



Land Suitability Evaluation for Rubber in the Tropical Humid Region of Kerala, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author MC designed the study, performed the statistical analysis, wrote the protocol and wrote the manuscript. Author RS helped to prepare soil characterization and author KSAK helped to classification of soils. Author KS prepared the map in GIS environment. Authors RH and SKS sanctioned the project and fund. Author HRN managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To assess the suitability of the rubber in Elamdesam block, Idukki district, Kerala.

Place and Duration of Study: Soil survey done and soil samples were brought from Elamdesam block, Idukki district, Kerala, India in the year 2016 and laboratory characterization and suitability assessment was done during 2017 in *National Bureau of Soil Survey and Land Use Planning, Regional Centre, Hebbal, Bangalore*

Methodology: Soil suitability of rubber in Elamdesam block has been worked out in two steps. In the first step suitability criteria for rubber crop have been evolved with the help of existing literature with special reference to a tropical humid region of India. Emphasis was placed on land characteristics or land qualities which determine the limitations. Together, these diagnostic features (limitations) determine soil suitability when matched with crop or ecological requirements. In the

second step, the defined suitabilities are shown on soil maps according to the map legend (soil composition) to prepare a relative suitability map for rubber in Elamdesam block.

Results: Results revealed that rubber is moderately suitable in the area constituted 23.4 per cent of the total with the limitation of root restriction, soil fertility, topography and soil texture. Marginally suitable in 20.75 per cent of the total geographical area with the limitation of topography, root restriction and soil fertility and 20.23 per cent of the total area is unsuitable with the limitation of depth to water table and root restriction in the Elamdesam block.

Conclusion: More than 60 per cent of the total geographical area is under rubber cultivation in Elamdesam block, Idukki district, Kerala apart from soils are having the limitation of root restriction, soil fertility, topography, depth to water table and soil texture.

Keywords: Land suitability; evaluation; rubber; tropical humid region; Kerala.

1. INTRODUCTION

Soil survey data and the soil maps have been widely used for interpretative purposes by defining relative suitability or limitations of various soil types for different land use. Land suitability evaluation is the process of determining the potential of the land for alternative uses and forms a pre-requisite for land use planning [1]. It integrates soil characteristics with climate and land use. The optimal requirement of a crop is always region specific, and soil site characteristics determine the degree of suitability for land use and help in planning expansion of area under a particular crop [2]. In Asia, especially in the Southeast Asian region, countries like Thailand, Malaysia and Indonesia have dominated global rubber cultivation over the last five decades. Thailand has been the world's leading rubber producing country since 1995, with an annual increase of 4 to 7 percent per year [3]. To meet the economic demands of the growing world population, an increased economic return is required. Both population increases and the process of urbanisation have increased the pressure on agricultural resources [4]. Rubber is, therefore, one of the most important cash crops and also has socio-economic importance owing to its productive value, the income from exports, and the job opportunities in this sector [5]. The potential of land suitability for agricultural use is determined by evaluating the process of climate parameter, soil, water resources and topographical, as well as the environmental components under the criteria given and the understanding of the local biophysical restraint [6].

Efforts have earlier been made to evaluate soil-site criteria for rubber in the traditional tracts in India [7]. Characterization of soils is fundamental objectives of all soil studies, as it is an important tool for the soil classification, which is based on

soil properties like organic carbon, pH, electrical conductivity, calcium carbonate equivalent, percent gravels, exchangeable cations, percent base saturation, exchangeable sodium percentage, cation exchange capacity, percent sand, silt and clay [8]. Delineation of suitable areas and identification of soil and climatic constraints for better management [9] were attempted through the present study so that the information can serve as a base material for implementing the developmental programmes.

2. MATERIALS AND METHODS

2.1 Details of the Study Area

Elamdesam block falls under the agro-ecological zone foothills and high hills, the agro-ecological units 12 and 14 i.e. southern and central foothills and southern high hills, respectively. These units are subdivided into forests, denudational hills, lateritic terrain and lateritic valley lying between north latitudes 9°46'38.2" and 10°2'18.14" and east longitudes 76°42'59.49" and 76°53'46.99". There are seven panchayats namely Vannapuram, Kodikulam, Karimannor, Udumbannoor, Alakode, Velliyamattom and Kudayathoor in the Elamdesam block and eight villages covering a total geographical area of 40,307 ha. Villages are further divided into a number of wards for the purpose of administration. Geology of the area is charnockite and granite gneiss of the Archaean age. Elevation ranges from 30 m in low land to 850 m in high hills. Climate is tropical humid monsoon type. Rainfall ranges from 3462 mm to 3602 mm and means annual temperature varies between 22°C to 27°C. Length of dry period is two to two and a half months. High hills are covered by mixed forest whereas foothills and midlands have a plantation of rubber, coconut, pepper, banana, pineapple, arecanut, cocoa, nutmeg, cashew. Low land is occupied by paddy and tapioca, banana, coconut arecanut and

