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An Ontology Model to Assess the Agro-Climatic and Edaphic Feasibility of a Location for Rubber Cultivation

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Abstract: ***One of the important commercial agricultural products is rubber. It is collected from the latex of the tree Hevea Brasiliensis. Because of the rubber's invaluable qualities such as non-conduction of electricity, elasticity and resistance to water it is used for different purposes. During the last five decades, natural rubber has achieved the highest growth among major crops in the country in terms of expansion area, production and productivity. Sowing, tapping and processing are some common methods of rubber cultivation.Rubber cultivation is considered as an important source of income for rural communities. Various agro-climatic factors such as temperature, latitude, water availability, altitude, wind and edaphic factors such as soil drainage, slope, soil type, soil depth, soil water table and pH have to be considered to find the feasibility of an area for rubber cultivation. In this paper, ontology is constructed to assess the edaphic and agro-climatic feasibility of an area for rubber cultivation. Carefully-collected knowledge that is very domain-sensitive is required for constructing ontology. Ontology contains domain specific knowledge to increase the powerfulness of a particular search engine. Based on the constructed ontology, the edaphic and agro-climatic feasibility of an area is assessed for rubber cultivation.***

Index Terms**:** ***Agro-climatic, Edaphic , Hevea, Cultivation, Ontology.***

I. INTRODUCTION

Natural rubber is having a life span of 25 to 30 years .The production and productivity of natural rubber is high when it is compared to other crops in India. The climatic conditions play a vital role in the optimum growth of rubber trees.The production of rubber will be improved by cultivating the rubber plant with the consideration of temperature, latitude, water availability, altitude, wind, soil drainage, slope, soil type, soil depth, soil water table and soil pH.The growth of Hevea is influenced by physical, chemical and mineralogical properties of soil. The removal of nutrients through crop is less in rubber when compared to that of other crops. Large quantities of nutrients get locked up in the biomass of the trees. They are lost permanently from the soil system, with the removal of timber at the time of replanting. Most plantations are in second or third replanting cycle. To ensure optimum growth and yield and to protect the sustainability of the system, analysis and maintenance of soil fertility through application of fertilizers is important. The four components of soil are inorganic or mineral materials, organic matter, water and air [1]. The composite effect of environment variables also influences the rubber yield. The fundamental elements that influence rubber cultivation are rainfall, temperature, sunshine, relative humidity and wind.

In this paper, ontology model is developed by using protege to assess the agro-climatic and edaphic feasibility of an area for rubber cultivation. Protege is a multi-user, collaborative editing environment for OWL ontologies. Ontology is defined as a theory of conceptualization in artificial intelligence. This conceptual level of knowledge can be reused and shared among related users in a group. For a specific group this can be a standard, and ultimately it can be extended to a global standard. Here ontology is constructed for each class i.e., temperature, latitude, water availability, altitude, wind, soil drainage, slope, soil type, soil depth, soil water table and soil pH. The ontology is used to know the suitability of an area for rubber cultivation and a working model is developed in java.

II. LITERATURE SURVEY

For analysing greenrubber cultivation in southwest china, an integrative analysis of stakeholder perspectives [2] was presented. This analysis concluded that more effort was required to develop a mechanism which integrated technical knowledge, improve social relationships and present a discussion for reconciling.

The current and upcoming distribution patterns of rubber tree in two distinct bio-geographical regions of Indiawere analysed by using a maximum entropy model [3]. From the analysis of Western Ghats and Brahmaputra valley, it came to know that a large number of areas were suitable for rubber cultivation whereas a small number of areas were partially unsuitable for rubber cultivation in the Western Ghats. Based on the relation between landscape and soil attributes in India, the distribution of natural rubber cultivation [4] was analysed. This analysis was carried out in Kottayam district of Kerala where the major rubber area was distributed on moderately suitable land and then on highly suitable land.

