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GIS Approach to Determine Suitability of Trees for Afforestation

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ABSTRACT- 9.4 million trees across forest areas in India have been lost to development projects over the period of past 4 years (2015-16 to 2018-19). This is according to the Union ministry of environment, forests and climate change (MoEFCC). Afforestation refers to the effort to plant trees in barren lands to create a forest. Planting trees, sowing seeds in a barren land so as to create a forest. It is very vital as it helps to keep in check the over usage of natural resources by providing an alternative source. Planting trees is always beneficial to the environment regardless of the habitat.

KEYWORDS- Geographical Information System, Weighted Sum, Rasters, Landscape Model.

I. INTRODUCTION

Controlling of the carbon outflow frequently is a difficult undertaking for a nation like India. Much of the areas are covered by large industries and power plants. Creating Infrastructure, Industries (Steel, Power, Engineering, etc.), Mining (Coal, Minerals, Metals, etc.), Oil and Gas exploration, Thermal Power plants, etc are some of the reasons why major deforestation has occurred in India. Conversion of forested land to non -forested land by humans is referred to as Deforestation. It is one of the most challenging problems India is facing. Deforestation happens when a land overwhelmed by normally happening trees is changed over to offer particular types of assistance because of human interest. The erratic chopping down of trees has brought about the worldwide forest cover diminishing by 3.16% from 1990 to 2015. There are significant amounts of regions in India which have seen a decrease in forest cover, even though the country has seen an increment in total forest cover of ca. 1%. Shifting cultivation, rotational felling, other biotic pressures, diversion of forest lands for developmental activities are some of the main reasons for deforestation in the country. Continuous cutting of trees has severely impacted the microclimatic conditions, hydrological cycle, soil quality, etc. of the country, making the country vulnerable to an eventful happening. [1]

II. RELATED WORK

A. Remote Sensing

The remote sensor collects data by detecting the energy that is reflected from Earth.[2] These sensors can be on satellites or can be mounted on an aircraft. These sensors can be either active or passive. Passive sensors respond to external stimuli. Natural energy is recorded that is reflected or emitted from the Earth's surface. Reflected sunlight is the most common source of detected radiation by passive sensors.

B. Geographical Information System

Geographic information system is a system designed and is used to store, manage, manipulate, capture, analyse, and present all types of geographical data. The word Geography is the critical element – it means that some portion of the data is spatial. In other words, data that is in some way referring to locations on the earth.[3] Along with spatial data, tabular data widely known as attribute data, which can be defined as additional information about each of the spatial features. For example, the actual location of the monument is the spatial data. Additional data such as the monument name, year of creation, tourist data would make up the attribute data.

C. Forest Assessment Using GIS

Humans have always considered forests to be the best renewable source due to their role in preserving an environment that is ideal for life.[4] Management of forests is a discipline that has been embraced by the greater part of the nations over the world. Financial matters managing the estimation of forest development, volume, timber harvest, utilization and benefits. GIS technology has been responsible for the decision-making processes for a few years now. GIS with other technologies has helped environmentalists to keep clear records regarding forests and make decisions based on the data obtained. GIS is becoming popular due to its benefits on the environment.

III. APPROACH

Here, we will be giving the details about our approach regarding all the steps of this project. Right from data collection and generation to landscape modelling, every part is covered in this section.

A. Dataset

The whole of Indian Subcontinent was taken into consideration during the conduct of this research. We have prepared a dataset of all the required parameters by collecting the rasters of the same.[5] Some images of the Rasters have been shown below from figure number 1 to 5, which are taken from various sources.