rubber were also cultivated in raised beds. Laterites and Ultisols are the major soil type which, are well drained, shallow to very deep, strongly acidic in nature. A location map is given in Figure 1. In Elamdesam block agriculture is the fundamental livelihood activity among the people. Major land uses are rubber plantations, mixed forest plantations and paddy cultivation.

2.2 Soil Suitability Evaluation

Soil suitability of rubber in Elamdesam block has been worked out in two steps. In the first step

suitability criteria for rubber crop (Table 1) have been evolved with the help of existing literature with special reference to a tropical humid region of India. Emphasis was placed on land characteristics or land qualities [10,11] which determine the limitations. Together, these diagnostic features (limitations) determine soil suitability when matched with crop or ecological requirements. In the second step, the defined suitabilities are shown on soil maps according to the map legend (soil composition) to prepare a relative suitability map for rubber in Elamdesam block [11].

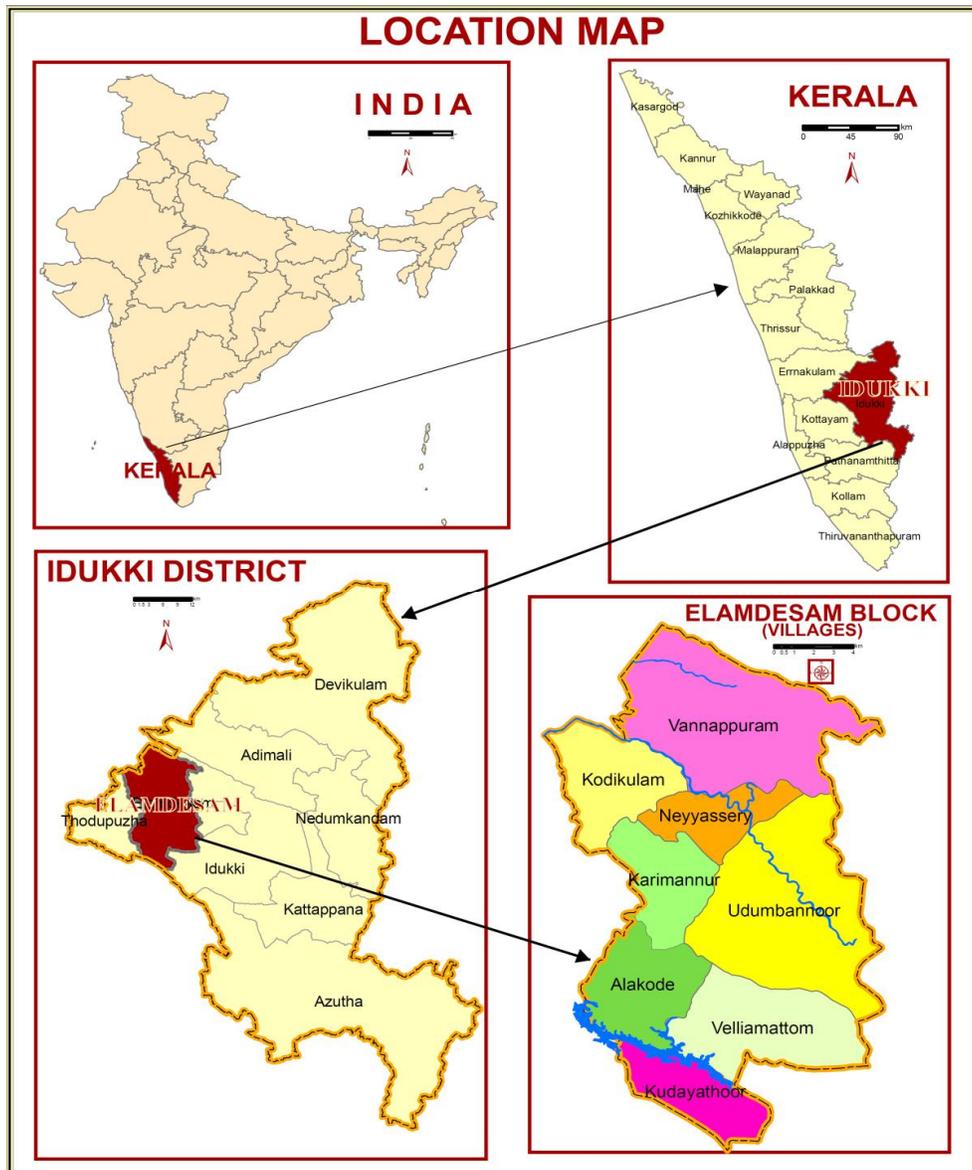


Fig. 1. Location map of the study area (Elamdesam block)

