Land suitability evaluation for rubber in the tropical humid region of Kerala, India

Abstract

Land suitability assessment is a specific type of land evaluation method to assess the resources of an area for a specific crop rather than for a general use. Using the soil site suitability criteria, land resources of the Elamdesam block, Idukki district, Kerala was assessed for their suitability for the rubber. 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 total area is unsuitable with the limitation of depth to water table and root restriction in the Elamdesam block.

Keywords: Land suitability, evaluation, rubber, tropical humid region, Kerala

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 (Sehgal, 1995). 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 (Shashi Yadav *et al*., 2005). In Asia, especially in the Southeast Asian region, countries like Thailand, Malaysia and Indonesia have dominated global rubber cultivation over the last five decades (Somboonsuke, 2001). Thailand has been the world's leading rubber producing country since 1995, with an annual increase of 4 to7 percent per year (Somboonsuke, 2001). 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 (Hedges et al., 2015). 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 (Jawjit *et al.*, 2010). 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 (Ahmed et al., 2017).

Efforts have earlier been made to evaluate soil-site criteria for rubber in the traditional tracts in India (Chandran *et al.*, 1992 and Kharche *et al.*, 1995). 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 (Gahlod et al., 2017). Delineation of suitable areas and identification of soil and climatic constraints for better management (Naidu *et al*., 2009) were attempted through the present study so that the information can serve as a base material for implementing the developmental programmes.

Materials and methods

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 9^0 46' 38.2" and 10^0 2' 18.14" and east longitudes 76^0 42' 59.49" and 76^0 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 Archaen 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 ^{o}C to 27 ^{o}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 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 cultivating in raised beds. Laterites and Ultisols are the major soil type which, are well drained, shallow to very deep, strongly acidic in nature. 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.

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 (Sys, 1985 and Naidu *et al.,* 2006) 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 (Naidu *et al.,* 2006).

