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Soil suitability of some major crops for sustainable production in the North Eastern dry zone of Dabarbad sub-watershed of Kalaburagi district, Karnataka

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Abstract
A study was undertaken to evaluate six soil series belonging to Dabarbad sub-watershed of Kalaburagi taluka, Kalaburagi districtin North Eastern Dry Zone (Zone-2) of Karnataka for sustainable land use planning. Six soil series were tentatively identified and mapped into 27 mapping units using GIS technique. Weighted mean of each soil property was calculated and soil-site characteristics of different soil mapping units were matched. The results revealed that twenty seven mapping units were grouped into land capability class III and IV with limitations of erosion and physico-chemical properties Most of the area (36.10%) was marginally suitable (S3l) followed by moderately suitable (S2l) for agriculture crops (sorghum, redgram, blackgram, bengalgram and sugarcane) due to slight to moderate limitation of topography. Majority of the study area (71.01%) was currently not suitable (N1) for cultivation of horticulture crops (mango, sapota, guava and lime) due to severe limitations of rooting depth, texture and topography of soils. Suitable agronomic soil conservation practices are adopted to improve the soil productive constraints such as soil slope, erosion and soil depth.

Keywords: Soil series, mapping unit, soil-site characteristics and land capability classification

Introduction
The agriculture and fruit crops are important for ensuring nutritional security as well as livelihood security. Rapid decline in the land holding size due to fast population growth and urbanization results in the lowering of area under cultivation of crops, therefore for effective and efficient utilization of land resources for alternative land use options may developed, In this context land evaluation for site-specific crop suitability assessment is an important tool for identifying suitable areas for crop production. Site specific Land Resource Inventory (LRI) for farm level planning of watershed has gained importance in recent times because of improper utilization of natural resources and unscientific conservation measures that have led to the deterioration of watershedsin the country (Rajendra *et al*., 2015) [11].

The Land Capability Classification (LCC) system is a land evaluation ranking that group soils based on their potential for agricultural and other uses. There are defined classes ranging from I to VIII (London, 1991) [8]. Land suitability evaluation provides information on the constraints and opportunities for the use of the land to a particular crop. Therefore, it guides on optimal utilizations of resources, whose knowledge is an essential prerequisite for land use planning and development.This classification is useful as some soils can be suitable for specific crops and unsuitable for another's; therefore precision of land utilization types is necessary. The detailed land resources inventory (LRI) will help in addressing these issues site specifically. It also provides relevant information about land resources that are necessary for planning, development and for taking site specific management decisions for specific crop production (Sys *et al*., 1991) [17].

Remote sensing (RS) and GIS technologies have emerged as powerful tools for generating reliable spatial information on various natural resources. Application of RS technology for characterizing and mapping of soils are increasing rapidly due to great strides made in space-borne RS in terms of spatial, temporal and spectral resolutions. Use of GIS and GPS has added a new dimension to resources survey and information integration. By interfacing RS with GIS and GPS, different management scenarios can be processed allowing the resource manager to analyze various management alternatives and come out with the best and most suitable alternative (Rajendra *et al.*, 2018) [12].

Hence, the study was carried out with the objectives to collect site specific data base, to provide farm specific crop choices.

Material and Methods

Dabarabad sub-watershed is situated in Kalaburagi Taluk, Kalaburagi District of North Eastern Dry Zone (Zone-2) of Karnataka, India located between $17^0$20' – $17^0$22' N and $76^0$42' – $76^0$44' E, covering a total area of about 4213.32 ha (Fig.1). The average annual rainfall of this region is about 866 mm. Generally, the Length of Crop Growing Period (LGP) is 120-150 days and starts from 3rd week of June to 2nd week of October. Geologically the study area is characterized by granite and gneiss.

The detailed soil survey was carried out using IRS and quick bird satellite at the scale of 1:8,000 and toposheet of 1:50,000 from Survey of India (SOI). The pedons were exposed and studied for their morphological properties following the procedure outlined (Soil Survey Staff, 1999). The physico-chemical properties (horizon-wise) were estimated following standard procedures. Six soil series were tentatively identified in the study area and mapped into 27 mapping units as phases of soil series (Fig. 2). Weighted mean of each property was calculated and soil-site characteristics of different soil units were obtained. These weighted average data of soil-site characteristics have been used to evaluate the land capability classification and soil-site suitability (FAO, 1983). Land capability map and soil-site suitability maps were prepared using Arc view 3.2a GIS software.

Results

Soil site characteristics

Twenty seven soil mapping units identified in Dabarabad sub-watershed and these associations were mapped into six soil series (Fig. 2). Depth of the soils of Dabarabad sub-watershed ranging from very shallow (<25 cm) to very deep (> 150 cm), texture varied from clay to clay loam, slope varied from very gently (1-3%) to gently (3-5%) with moderate (e2) to severe (e3) erosion, all soils are moderately well drained soils (table 1).