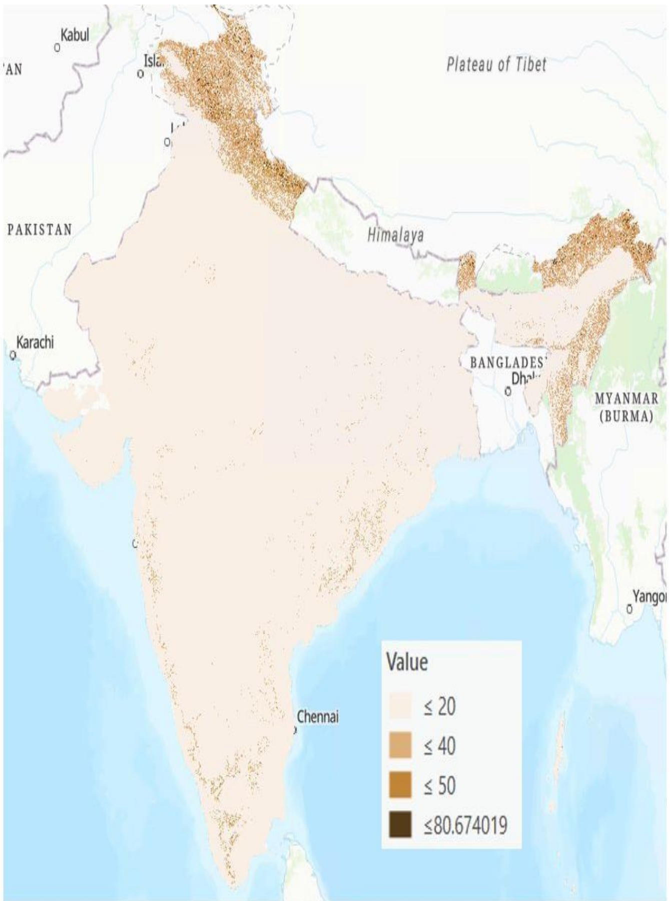

Fig. 1: Slope map

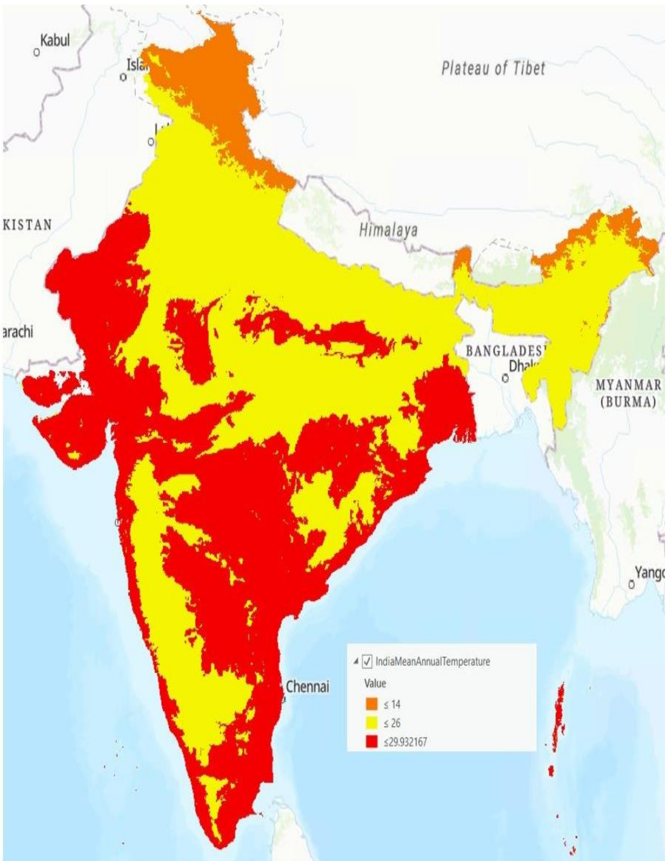

Fig. 2: Temperature Map

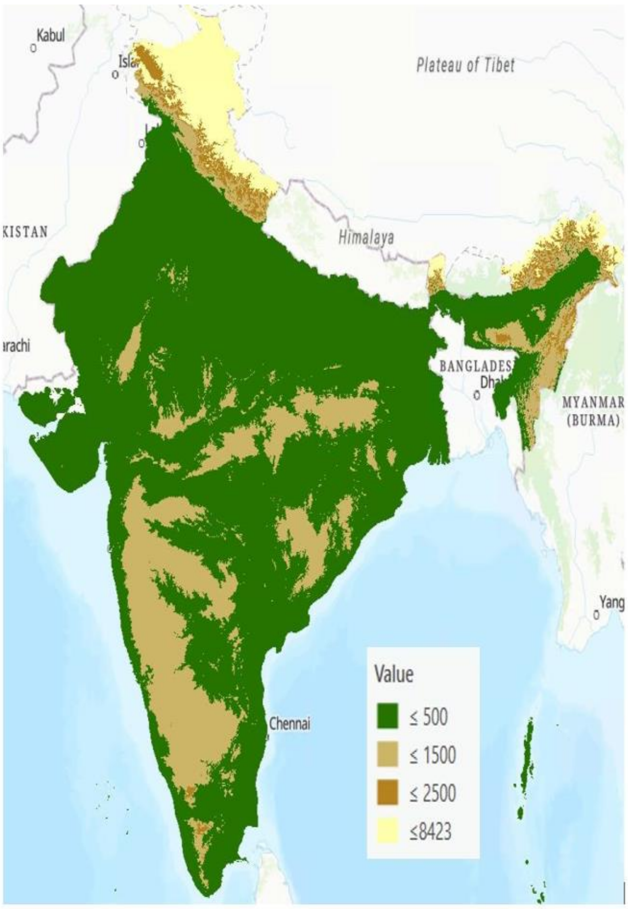

Fig. 3: Elevation map

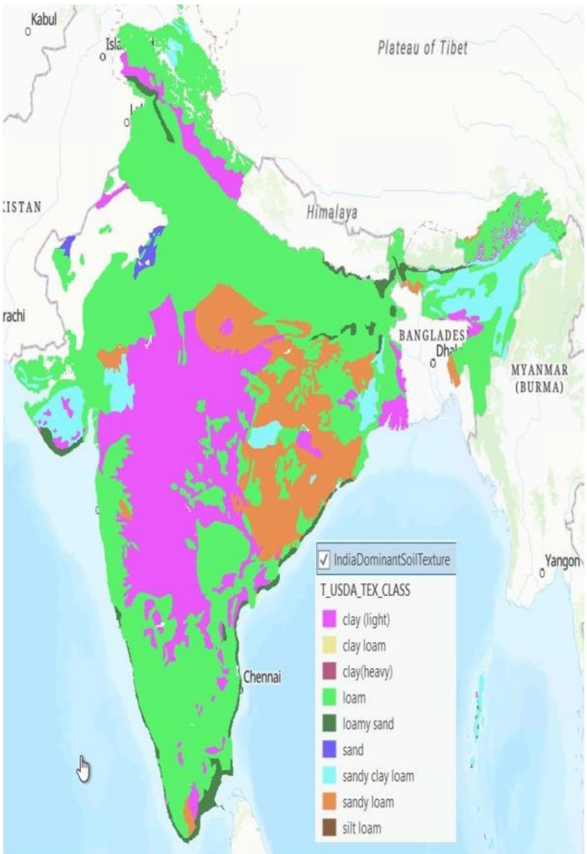

Fig. 4: Soil Texture Map

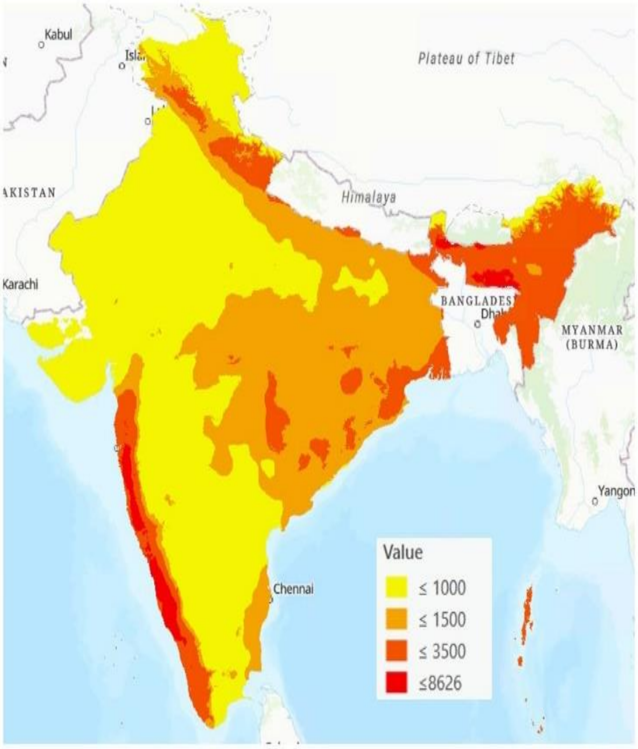

Fig. 5: Annual Rainfall Map

B. Quantification Of Data

The input parameters taken into consideration were temperature, elevation, slope, soil texture and the rainfall.[6] These were divided into several categories as presented in the Table 1, Table 2 and Table 3. For every one of the classes, an integer value was defined. This value represents the suitability of a particular tree species concerning a certain parameter.[7]