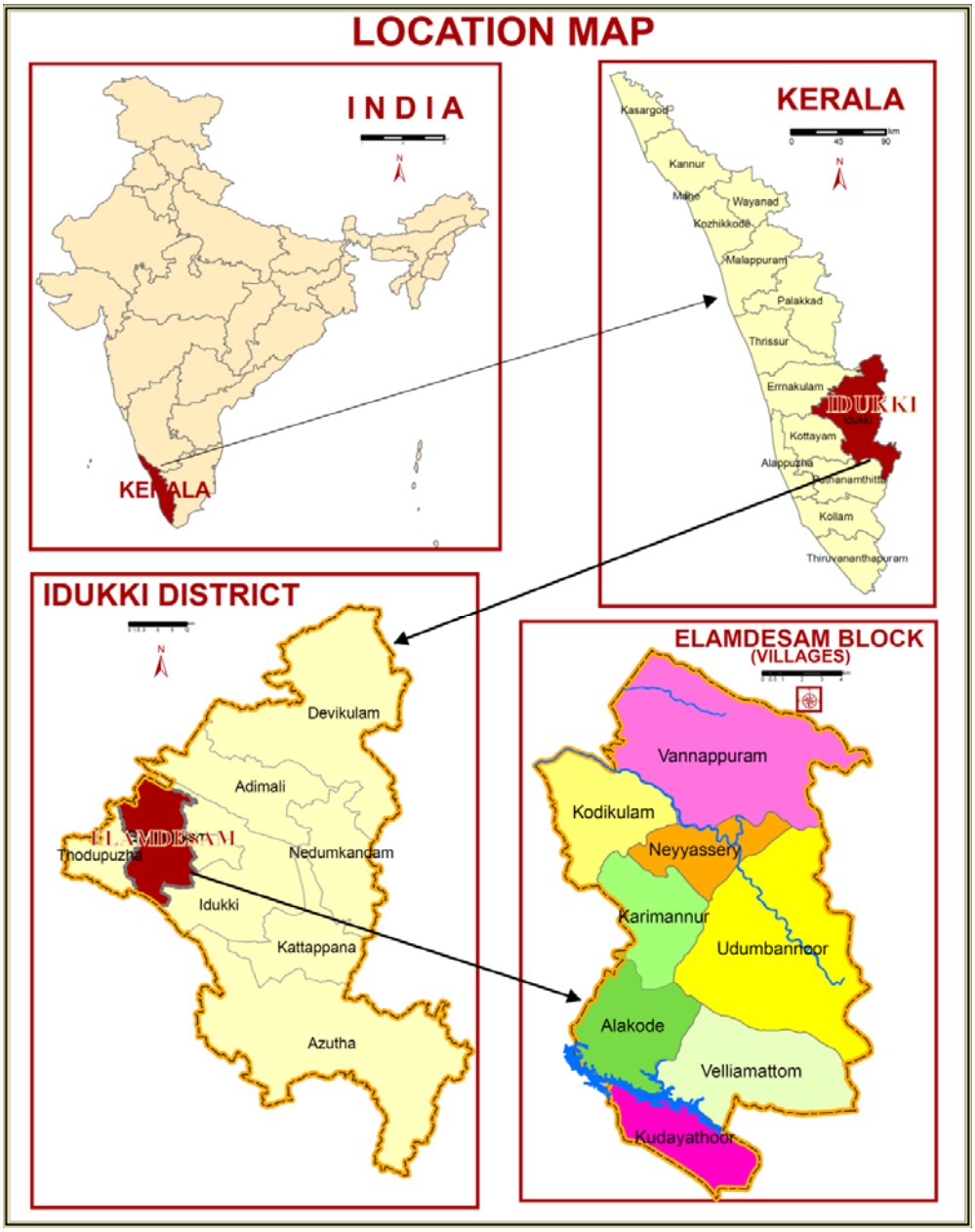


Fig. 1: Location map of the study area (Elamdesam block)

Table 1. Soil-site suitability criteria for rubber

Soil site characteristics			Rating			
		Unit	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, some what 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	sicl, 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

Result and discussion

In Kerala rubber is grown in about 4.78 lakh hectares, and production is 6.55 lakh tons with average productivity of 1369 kg per ha. It is the most important commercial perennial plantation cum latex yielding 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 ^{o}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 (Sanjeeva Rao and Vijayakumar, 1992). 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 (Krishnakumar and Potty, 1992). 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 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 (Krishna Kumar and Potty, 1989) and 7.0 at the higher side (Krishna Kumar and Potty 1992). Rubber is grown in soils with a wide range of CEC. While CEC of2 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 (Krishna Kumar and Potty, 1992). In Tripura, the rubber growing soils have a CEC range of 3-13 cmol(+)kg^{-1} (Bhattacharyya *et al*., 1998). The crop is sensitive to poor drainage and water logging, 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 (Bhattacharyya *et al.*, 1996).

Mongkolsawat and Putklang (2010) discussed land use suitability for rubber using parameters such as the availability of water, oxygen, and nutrients in northeast Thailand 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. Mongkolsawat and Paiboonsak (2009) evaluated 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. They 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 *et al*. (2015) 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 physico-chemical attributes such as base saturation, pH and soil moisture regime etc (Gahlod