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As regards 11% rubber area is distributed on marginally suitable land having limitation with respect to high gravel content, shallow soil depth, steep slope and nutrient toxicity or deficiency. Land utilization with the above information was served as decision support tools for the extension administrators, people, farmers and planners.

Land suitability was analysed in [5] for protractible rubber cultivation in Moneragala district. In this analysis they used Geographic Information System (GIS) approach and they found out that nearly 6 percent of the recognized land was more suitable for rubber cultivation.

The rubber distribution pattern and spatial-temporal dynamic was analysed in [6] with Planted Intensity (PI) and GIS. From the analysis it was determined that the average of rubber plantation was 6014 square kilometre in 2010. In addition to this, from the rubber plantation structure, the ratio of younger and mature plantation was 7:5.

III. METHODOLOGY

A. Ontology Model to measure agro-Climatic and edaphic Feasibility of a location for rubber cultivation

Table 1: Properties in Ontology Model

Classes	Object Properties	Data Properties	Annotation Properties
Latitude, Altitude, Temperature, Relative Humidity, Rainfall, Irrigation, Water availability, Wind, Slope, Soil type, Soil depth, Soil drainage, Soil water table, Soil pH	meterr, degree,pH, S, RH,degreecelsius, meter, cm, N, m	Classes and their objects values	Objects and their Internal ID (IRI)

Table I shows the classes, object properties, data properties and annotation properties involved in the ontology model to measure agro-climatic and edaphic feasibility of an area for rubber cultivation. 8 agro-climatic factors and 6 edaphic factors are considered as classes in ontology model. The agro-climatic features are latitude, altitude, temperature, relative humidity, rainfall, irrigation, water availability and wind. The edaphic factors are slope, soil type, soil depth, soil drainage, soil water table and soil pH. Each class are measured by a unit which are considered as object properties of ontology model. The data properties represent the classes and their objects values. The annotation property represents the objects and their IRI.

B. Annotation Properties of Ontology Model

Ontology is created for annotation properties and it concludes the following in Table II.

Table II: Annotation Properties in Ontology Model

Annotation Property	IRI
N	lince.stanford.edu/R73S8YuKuZUTHH71uZAO8tL
degree	lince.stanford.edu/RBB0ErHq4JotvZTAbIkNWHm
S	lince.stanford.edu/RCBqqiLtyvfaDDmQZhR0J4O
m	lince.stanford.edu/RCQnDILcKkk8pVkLkOL7DwJ
meter	lince.stanford.edu/RCTXEpr9B3aqHd6jWCuMOg7
meterr	lince.stanford.edu/RCoAzJL6pUrqHyrMeT3cfqL
cm	lince.stanford.edu/RDUlNa7PMyXN2wCvc4Jwhhc
degree celsius	lince.stanford.edu/RGHrSdeEvEn3te3dPysta7
RH	lince.stanford.edu/RKCmNV9o8NQj6qOEwNQc5k
pH	lince.stanford.edu/RygDmRxA2Fmg4dTRxfHcA0

C. Object Properties of Ontology Model

From the ontology created for object properties and their values are tabulated in Table III .The values suitable for rubber cultivation is obtained from [7], [8], [9]. For example, the latitude can be measured as North (N) or South (S) those are less than or equal to 10 or greater than 10.

Table III: Object Properties of Ontology Model

Objects	Values
meterr	>1
meterr	low or high
degree	>18
degree	<18
degree	>47
degree	<47
pH	>10
pH	≥4.2/≤10
pH	<4.2
pH	4.5-7
S	>12
S	≤12
RH	60-92
RH	<60/>92
degree celsius	≤40
degree celsius	<22
degree celsius	≥22
degree celsius	>/<30
degree celsius	=30
degree celsius	>40
meter	≥1
meter	<1
cm	250-480
cm	>480
cm	<250
N	>12
N	≤12
m	≤500
m	>500

D. Data Properties of Ontology Model

-->
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```

rainfedcultivation</protege:RDUlNa7PMyXN2wCvc4Jwhhc>
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From the ontology, the data properties and their values are shown in Table IV.