Table 1: Sal Tree Classification Values

	Range	Value
Rainfall	< 1500	2
	1000 - 1500	5
	1500 - 3500	9
	> 3500	4
Slope	< 20	9
	20 - 40	7
	40 - 50	3
	> 50	1
Elevation	< 500	2
	500-1500	5
	1500 - 2500	9
	> 2500	4
	< 28	5
	28 - 34	9
	> 34	4
Soil Texture	Loamy Soil	9
	Clay soil	9
	Sandy soil	9
	Clay Loam	4

Table 2: Gulmohar Tree Classification Values

	Range	Value
Rainfall	< 700	2
	700 - 1000	7
	> 3500	9
Slope	< 20	9
	20 - 40	7
	40 - 50	3
	> 50	1
Elevation	< 1000	7
	1000 - 2000	9
	2000 - 2500	5
	> 2500	4
Temperature (°C)	< 14	5
	14 - 26	9
	> 26	4
Soil Texture	Loamy Soil	5
	Clay soil	9
	Sandy soil	7
	Clay Loam	3

Table 3: Arjuna Tree Classification Values

	Range	Value
Rainfall	< 750	2
	750 - 1000	5
	1000 - 2000	9
	> 2000	4
Slope	< 20	9
	20 - 40	7
	40 - 50	3
	> 50	1
Elevation	< 500	2
	500-1200	9
	1200 - 2000	7
	> 2000	4
	< 5	1
	5 - 20	3
	> 20	9
Soil Texture	Loamy Soil	5
	Clay soil	6
	Sandy soil	8
	Clay Loam	9

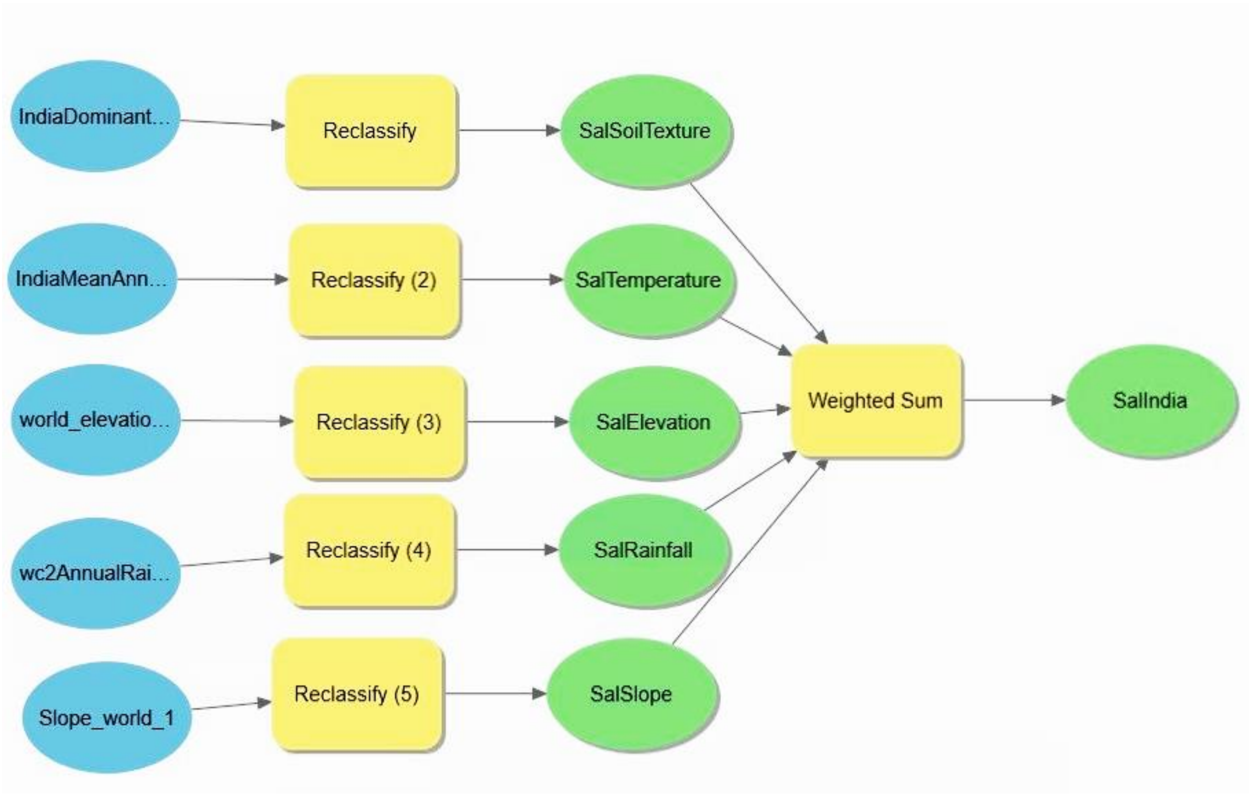

Fig. 6: Model Diagram

The diagram in the Fig. 6 shows the model created for the suitability classification of Sal Tree in the Indian Subcontinent. In this model:

- The Yellow Rectangular boxes represent geoprocessing tools used i.e. Reclassify and Weighted Overlay.
- Blue Ovals represents input raster
- Green Ovals represents processed rasters.

Here each raster obtained as explained above is taken as inputs and sent into a reclassifier to give rasters as per the classification given in the above tables. These reclassified rasters are then overlapped according to the value from the raster and the weight of the raster. This process is carried out at a pixel level and output gives the desired raster.
In the above model weights of the raster layers are taken as represented in Table 4.

Table 4: Layers and Weights

Layer	Weight
Rainfall	0.22
Soil Texture	0.22
Temperature	0.22
Slope	0.17
Elevation	0.17

C. Algorithm Implementation

Designing plan choices frequently require the generation, correlation and comparison of design alternatives in an environment of multiple plan models. To help in such dynamic, designers go to numerical formalisms to help with positioning the other options. A famous way to rank alternatives against a bunch of n criteria is the weighted sum method. The weighted sum method is very popular due to its ease of use and its compelling form. It commonly takes form

$$R_j = \sum_{i=1}^{n} w_i q_{ij}$$

Weighted sum formula

In our project, the final formula can be represented as:

(Rainfall value*weight)+ (Soil Texture*weight) + (Temperature value*weight) + (Slope value*weight) + (Elevation value*weight)

Here the weight refers to the weights of each parameter as described in the above table.

D. Results And Discussion

The results of this research and the method used enables us to prepare a suitability map of each of the three species of plants namely Sal, Gulmohar and Arjuna tree shown in Fig. 7, Fig. 8 and Fig. 9 respectively, which categorizes the region based on the suitability where the tree can grow in the Indian Subcontinent. A detailed description of each species and its corresponding map is given below.

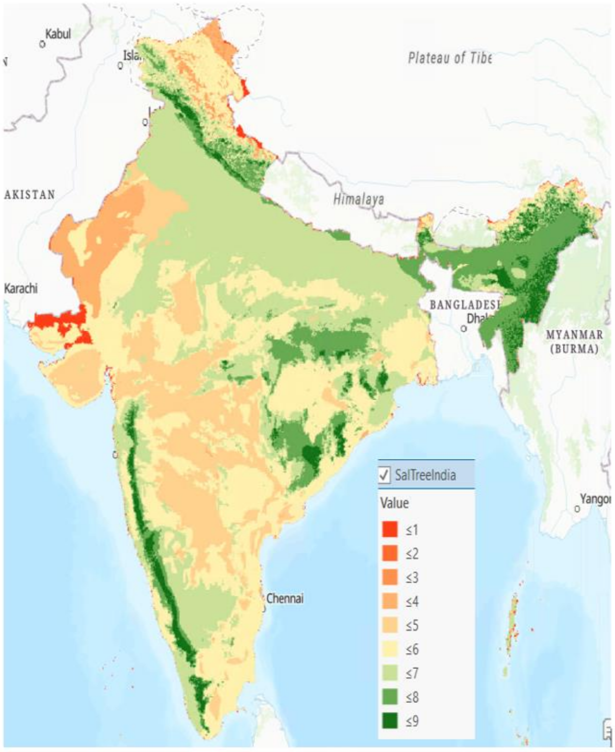

Fig. 7: Shorea robusta (Sal tree)

A plant of the tropics, where it is found at elevations up to 2000 metres. It grows best in areas where annual daytime temperatures are within the range 28-34 ^{0} c.