Land capability classification

Soil site characteristics of soil units (Table 1) are matched with the criteria for land capability classification (Sehgal, 1996) [15]. The land capability classification of mapping units and their extent in Dabarabad sub-watershed is presented in (Fig.3). The 27 soil mapping units identified in the Dabarabad sub-watershed are grouped under two land capability classes (III and IV) based on soil characteristics, external land features and environmental factors and three land capability subclasses (IIIs, IIIes and IVes) based on dominant limitations within the given capability class. An area of about 1471 ha (34.91%) in the sub-watershed belongs to class IV which is marginally suitable (IVes) for agriculture with severe limitation of erosion, slope, texture, depth and soil limitations and an area of about 1578 ha (37.45%) belongs to class IIIes and an area of 779 ha (18.49%) belongs to class IIIs, which is moderately suitable for agriculture land due to limitations of erosion, texture and organic carbon content.

Soil-site suitability evaluation for crops

The optimum requirements of a crop are always region specific. Climate and soil-site parameters play significant role in maximizing the crop yields. The kind and degree of limitations were evaluated and soil properties from the study area (Table 1) were matched with soil site suitability criteria (Sehgal, 1996) [15].

Table 1: Soil-site characteristics of Dabarabad sub-watershed for land evaluation

Sl. No.	Soil Series	Dept (cm)	Colour	Texture	Slope (%)	Erosion	Drainage	Gravels (%)	Calcareousness
1	Bhimanahalli (BHI)	25-50	10YR 4/3, 4/2	gc, gcl	1-5	Moderate	Moderately Well Drained	15-35	-
2	Gutti (GTT)	50-75	10YR 3/2, 7.5YR 3/3	gc	1-3	Moderate	Moderately Well Drained	15-35	-
3	Kalamandaragi (KGI)	25-50	10YR 3/2, 4/2 7.5YR 3/4	gc	1-3	Moderate	Moderately Well Drained	15-35	-
4	Mahagaon (MAN)	>150	10YR 3/2	gc, gcl	1-3	Moderate	Moderately Well Drained	<15	-
5	Margutti (MGT)	0-25	10YR 3/3, 4/3 7.5YR 4/3	gc	1-5	Moderate to severe	Moderately Well Drained	15-35	-
6	Rajanala (RNL)	100-150	10YR 3/2, 4/2	c	1-5	Moderate	Moderately Well Drained	15-35	-

Note: gc-gravelly clay, gcl-gravelly clay loam, c- clay

Major annual Agriculture Crops

The suitability assessment for Sorghum (*sorghum bicolor*), redgram (*Cajanus cajan*), blackgram (*Vigna mungo*), bengalgram (*Cicer arietinum*) and sugarcane (*Saccharam officeanarum*) in Dabarabad subwatershed showed that an area of 836 ha (19.83%) was moderately suitable (S2l), an area of 1521 ha (36.10%) was marginally suitable (S3l) for cultivation due to slight to moderate limitations of topography and an area of 1471 ha (34.91%) was currently not suitable (N1rl) for production of Sorghum, redgram, blackgram, bengalgram and sugarcane with severe limitations of rooting depth condition and topography in Dabarabad sub-watershed.(Fig.4, 5, 6, 7 & 9). Cotton (*Hirusitum gossypium*) being a long duration crop with deep rooting system.

The suitability assessment for Cotton in Dabarabad sub-watershed showed that an area of 2357 ha (55.93%) was marginally suitable (S3l) due to limitations of topography of soil and remaining area of about 1471 ha (34.91%) was currently not suitable (N1rl) due to the severe limitations of rooting depth condition and topography in Sub-watershed (Fig. 8).

Major Perennial Horticulture Crops

Mango (*Mangifera indica*) popularly known as king of fruits is well adapted to tropical and subtropical climate. The suitability assessment of mango (*Mangifera indica*), Sapota (*Manilkara zapota*), Guava (*Psidium guajava*) and lime (*Citrus aurantifolia*) in the study area showed that an area of 836 ha (19.83%) was moderately suitable (S2t) due to slight limitation of texture, as the majority of the Dabarabad sub-watershed has a clay loam texture and an area of about 1521 ha (36.10%) was currently not suitable (N1rt) with severe limitations of rooting condition and texture, where an area of 1471 ha (34.91%) was currently not suitable (N1rl) with severe limitations of rooting depth condition and topography.(Fig. 10, 11,12 & 13).