Table 1. Soil-site suitability criteria for rubber

Soil site characteristics		Unit	Rating			
			Highly suitable S1	Moderately suitable S2	Marginally suitable S3	Not suitable N
Climatic regime	Mean temperature in growing season	°C	25-30	24-20 31-32	20-18 33-34	<18 >34
	Mean max. temperature in growing season	°C	29-34	28-24 35-36	23-22 37-38	<22 >38
	Mean min. temperature in growing season	°C	>18	18-16	15-10	<10
	Total rainfall	mm	1750	1750-1500	1500-1250	<1250 >6000
	Dry months (Months with less than 50 mm rainfall)	Months	<3	3-5	5-7	>7
	Months with more than 500 mm rainfall)	Months	<3	3-4	4-5	>5
Land quality	Land characteristics					
Oxygen availability to roots	Soil drainage	Class	Well-drained	Moderately well drained, somewhat excessively drained	Imperfectly drained	Poorly drained, excessively drained
	Depth of water table	m	>3	2-3	1-2	<1
Nutrient availability	Texture	Class	scl, l	sil, sil (non-swelling)	c (swelling), sc	s
	pH	1:2.5	4.5-5.5	5.6-6.5 3.5-4.4	6.6-7.3 <3.5	>7.3
	CEC	cmol (p+) kg ⁻¹	>4	2-4	<2	
	BS	%	<30	35-50	50-80	>80
Rooting conditions	Effective soil depth	cm	>100	75-100	50-75	<50
	Presence of gravel in sub soil (loamy soils)	%	<35	35-60	>60	
	Presence of gravel in sub soil (clayey soils)	%	<60	60-80	>80	
Erosion hazard	Slope	%	10-15	15-30, <10	30-50,	>50

3. RESULTS AND DISCUSSION

In Kerala rubber is grown in about 4.78 lakh hectares, and production is 6.55 lakh tons with an average productivity of 1369 kg per ha. It is the most important commercial perennial plantation cum latex yielding a crop of the state. Areas receiving good rains throughout the year (1750-2000 mm) and high relative humidity (>80%) and preferably with a dry period of less than 3 months and temperature ranges from 25 to 30°C are favourable, preferably with warm and sunny days (>6 hrs sunshine per day). An annual rainfall of 2000 mm has been observed to be the lower limit of rainfall for the optimum growth of rubber [12,13]. However, rubber can grow without limitation up to 4500 mm of rainfall. Soil moisture stress influences the yield components viz. initial flow rate, plugging index and the dry rubber content besides the direct effect on turgor pressure and water deficit triggering a series of biochemical changes in latex. Rubber gets affected by extreme temperatures. The soil depth determines both the available space for root growth and proliferation and the amount of soil moisture storage [14]. It has been observed that for different plantation crops, including rubber, the growth is seriously affected due to a shallow depth.

Rubber is grown at elevations of less than 600 m and ideally below 200 m on 10-15 per cent slopes on a wide variety of soil types, ranging from heavy clay to sandy soils, however deep to very deep, well drained and medium textured soils are most suitable. The valley lands, however, are unsuitable for rubber due to water stagnation. Steep slopes with slope per cent greater than 30-50 act as a severe limitation for rubber without conservation measures. Soil pH from 4.5 to 5.5 is ideal and it thrives well under an acid environment in the soil. The optimum pH for rubber is reported to be in the range of 4 to 6.5 and it can tolerate up to the pH of 3.8 at the low [15] and 7.0 at the higher side [14]. Rubber is grown in soils with a wide range of CEC. While CEC of 2 to 16 cmol(+) kg⁻¹ is reported in Malaysia, it ranges from 3.5 to 18 cmol(+)kg⁻¹ in soils under rubber in India [16]. In Tripura, the rubber growing soils have a CEC range of 3-13 cmol(+)kg⁻¹ [16]. The crop is sensitive to poor drainage and waterlogging, presence of free iron and aluminium, low pH in the subsoil, extreme gravelly and stony soils, sodicity and salinity.