Table IV: Data Properties in Ontology Model

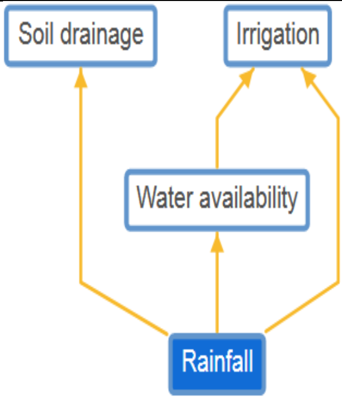
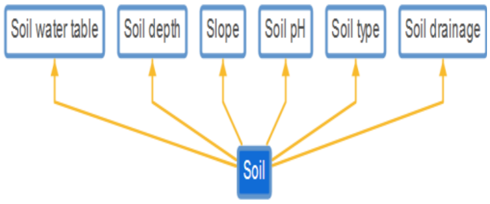
Classes	Data Properties	Values and Decision
Altitude	m	≤500-Suitable
	m	>500-Not Suitable
Irrigation	cm	Rainfall<250 & irrigation not available-Explore rainfed cultivation
	cm	Rainfall<250 & irrigation-available and adequate-Suitable
	cm	Rainfall 250-480 & irrigation-not available-Suitable
Latitude	S	≤12-Suitable
	S	>12-Not Suitable
	N	≤12-Suitable
	N	>12-Not Suitable
Rainfall	cm	250-480 without prolonged drought-Suitable
	cm	>480-excess-Suitability depends on soil drainage
	cm	<250-deficient-suitability depends on availability of irrigation
Relative Humidity	RH	60-92-Suitable
	RH	<60/>92-Not Suitable
Slope	degree	<18-Suitable
	degree	>18 but <47-Suitable
	degree	>47-Not Suitable
Soil depth	meter	<1-Not Suitable
	meter	≥1-Suitable
Soil drainage	Type	Poor drainage or water logging-Not Suitable
	Type	Well drained-Suitable
Soil pH	pH	>10-Correct by acidic amendment
	pH	<4.2-Correct by basic amendments
	pH	4.5-7-Optimum
	pH	≥4.2/≤10-Tolerable
Soil Type	Type	Forest soil, alluvial,laterite/lateritic, red soil-Suitable
	Type	Clay-Not Suitable
Soil water table	meterr	low or high-Not Suitable
	meterr	>1-Suitable
Temperature	degree celsius	≥22 &≤40-Suitable
	degree celsius	>/<30-Not ideal
	degree celsius	<22 &>40-Not Suitable
	degree celsius	=30-Ideal
Water availability	cm	<250 & irrigation not available-Suitable only for rainfed cultivation
	cm	Rainfall 250-480 or <250-

		Suitable
Wind	Type	cyclone/storm/wind free-Suitable
	Type	cyclone/storm/hot dry wind prone-Not Suitable

D. Classes of Ontology Model

Table V shows the entity model for each class. The soil drainage is the sub class of rainfall; the water availability is the sub class of rainfall and irrigation is the sub class of rainfall. The irrigation is the sub class of water availability

Table V: Entity Model for each Class

Classes	Entity Model
Altitude	
Latitude	
Rainfall	
Soil	
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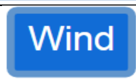
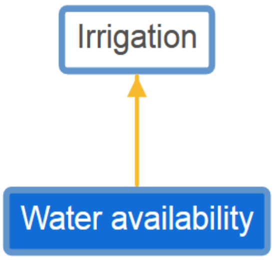
Wind	
Irrigation	
Water availability	
Relative Humidity	

IV. RESULTS

A. Sample Run of ontology model to measure agro-climatic and edaphic feasibility of a location for Rubber Cultivation

Sample run of the ontology model with two set of values were carried out in and the results are displayed in the Table V1, and V11. These tables clearly show the decision making efficiency of the ontology model for assessing the suitability of an area with respect to each agro-climatic and edaphic factors as well as on an overall basis.