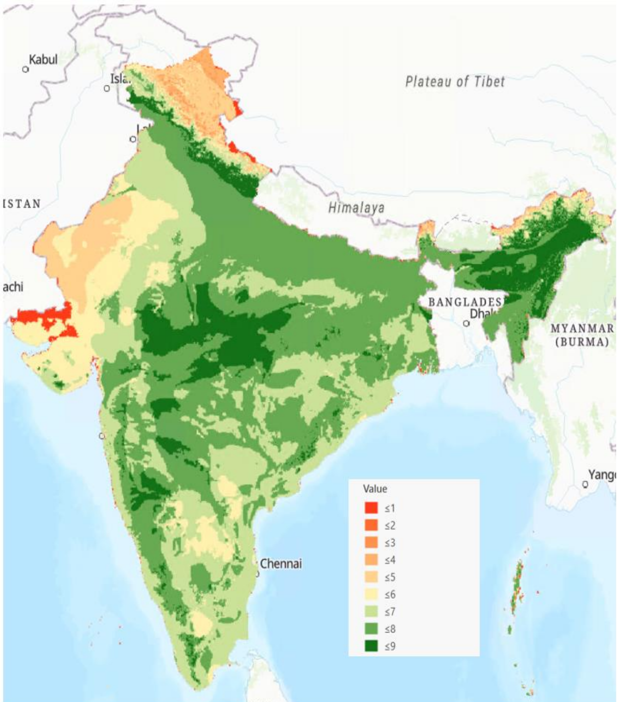

Fig. 8: Delonix regia (Gulmohar tree)

Delonix regia requires well-drained soils (clay to sandy, but it prefers sandy soils) in full sun, altitude 0-2000 m, mean annual temperature 14-26 deg C, Mean annual rainfall over 700 mm.

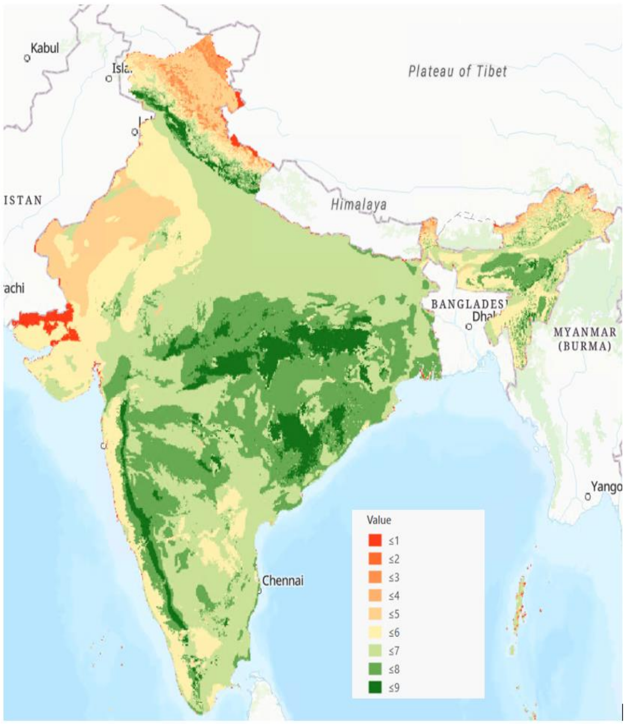

Fig. 9: Terminalia arjuna (arjuna tree)

Terminalia arjuna grows best in areas where annual daytime annual temperatures are within the range 20-33^{0} c. and it prefers a mean annual rainfall of 1000-1500 mm. Succeeds in any moderately fertile, well-drained soil.

IV. VALIDATION

We have verified the satisfiability and validity of our model with the actual suitability of the tree species in the region of Thane district from Mr. Rajendra Magdum, who is assistant conservator of forests, Mumbai mangrove conservation unit.

V. CONCLUSION

The results certainly showed some satisfactory results for all the species we considered. However, if further developed by considering more essential parameters the system can become very consistent and accurate. The results can still be rightly doubted and various experts will have a say regarding their respective field of expertise. With more detailed information, one can certainly cover the gaps seen in the current tree suitability maps. There is no certain proven formula that can determine the exact suitability of a tree in a specific area. The formula can grow more complex if detailed input is provided. This way of producing suitability maps for afforestation purposes has not been carried out in the past in India. The method needs a lot more input data for it to be referred to as an absolutely reliable system. However, this research, for a start, shows a very good approach for creating such maps, which results in maps that are satisfactory. In our research, the suitability maps resulted in reliable spatial distribution and accuracy. Tree species have been selected very carefully (ingenuous species) offering various possibilities for afforestation throughout

India.[8] Such models have been created for the first time for the Indian Subcontinent and with considerable development, the system can be made robust and can be used for afforestation in any locality.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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