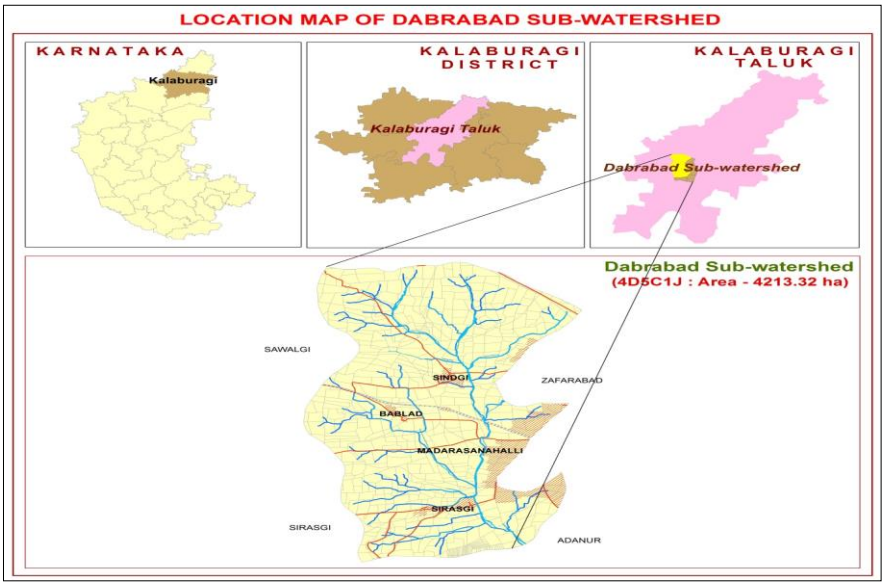

Fig 1: Location of the Dabarabad sub-watershed

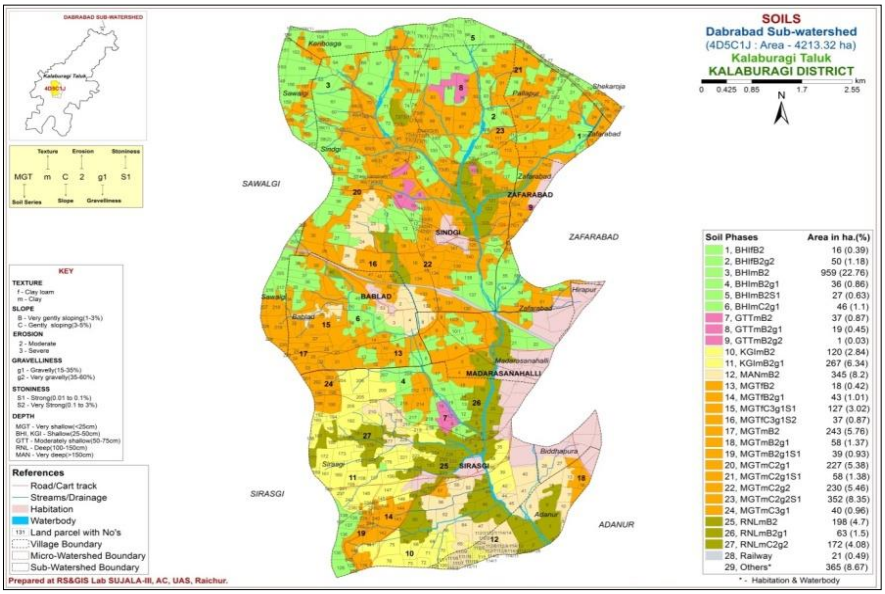

Fig 2: Soil phase map of Dabarabad Sub-watershed

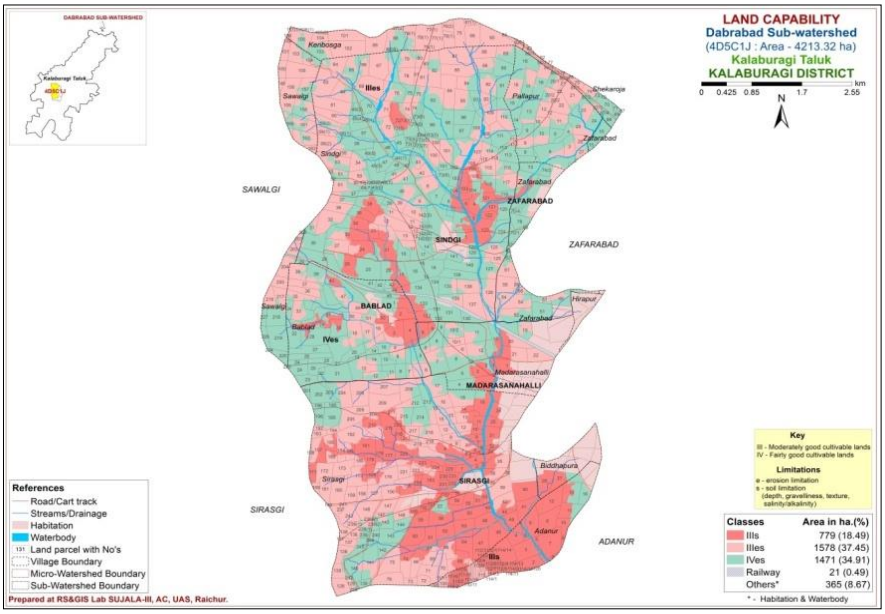

Fig 3: Land Capability Classification in Dabarabad sub-watershed

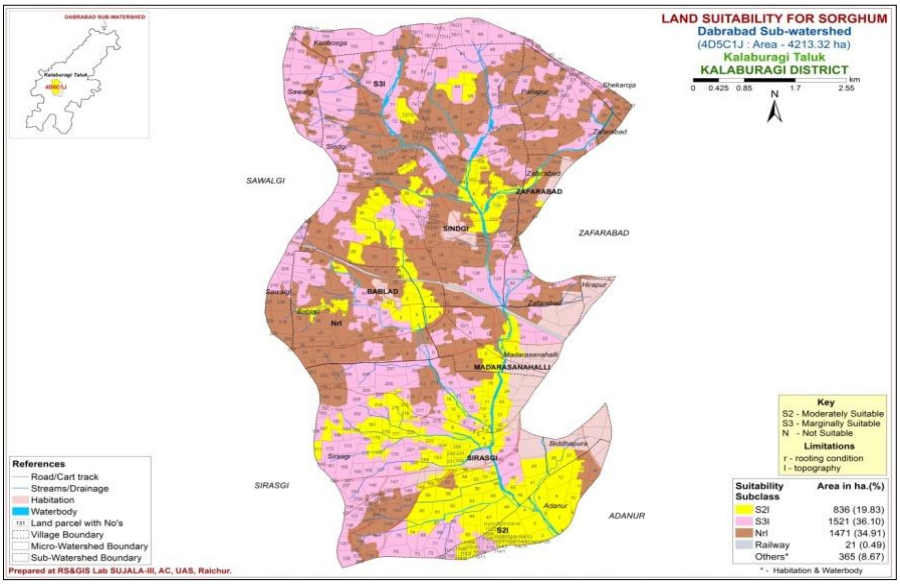

Fig 4: Crop suitability of sorghum in Dabarabad sub-watershed

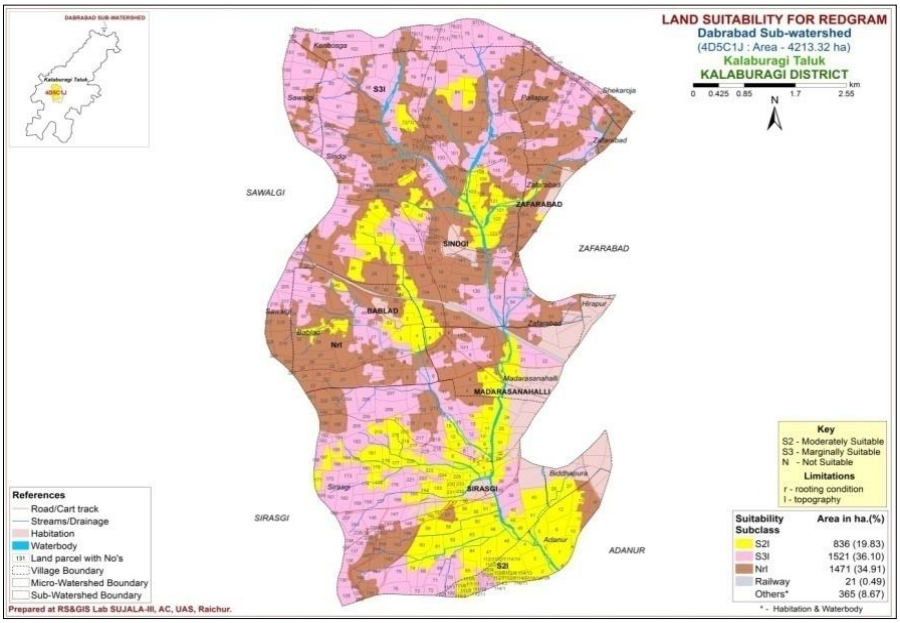

Fig 5: Crop suitability of redgram in Dabarabad sub-watershed

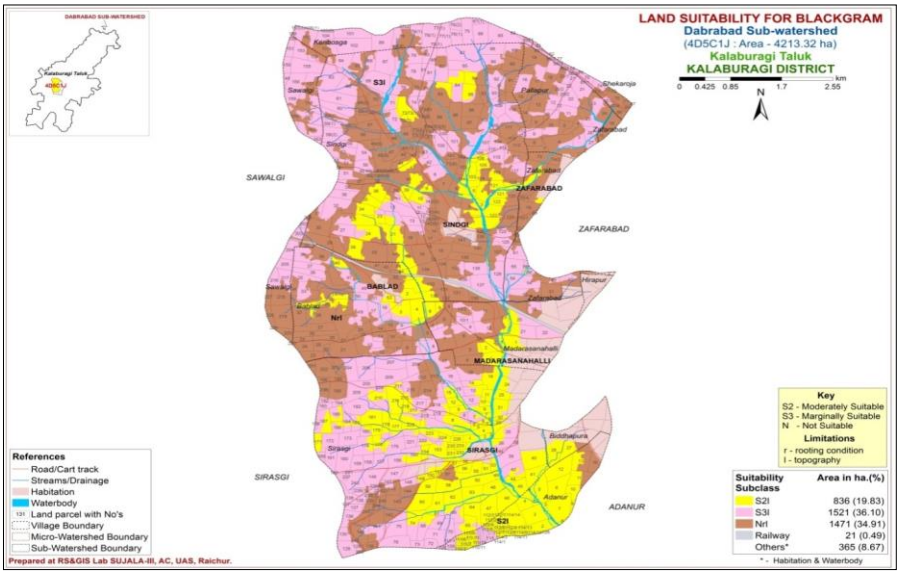

Fig 6: Crop suitability of blackgram in Dabarabad sub-watershed