Table VI: Results of ontology model for first set of values

Agro-climatic and edaphic factors	Prevailing factors in the area	Decision of feasibility assessment
Latitude (degree N or S)	15	Latitude wise area is not suitable. If the temperature, soil and water availability is feasible, then the area may be considered as available
Altitude (m)	550	Altitude wise area is not suitable. If the temperature, soil and water availability is feasible, then the area may be considered as available
Temperature (degree celsius)	Minimum 25 and Maximum 42	Temperature wise area is not suitable
Mean annual temperature (degree celsius)	30	Mean annual temperature wise area ideal
Relative humidity	57	Humidity wise area is not suitable
Rainfall (cm)	220	Rainfall is deficient and area suitability depends on availability of irrigation
Irrigation	Not available	Irrigation wise area is not suitable
Water availability		Suitable only for rainfed cultivation
Wind	Cyclone/Storm prone	Being free from cyclone, storm and hot wind area suitable
Slope (degree)	50	Slope wise area is not suitable
Soil type	Red soil	Soil type suitable
Soil depth (meter)	0.7	Soil depth of area is not suitable
Soil drainage	Well drained	Soil drainage wise area is suitable
Soil water table (meterr)	low	Water table wise area is not suitable
Soil pH	6	pH of soil is optimum
Recommendations		Area is not suitable for rubber cultivation because of unfavorable high temperature, low humidity, high slope area, low soil depth and low soil water table

Table VII: Results of ontology model for second set of values

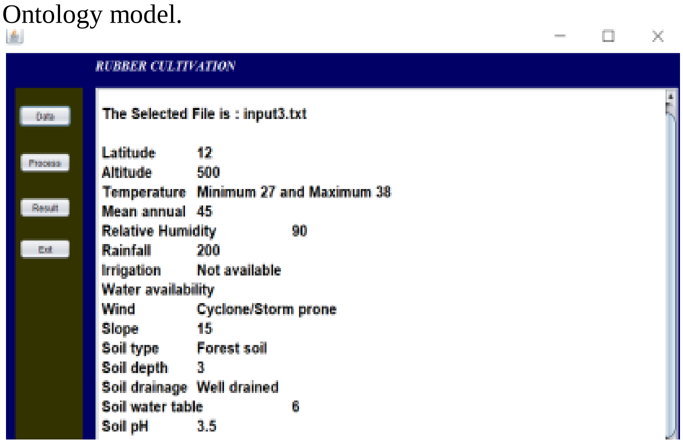
Agro-climatic and edaphic factors	Prevailing factors in the area	Decision of feasibility assessment
Latitude (degree N or S)	12	Latitude wise area is suitable
Altitude (m)	500	Altitude wise area is suitable
Temperature (degree celsius)	Minimum 27 and Maximum 38	Temperature wise area is suitable
Mean annual temperature (degree celsius)	30	Mean annual temperature wise area ideal
Relative humidity	90	Humidity wise area is suitable
Rainfall (cm)	200	Rainfall is deficient. Suitability depends on irrigation
Irrigation	Not available	Explore rainfed cultivation of drought tolerant clones
Water availability		Water availability not adequate
Wind	Cyclone/Storm prone	Being free from cyclone, storm and hot wind area suitable
Slope (degree)	15	Slope wise area suitable
Soil type	Forest soil	Soil type suitable
Soil depth (meter)	3	Soil depth of area is suitable
Soil drainage	Well drained	Soil drainage wise area is suitable
Soil water table (meterr)	6	Water table wise area is suitable
Soil pH	3.5	Correct pH by basic amendments
Recommendations		Area is suitable. Subject to and limited to rainfed cultivation of drought tolerant clones. Subject to pH correction by adding basic soil amendments

V. CONCLUSION

The performance of Hevea is best where the features of climate, soil and land closely resemble that of its original habitat. This work proposes an ontology model which finds the land suitable for rubber cultivation considering all its climatic and edaphic parameters. These parameters are given as inputs to the developed working model and it provides the output whether the land is suitable for Hevea cultivation or not. This ontology model further feeds inputs to a proposed predictive system on Hevea Cultivation. All these efforts are made to improve and sustain the crop production.