Soil suitability for rubber in Elamdesam block is given in table 2 and map 1. Moderately suitable

area constituted 23.4 per cent of total area with the limitation of root restriction, soil fertility, topography and soil texture. The marginally suitable area is present in 20.75 per cent of the entire geographical area with the limitation of topography, root restriction and soil fertility and 20.23 per cent of the total area is unsuitable with the limitation of depth to water table and root restriction. Most of the areas which are moderately suitable for rubber fall in the undulating plains and uplands without forests. The area of moderately suitable (S2) lands for rubber is 91,000 ha which forms about 8.3 per cent of the total geographical area of the Tripura state. It may be mentioned that most of the horticultural crops have soil-site requirements similar to rubber and these crops, therefore, may compete for the expansion of the rubber growing areas [17].

Land use suitability for rubber using parameters such as the availability of water, oxygen, and nutrients in northeast Thailand was discussed and concluded 5.28 percent land was highly suitable and 16.70 percent land was moderately suitable with the remainder being less suitable or unsuitable for the cultivation of rubber [18]. The land use suitability for rubber in the Chi watershed, central northeastern Thailand using multicriteria decision making (MCDM) and GIS, based on a nutrient index, soil drainage, texture, depth, and salinity was evaluated [19]. The study concluded that 3.01 percent of the land was highly suitable and 22 percent land was moderately suitable with the remainder being less suitable or unsuitable for the cultivation of rubber. Nurmegawati [20] reported that Rubber plant land suitability class people of North Bengkulu are quite appropriate (S2) with a temperature limiting factors, availability of water, availability of oxygen, rooting media and nutrient retention. Land suitability classes of rubber plants that suit the farmers' in Seluma was marginal (S3) by a factor limiting nutrient retention. The actual land suitability class rubber plant people of South Bengkulu is appropriate marginal (S3) by a factor limiting of nutrient retention.

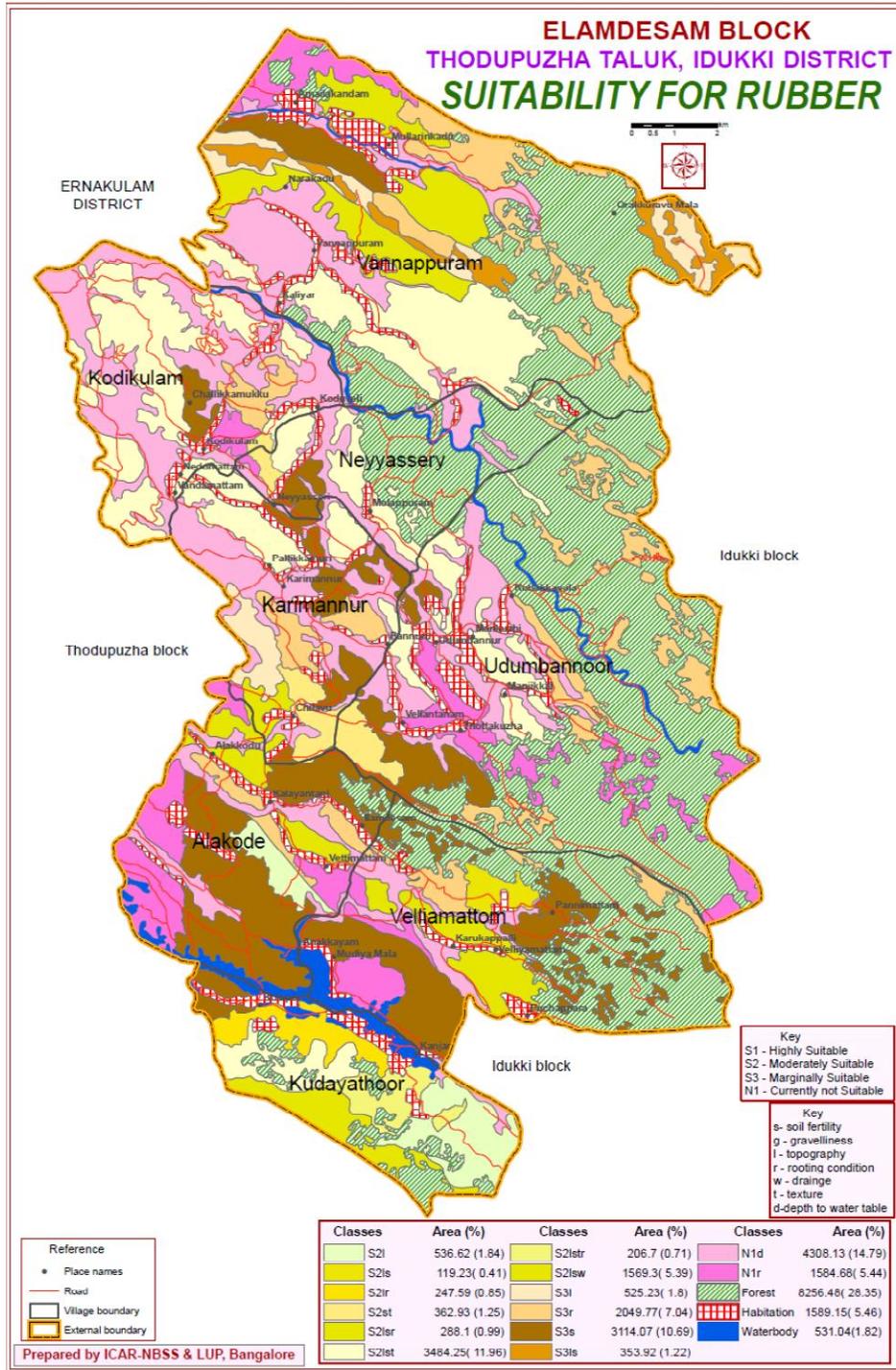
Kerala is one of the important states contributing to the production of plantation crops and spices in the country. Soil and Land evaluation in various land utilisation types has been carried out to assess the land suitability for tea, cardamom and rubber in Wayanad district of Kerala. The natural habitat of rubber (*Heavea brasiliensis*) is rainforests of the Amazon basin,