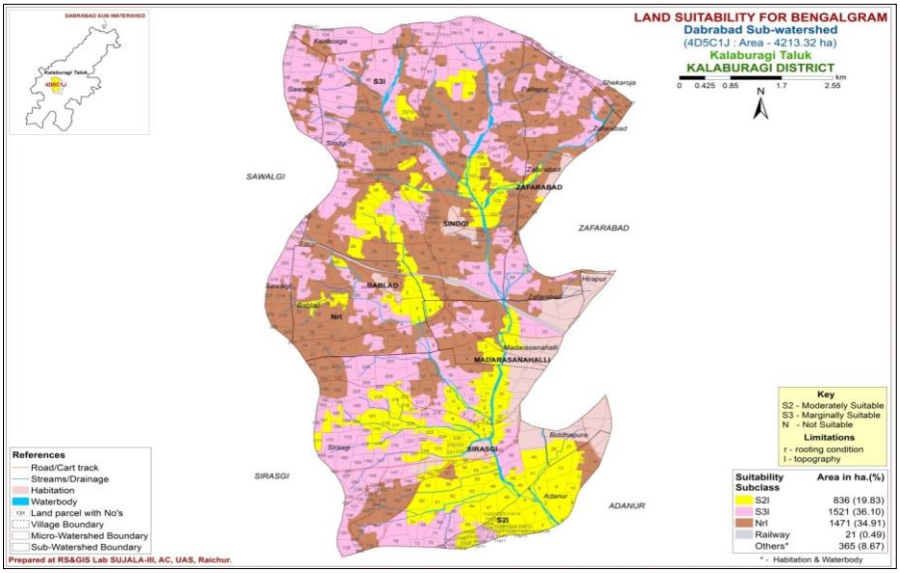

Fig 7: Crop suitability of bengalgram in Dabarabad sub-watershed

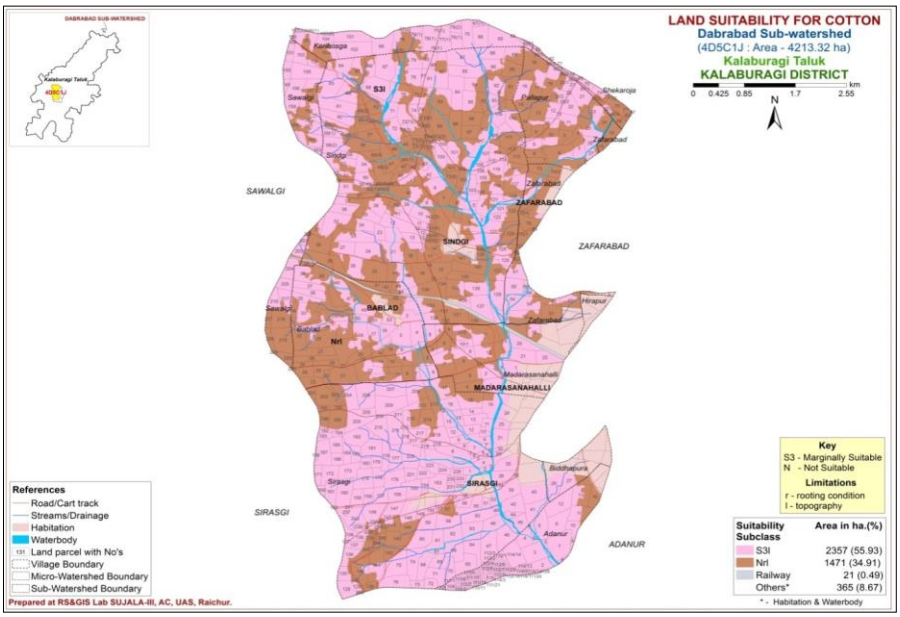

Fig 8: Crop suitability of cotton in Dabarabad sub-watershed

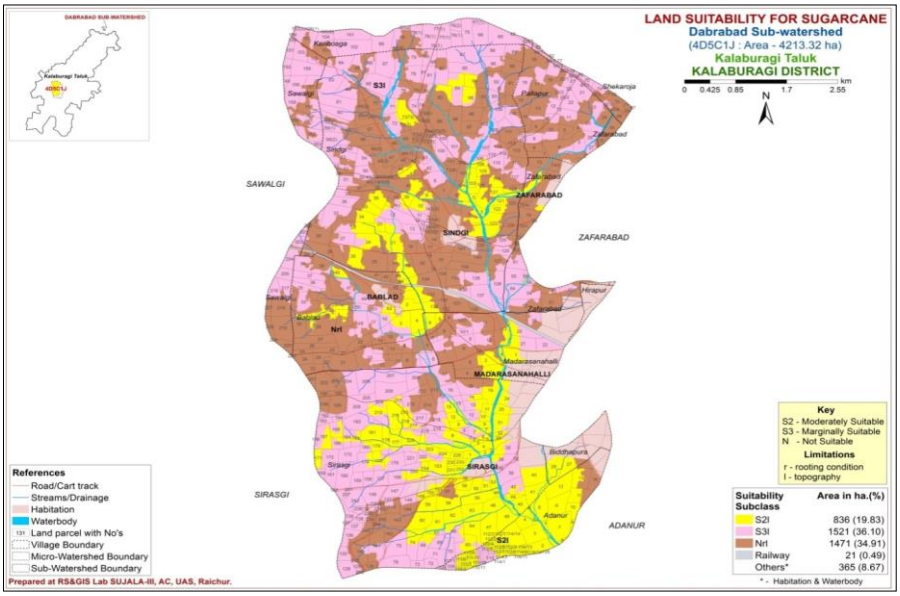

Fig 9: Crop suitability of sugarcane in Dabarabad sub-watershed

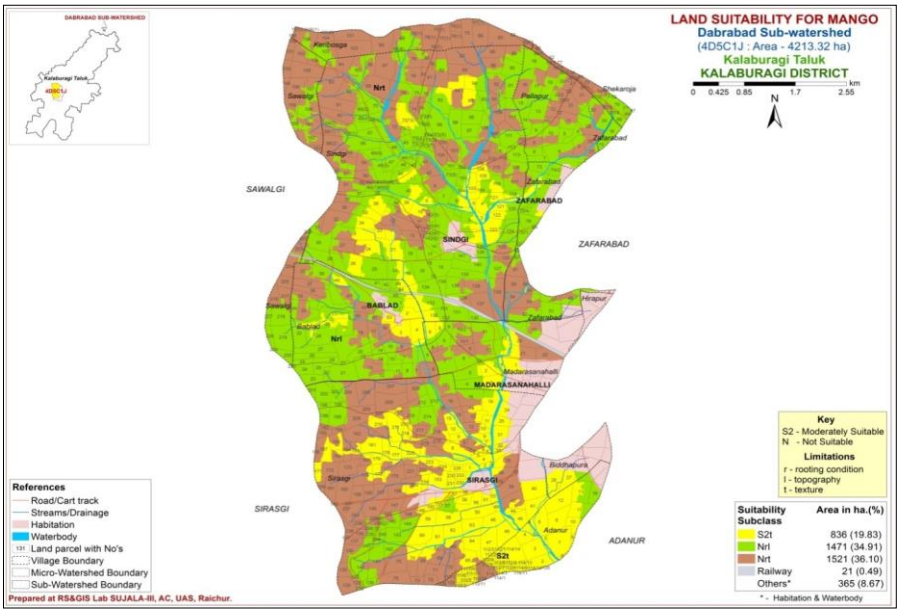

Fig 10: Crop suitability of mango in Dabarabad sub-watershed

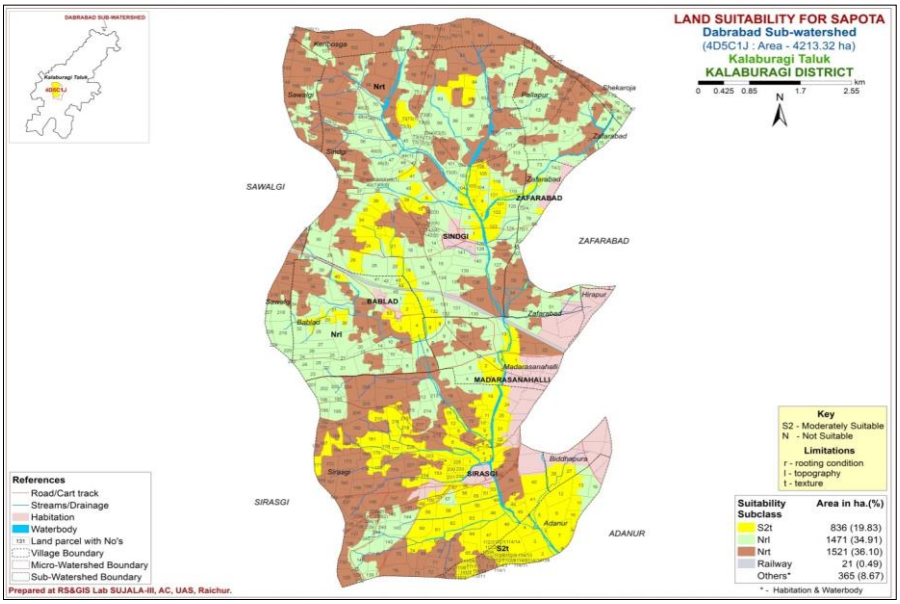

Fig 11: Crop suitability of sapota in Dabarabad sub-watershed

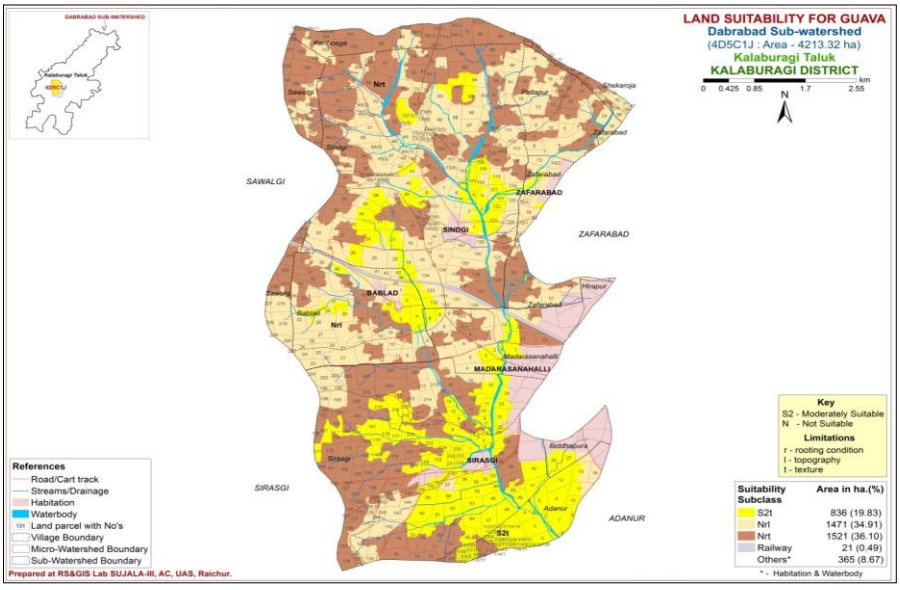

Fig 12: Crop suitability of guava in Dabarabad sub-watershed