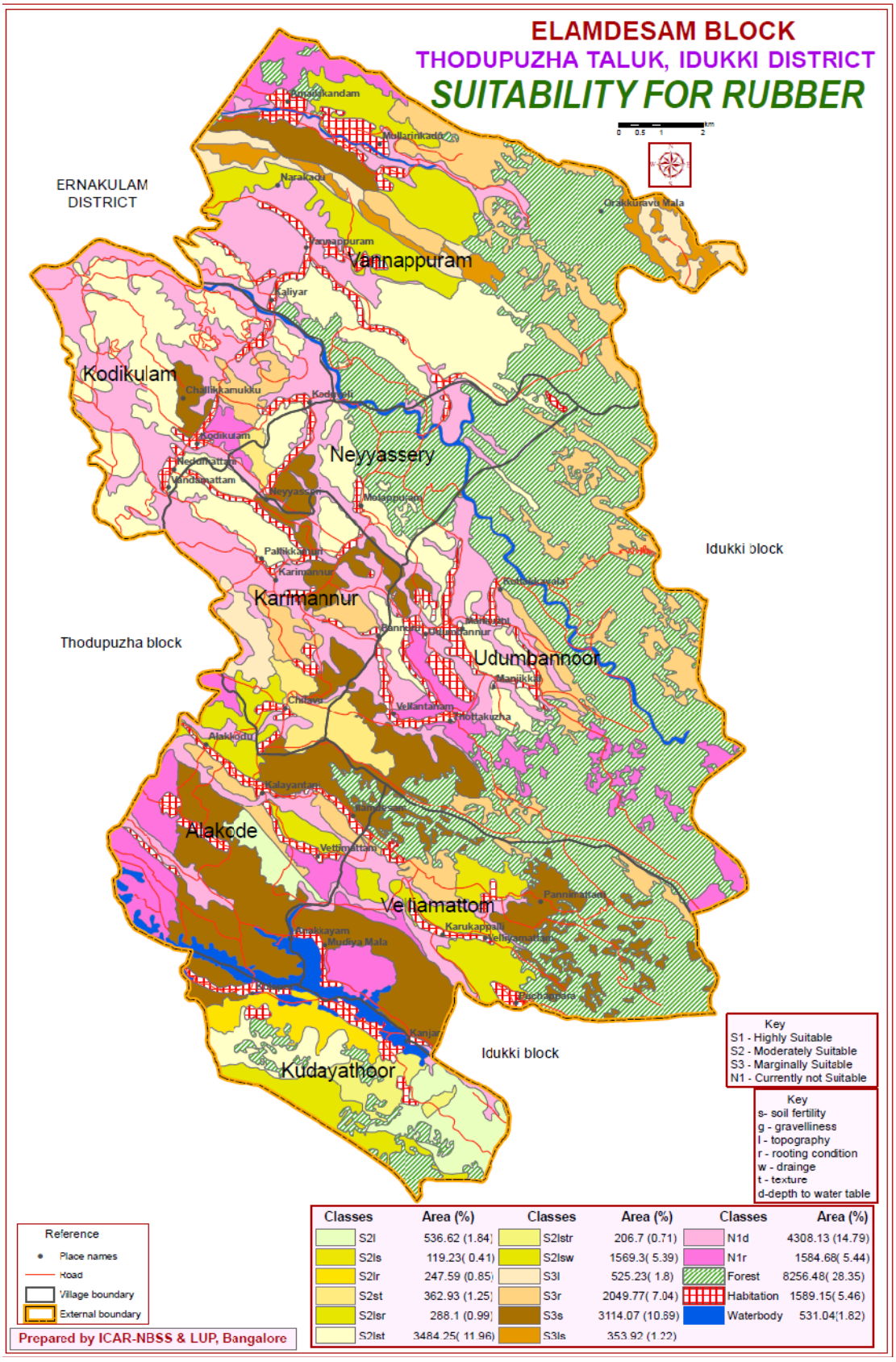
et al., 2017). Similar findings reported by Chandrasekhar *et al*., (1990) and Vijayakumar *et al*. (1998).

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

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.



Map 1: Soil suitability for rubber in tropical humid region

ETHICAL ISUE : NA

CONSENT : NA

References

Ahmed, G. B., Shariff, A. R. M., Idrees, M. O., Balasundram, S. K., & bin Abdullah, A. F. (2017). GIS-Based Land Suitability Mapping for Rubber Cultivation in Seremban, Malaysia. *International Journal of Applied Engineering Research*, *12*(20), 9420-9433.

Bhattacharyya. T., Sehgal, J. and Sarkar, D. (1996). Soils of Tripura for optimising land use: their kinds, distribution and suitability tor major field crops and rubber. National Bureau of Soil Survey and Land Use Planning, Publication No. 65, Nagpur, India.

Bhattacharyya, T., Sarkar, D., Oangopadhyay, S.K., Dubey, P.N., Baruah, U., Chamuah, O.S., Mukhopadhyay, S., Nayak, D.C., Maji, A.K., Saxena, R.K., Barthwal, A.K .. Krjshna, N.D.R., Mandai, C., Sehgal, .J., Bhowmick, K.R., Sinha, K., Chakrabarty, R., Nandi majumdar, S., Pal, P.K., Krishna Kumar, A.K., and Sethuraj, M.R. (1998). Soils ofTripura. I - their characteristics and classification. *Agropedology,* 8, 47-54.

Chandrasekhar, T. R., Jana, M. K., Thomas, J., Vijayakumar, K. R. and Sethuraj, M. R. (1990). Seasonal changes in physiological characteristics and yield in newly opened trees of Hevea Brasiliensis. In North Konkan. *Indian Journal of Natural Rubber Research.* 3(2): 88-89.

