S2c	S1	S2c
MVDfB2g1	S2cs	S2cs	S2s	S2cs
MVDfD3	S3e	S3e	S2e	S2ce
RMNiC3g2	S3s	S3s	S3s	S3s
RMNiD3g2	S3se	S3se	S3s	S3s
SDKhB2	S3s	S3s	Ns	S3s
SDKhB2g1	S3s	S3s	Ns	S3s
SDKiB2g1	S3s	S3s	Ns	S3s
SDKiC3g1	S3s	S3s	Ns	S3s
SGLmB1	S2cws	S3s	S3s	S3s
SGLmB1g1	S2cws	S3s	S3s	S3s
SSKcD3g2	S3se	S3e	Ns	S3s
SSKcE3g2	Ne	Ne	Ns	S3se
SSKhC3g1	S3s	S3s	Ns	S3s
UGKmB2	S2cws	S2cws	S3s	S2cws
YSJhB2g2	S3s	S3s	Ns	S3s

the mapping units were highly suitable to currently not suitable (N), having none to slight, moderate, severe and very severe limitations of soil drainage, soil physical properties and limitations of land form characteristics. Areas of highly (S1), moderately (S2), marginally (S3) and currently not suitable (N) classes for rose were 157 (3.63%), 899 (20.79%), 1337 (30.92%) and 1575 ha (36.43%), respectively (Fig. 9). The soil suitability class S1 (MVDfB2) is highly suitable for rose cultivation, with either no limitations or only slight ones. Within the S2 class, sub-classes have been defined based on the types of limitations present: S2e (0.38%), S2s (8.35%) and S2ws (12.06%) (Tables 1, 2). The soil suitability class S3, which is marginally suitable for rose cultivation, has been subdivided into S3s sub-classes due to severe limitations in soil physical factors such as depth, $CaCO_3$ content, and gravel content (Tables 1 and 2). Areas classified under the sub-class Ns (36.43%) are currently unsuitable for rose cultivation due to significant limitations in soil physical factors such as depth, $CaCO_3$ content and gravel content. Similar findings of moderately to unsuitable conditions for rose cultivation were reported by Manjunatha et al. (2017) and D'Souza and Patil (2021).

Jasmine: Jasmine garden requires a soil depth of more than 75 cm, sandy loam, silt loam, clay loam, loam texture, soils free of salinity and alkalinity and well-drained soils. The most suitable temperature for jasmine cultivation is 18°C to 23°C

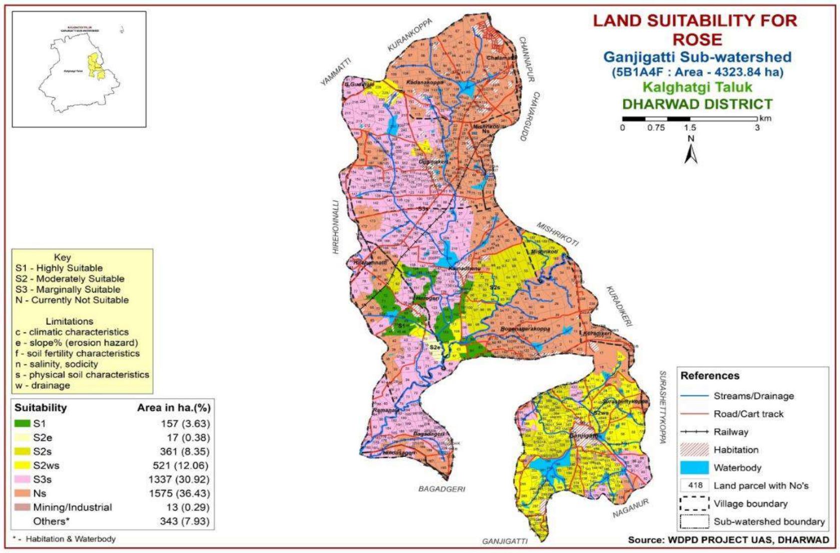

Fig. 9. Soil sitesuitability map for Rose garden in Ganjigatti sub-watershed

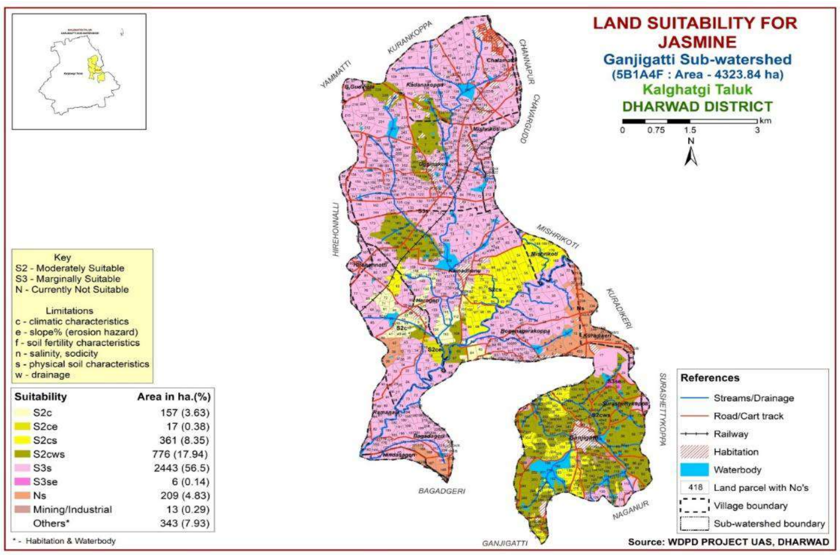

Fig. 10. Soil sitesuitability map for Jasmine garden in Ganjigatti sub-watershed

(Naidu et al., 2006). The suitability of soil phases in the Ganjigatti sub-watershed for growing jasmine indicated that all the mapping units were moderately suitable to currently not suitable (N), having moderate, severe and very severe limitations of climate, soil drainage, soil physical properties and land forms. Areas of moderately (S2), marginally (S3) and currently not suitable (N) classes for jasmine were 1311 (30.30%), 2449 (56.64%) and 209 ha (4.83%), respectively (Fig. 10). The S2 class was subdivided into S2c, S2ce, S2cs and S2cws based on the types of limitations and they covers an area of 3.63, 0.38, 8.35 and 17.94% of TGA, respectively (Table 1, 2). Based on the types of limitations, the soil site suitability class S3 was subdivided into S3s (56.50%) and S3se (0.14%). The mapping units, namely BGDhB2g1, BGDhC3g2, MLPdB1g1, MLPdC2g1 and MLPdC2g2, are included under sub-class Ns and are currently not suitable for jasmine cultivation due to limitations in depth.

CONCLUSION

The majority of soils in the Ganjigatti sub-watershed were found to be suitable for growing chilli, tomato, rose and jasmine, albeit to varying degrees. Most soil mapping units are moderately (S2) to marginally suitable (S3) for cultivation due to moderate to severe limitations related to climate, soil, drainage and slope. The soil series BGD and MLP are not suitable for any of the four crops due to very severe limitations in soil depth. The main limitations across all soil mapping units include shallow soil depth, slope, texture, $CaCO_3$ content and climatic factors. However, the severity of these limitations varies from slight to very severe. To identify specific soil resource constraints for sustainable crop production in the study area, the results of this research could serve as a foundational data set. Additionally, combining remote sensing and GIS techniques could be a valuable approach for modeling crop growth and supporting sustainable land use planning decisions in the research area.

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