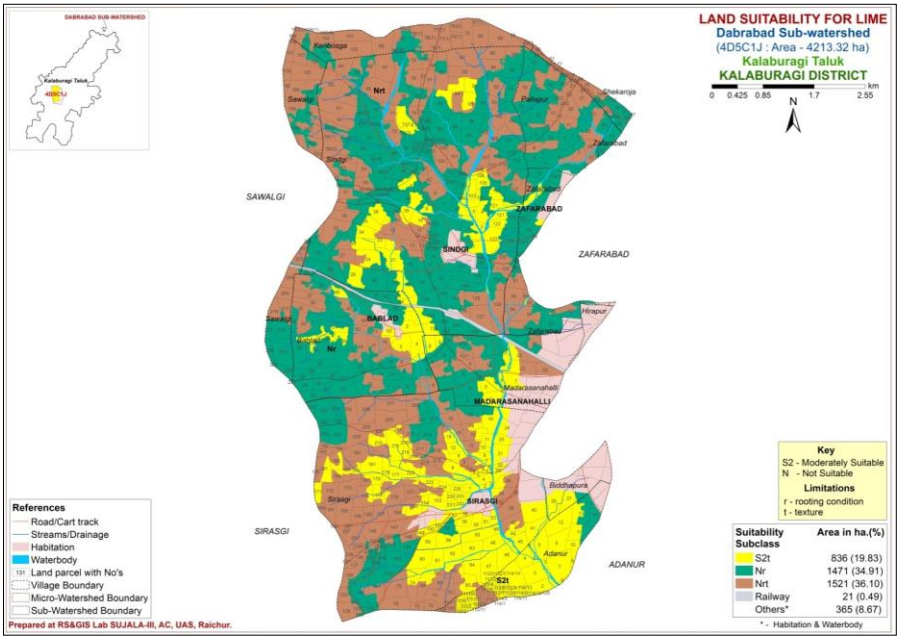

Fig 13: Crop suitability of lime in Dabarabad sub-watershed

Discussions

Land capability classification

Based on soil-site characteristics, the soils of Dabarabad sub-watershed of Kalaburagi district have been classified into two land capability classes *viz*., III and IV (Fig.3). Major area of about 37.45% belongs to class IIIes which indicates the moderately suitable for cultivation with slight limitation of erosion, slope, texture, depth and soil limitations and an area of 34.91% belong to class IVes which is marginally suitable for cultivation with severe limitation of erosion, slope, texture, depth and soil limitations. Rejuvenation of these lands by means of converting the Class IV to Class III and Class III to Class II can be achieved by adopting proper soil and water conservation measures such as trench cum bunding, graded bunding, contour bunding, staggered trenching, Bunding through surface scraping. Rajendra *et al.*, (2021) [10] also published similar results.

Soil-site suitability evaluation for crops

Sorghum is a medium to long duration crop, redgram is a long duration crop. Blackgram and bengalgram, both are medium to long duration crops. Sugarcane is a long duration crop. The suitability assessment for sorghum, redgram, blackgram, bengalgram and sugarcane in Dabarabad subwatershed revealed that major area comes under marginal suitable (S3) class fallowed by currently not suitable (N1) class for cultivation of sorghum and redgram due to major area covers gently sloping lands and also very shallow depth of soil (0-25 cm).Similar works on soil-site suitability carried out in 48A distributary of Malaprabha right bank command by Ravikumar *et al.* (2009) [14] and Geetha *et al.* (2017) [7] in Giddadapalya Micro-watershed.