Gahlod, N. S., Sonam Binjola, Ravi and V. S. Arya, 2017, Land-site suitability evaluation for tea, cardamom and rubber using Geo-spatial technology in Wayanad district, Kerala. *Journal of Applied and Natural Science*, 9 (3): 1440 – 1447. J

Hedges, L., Lam, W. Y., Campos-Arceiz, A., Rayan, D. M., Laurance, W. F., Latham, C. J., ... & Clements, G. R. (2015). Melanistic leopards reveal their spots: Infrared camera traps provide a population density estimate of leopards in malaysia. *The Journal of Wildlife Management*, *79*(5), 846-853.

Jawjit, W., Kroeze, C., & Jawjit, S. (2010). Greenhouse gas emissions from rubber industry in Thailand. Journal of Cleaner Production, 18(15), 403-411. https://doi.org/10.1016/j.jclepro.2009.12.003.

Kharche. V. K., Sehgal. J. and Challa. O., (1995). Evaluation of soil-site conditions for suitability of Rubber. *Agropedology*. **5**, 69-78.

Krishna Kumar. A.K. and Potty. S.N. (1989). A new fertilizer recomendation for NE Region. Rubber Ed. Bull. 24. 5-8.

Krishna Kumar. A. K. and Potty. S. N. (1992). Nutrition of *Hevea*. In "Natural Rubber: biology, cultivation and technology." (Eds. M.R. Sethuraj and N.M. Mathew) pp. (Crop Science 23. Elsevier).

Mongkolsawat, C., & Paiboonsak, S. (2009). GIS-based land evaluation for combining economic crops as a model for agricultural land use planning. Retrieved from https://www.researchgate.net/publication/24216 2621.

Mongkolsawat, C., & Putklang,W. (2010). An approach for estimating area of rubber plantation: Integrating satellite and physical data over the Northeast Thailand. Proceeding of 31st Asian Conference on Remote Sensing 2010, ACRS 2010 (Vol. 2, pp. 1228e1234). Hanoi, Vietnam: Asian Association on Remote Sensing (AARS).

Naidu, L.G.K., Ramamurthy, V., Challa, O., Rajendra Hegde, and Krishnan, P. (2006). *Manual Soil Site Criteria for Major Crops* NBSS Publication No. 129, NBSS&LUP, Nagpur, 118 p.

Naidu, L.G.K., Srinivas, S., Subbi Reddy, G., Ramesh Kumar, S. C. and Reddy, R. S., (2009). Identification and delineation of suitable areas for mango, banana, citrus and cashew crops in Andhra Pradesh. *Agropedology, **19** (1): 30-40.*

Nurmegawati, Afrizon, and Dedi Sugandi, Land Suitability Evaluation For Rubber (*Havea Brasiliensis*) Plants in Bengkulu, International Seminar on Promoting Local Resources for Food and Health, 12-13 October, 2015, Bengkulu, Indonesia.

Sanjeeva Rao. R. and Vijay Kumar (1992). Climate requirements In "Natural Rubber: biology. cultivation and technology." (Eds. M.R. Sethuraj and N.M. Mathew) (Crop Science 23. Elsevier).

Shashi s. Yadav, Swami, B.N., Shyampura, R. L. and Giri, J. D., (2005). Soil-site suitability evaluation of hot arid westerm plain soils of Rajasthan. *Agropedology*, **15** (l): 76-79

Sehgal, J. (1995). Land resource appraisal for land use planning to meet the challenges of 21st century. *Journal of the Indian Society of Soil Science.* **43,** 504-528.

Somboonsuke, B. (2001). Recent evolution of rubber-based farming systems in Southern Thailand. Kasetsart Journal: Social Science, 23(1), 61-74. Retrieved from https://kasetsartjournal.ku.ac.th/kuj_files/2008/A080408113516.pdf.

Sys. C., (1985). Land evaluation (part III). ITC, State Univ. Ghent. Belgium (Unpublished).

Vijayakumar, K. R., Dey, S. K., Chandrasekhar, T. R., Devakumar, A. S., Mohanakrishna, T., Rao, P. S and Sethuraj, M. R. (1998). Irrigation requirement of rubber trees (Hevea Brasiliensis) in the subhumid tropics. *Agricultural Water Management*. 35: 245-259.

Vilas Chandran. T., Usha. K., Motilal. V. S. and Sharma. M. R. (1992). A computer model for assessing agro-climatic and edaphic feasibility for rubber cultivation in the traditional Tract. *Indian Journal of Natural Rubber Research.* **5**, 206-216.