situated within 5° North and South at altitudes below 200 m. The climate of this region is an equatorial monsoon type characterised by mean monthly temperature by 25 to 28°C, well-distributed rainfall and no marked dry weather. Though it is originated in the Amazon basin, it is now predominantly grown in the tropics where an equatorial monsoon type climate prevails. Kerala accounts for 81 % of the area under rubber in the Country. The results of the study revealed that

only one suitability class, i.e. marginally suitable (S3) with an area of 69158 ha area (32.48%) reported for the rubber cultivation whereas 74,526 ha area (34.99%) comes under not suitable (N) due to constraints like relief, topography, soil physicochemical attributes such as base saturation, pH and soil moisture regime etc. [8]. Chandrasekhar [21] and Vijayakumar [13] reported similar findings.

Table 2. Soil suitability for rubber in Elamdesam block

Mapping unit no.	Suitability classes	Description	Area ha	Area %
1	S2l	Moderately suitable land with slight limitation of topography	536.62	1.84
2	S2ls	Moderately suitable land with slight limitation of topography and soil fertility	119.23	0.41
3	S2lr	Moderately suitable land with slight limitation of topography and root restriction	247.59	0.85
4	S2st	Moderately suitable land with slight limitation of soil fertility and soil texture	362.93	1.25
5	S2lsr	Moderately suitable land with slight limitation of topography, soil fertility and root restriction	288.1	0.99
6	S2lst	Moderately suitable land with slight limitation of topography, soil fertility and soil texture	3484.25	11.96
7	S2lstr	Moderately suitable land with slight limitation of topography, soil fertility, soil texture and root restriction	206.7	0.71
8	S2lsw	Moderately suitable land with slight limitation of topography, soil fertility and drainage	1569.3	5.39
9	S3l	Marginally suitable land with slight limitation of topography	525.23	1.80
10	S3r	Marginally suitable land with slight limitation of root restriction	2049.77	7.04
11	S3s	Marginally suitable land with slight limitation of soil fertility	3114.07	10.69
12	S3ls	Marginally suitable land with slight limitation of topography and soil fertility	353.92	1.22
13	N1d	Currently not suitable land with limitation of depth to water table	4308.13	14.79
14	N1r	Currently not suitable land with limitation of root restriction	1584.68	5.44
15	Forest		8256.48	28.35
16	Habitation		1589.15	5.46
17	Waterbody		531.04	1.82
Total			29127.16	100.00



Map 1. Soil suitability for rubber in the tropical humid region

4. CONCLUSION

It may be concluded that more than 60 per cent of the total geographical area is under rubber

cultivation in Elamdesam block, Idukki district, Kerala apart from soils are having the limitation of root restriction, soil fertility, topography, depth to water table and soil texture.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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