Cotton being a long duration crop with deep rooting system shows significant yield decline in shallow soils with low moisture storage. Higher yields could however be obtained in deeper soils. It tolerates fairly wide range of soil pH conditions *i.e.*, acidity and alkalinity (Munro, 1987) [9]. The field studies show that cotton is successfully grown in deep soils with good drainage (Bhaskar *et al.*, 1987) [6]. The suitability assessment for Cotton in Dabarabad sub-watershed showed that an area of 55.93 per cent was marginally suitable (S3l) due to limitations of soil slope and remaining area of about 34.91 per cent was currently not suitable (N1rl) due to the presence of very shallow (0-25 cm) to shallow (25-50 cm) soils in majority of the area and also topography of the soil. Similar works was conducted by Vidyavathi *et al.* (2017).

Mango (*Mangifera indica*) popularly known as king of fruits is well adapted to tropical and subtropical climate. It can be grown on wide range of soils i.e., from alluvial to laterite, having slightly acidic soils reaction (pH 5.5 to 7.0) and can be grown upto pH 8.7 under proper nutrient management. It requires deep and well drained soil condition for its optimum growth and yield. The crop is sensitive to saline/sodic conditions, water logging and free high $CaCO_3$ content and high pH in sub-surface soil layers. The area receiving frequent rainfall and high relative humidity during flowering period was not ideal for good fruit setting. Most favourable temperature is 25 ^{0}C. The suitability assessment of mango in study area showed that major area is currently not suitable for mango cultivation because the very shallow and shallow soils present in large extent which inhibit the root penetration activity of mango, also clay loam texture which not permits the mango cultivation and severe limitations of slope of soil. Similar works was conducted by Rajendra *et al.* (2021) [10] and Balappa and Hugar (2002) [3].

Sapota (*Manilkara zapota)* is a tropical crop. It needs warm (10-38^0 C) and humid climate (70% relative humidity) for growth and can be cultivated throughout the year. Guava (*Psidium guajava*) is considered as one of the nutritious fruits in India as it is rich in calcium, phosphorus and vitamin C. It is grown as tropical fruit. The crop is tolerant to high temperature and drought conditions. It can withstand as high as 46^{o}C temperature during summers but very susceptible to severe frost. Optimum temperature for its growth and development is between 23 ^{o}C to 28 ^{o}C. It can grow even under shallow as well as poorly drained soils. It can tolerate high salinity (ECe upto 8-9 d Sm^{-1}) and can be grown on a pH range from 4.5 to 8.2 (Ashok *et al.*, 2021). The results revealed that an area of 19.83 per cent was moderately suitable (S2t) due to presence of clay loam texture and an area of about 71.01 per cent was currently not suitable (N1) with severe limitations of soil depth as these crops require deep to

very deep soils for cultivation, texture and topography. Similar works was conducted by Baloda *et al.* (2014) [5] and Balappa and Hugar (2003) [4].

Lime (*Citrus aurantifolia*) grows well in tropical and subtropical climates and can withstand occasional light frosts. It requires an average temperature between 16-20 ºC for its optimum growth. It can be grown on almost all types of soil having good soil aeration besides sufficiently permitting the root penetration upto the desired depth. Deep, loamy, well-drained soils with pH range 5.5 to 7.5 are best suited for its cultivation. Saline/alkaline soils having lime nodules are not suitable lime cultivation. The suitability assessment of lime in study area showed that major area is currently not suitable for lime cultivation because major area covers clay loam texture which not permits the lime cultivation and severe limitations of slope of soil and depth of soil.

Conclusion

The study aims to evaluate site-specific soil characters which affect suitability of major annual agriculture and perennial horticulture crops in the study area. Six soil series were identified and mapped into 27 mapping unit in the study area. Land capability classification was carried out for the study area based on the inherent soil characteristics, external land features and environmental factors. Two LCC were found (III and IV) in the land capability map, different sub classes were identified *viz.*, IIIs, IIIes and IVes. Site specific suitable conservation measures such as Trench cum bunds, contour bunds, graded bunding and staggered trenching are adopted to improve the soil productive constraints such as soil slope from gently (3-5%) to very gently (1-3%), erosion from severe (e3) to moderate (e2) and soil depth can be improved by agronomic soil conservation practices in the soils of Dabarabad sub-watershed. The soils from the study area were matched with the soil suitability criteria for a few important agriculture and horticulture crops. An area of 1521 ha (36.10%) of the area was marginally suitable (S3l) for agriculture crops except cotton due to moderate limitation of topography. An area of 2992 ha (71.01%) of the study area was currently not suitable (N1) for cultivation of horticulture crops due to severe limitations of rooting depth, texture and topography of soils. Soil suitability maps provides farm specific crop choices, to evolve location specific soil and water conservation measures and to provide datasets and inputs needed for planning, implementing and monitoring of all land based developmental programmes to develop tools, packages and thematic outputs.

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