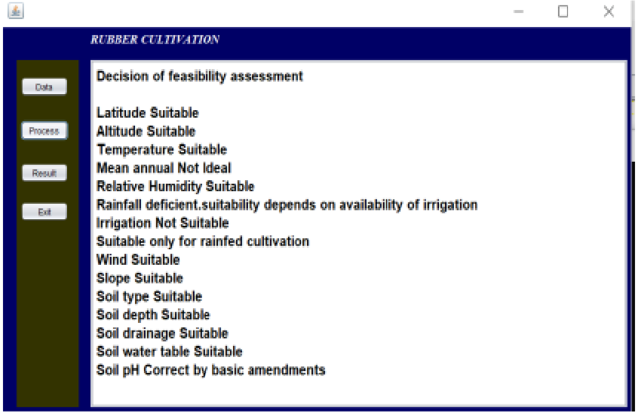
APPENDIX

Screen Shots of the working model.
Climatic and Edaphic parameters given as input to the Ontology model.



Screen Shot(a)

Suitability analysis done for the given input



Screen Shot(b)

Location suitability is resulted by the ontology model

Screen Shot(c)

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AUTHORS PROFILE

Lince Rachel Varghese holds M.Phil and is pursuing PhD in Computer Science from Department of Computer Science, Dr G R Damodaran College of Science, and Tamil Nadu. She is working as an Associate Professor in department of MCA at Union Christian College, Aluva, and Kerala. She has more than 15 years of experience in teaching and research in the field of Computer Science. She has completed M.Phil in Computer Science fromDr G R Damodaran College of Science, Tamil Nadu and MCA from P.E.S College of Engineering underVisveswaraiah Technological University with Distinction. She has attended many State Level, National Level and International Level workshops and colloquia. Her research interest includes Knowledge Management, Agricultural Computing and Applications, Data Mining, Big Data, and Climatic Variations. She has 4 publications in her credit.

Dr.K.Vanitha received her PhD Screen Shot(a)degree in Computer Science from Bharathiar University with SRF, at Indian Institute of Technology, Chennai Tamil Nadu on Pervasive Computing entitled "*Self-healing Model for transforming Precision Agriculture using Pervasive Sensor Networks and Mobile Robot Navigation*". Her research interest includes Pervasive Computing & IOT, Robotics. She is working as an Associate Professor, Department of Computer Science ,Dr G R Damodaran College of Science ,Tamilnadu from 2005 and has worked in Bharathiar University affiliated Colleges from 2002 and has worked as a Software Engineer in Profluent Technologies, Coimbatore with 3 of years of experience. She has worked as Summer Research Fellow at Indian Institute of Technology, (IIT-M) Chennai, 2009 sponsored by Indian Academy of Sciences under the guidance of Padmashree. Prof. Ashok Jhunjhunwala., Dept. of EE, IIT Madras, India. She is a member in board of studies of different Institutions and working as an Academic Counsellor for MCA Course for Indira Gandhi Open University, New Delhi from June 2002. She is working as an adjunct faculty in an International University for Python course and Robotics Course. She is delivering good number of guest lecturers to students and teachers. She is a professional member of IEEE., IASCIT member, Reviewer for IEEE Transactions on Parallel and Distributed Processing (2014), Research Forum, Teacher member in Indian Academy of Sciences, European Alliance for Innovation, Reviewer for AIRCC journals, Program Committee Member in Eighth International Conference on Computer Networks & Communications (CoNeCo2016) Zurich, Switzerland,and Member Internet Society .She is having 32 publications, and 5 books in her credit