REMOTE SENSING AND GIS BASED SITE SUITABILITY MODELING OF RAUVOLFIA SERPENTINA IN DEHRADUN DISTRICT OF UTTARAKHAND

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KEY WORDS: DEM, NDVI, SBI, RS & GIS

ABSTRACT

The state of Uttarakhand, located in the foothills of Himalaya, is a home to various rare, threatened and endangered species of medicinal plants. *Rauvolfia serpentina*, is one of the important species belonging to family Apocynaceae. It is one of the finest remedy that is widely used for high blood pressure and is also as sedative and tranquillizing agent. Keeping its importance in view present study is based on its distribution and suitable site identification for Sustainable development and livelihood generation for the people of the area. Remote sensing and GIS can play an important role in the identification of the suitable zones for conservation of *Rauvolfia serpentina* lower Shiwalik hill of Dehradun District. A total of 25 GPS points of the *Rauvolfia serpentina* were recorded in the study area. Digital Elevation Model (DEM) of the Cartosat satellite data was used for deriving topographic parameters like altitudinal zones, slope angle, slope aspect, which are important for the modeling of plant. Linear Image Scanning Sensor LISS IV & Cartosat fused satellite data was used for deriving land use / land cover, Normalized Difference Vegetation Index (NDVI), Normalized Differential Water Index (NDWI), Soil Brightness Index (SBI), etc. Apart from that, the climatic parameters i.e. annual average rainfall, annual average temperature and annual average humidity were used. The whole raster data cube was submitted to Spatial Multi-Criteria Evaluation (SMCE) module for suitability modeling of targeted species. The final results were validated from the remaining 30 % of GPS points gathered during field for verifying the results. The use of RS and GIS data shows highly useful in suitability studies as the results was incompetence with the ground validation. It shows the technological intervention can help to a greater extends for sustainable development and livelihood generation option in hilly areas for marginal farmers.

INTRODUCTION

Rauwolfia serpentine (Sarpgandha) belonging to family Apocyneae is an important medicinal plant. The plant is commonly distributed in foothills of Himalayan region and is found in India, China, Nepal,Srilanka, Burma, Thailand (Roy, S.K et al., 1994). It is an erect, evergreen 0.6 to 1m high. It is generally collected from wild. Its cultivation is on limited scale. It grows on a variety of soils, ranging from sandy-alluvial loam to red lateritic loam or even stiff dark loam. Very light sandy soils deficient in organic matter are not preferred for the species. The plant grows well in acidic and neutral soils. Soil with pH 8.5 and above are not considered fit for its cultivation. The plant is known to grow in wide range of climatic conditions. However, it flourishes better under hot and humid climate condition. Although, according to field visit of Dehradun district in natural habitat the plant is frequently found growing under shade. Temperature range of 10 to 38 ^{0} C appears to be well-suited to the plant. Rauwolfia serpentine roots, commonly known as serpentine roots or sarpgandha, is one of the most important drugs used in traditional as well as in modern system of medicine.The roots of Rauwolfia serpentine contain several alkaloids, the more important being two chemical classes known as the ajmaline and the serpentine group (Dr. GanpathSen and

Dr. Kartik Chandra Bose), the more important being two chemical classes known as the ajmaline and the serpentine group.

The greatest advantage of the satellite image is the synoptic view it provides, which gives a regional and integrated perspective of and interrelations between various land features such as vegetation cover, drainage pattern, etc. which can be better perceived on the image than on the ground (Tomar, M.S et al., 1974). This is of greater relevance in the inaccessible and difficult terrains of the Himalayas (Roy, P.S et al., 2001). Forest structure and composition are strongly correlated with environment factors, such as climate and topography .Studying the composition and diversity of species and its habitat types, perhaps becomes the yardstick to judge the level of adaptation to the environment and the ecological significance. There are several Remote Sensing and GIS based techniques in use worldwide for habitat modeling and ecological niche modeling of both flora and fauna. Some of the GIS procedures are DOMAIN, BIOCLIM, and Genetic Algorithm for Rule Set Production (GARP), Ecological Niche Modeling (ENM), Maximum Entropy (MAENT), Ecological Niche Factor Analysis (ENFA), etc. DOMAIN and BIOCLIM are run in DIVA-GIS and ENFA in BIOMAPPER GIS software. The ecological niche or habitat of the species can be defined as 'set of ecological conditions within which species are able to maintain populations without immigration (Grinnell, J et al 1917).

The GARP (Genetic Algorithm for Rule Set Production) modelling system uses a genetic algorithm, the basic concept of which was developed by Holland (1975). GAs have been applied to a wide range of domains, including numerical function optimization (Bethke 1981, Brindle 1981), adaptive control system design (DeJong 1980), and articial intelligence task domains where the structure of the problem domain prohibits the use of classical statistical methods and gradient search techniques (Goldberg, 1989). In addition to the well documented robust performance of GAs, the genetic algorithm in GARP has a feature which extends the capacity of GAs for generating and testing a wide range of possible solutions - the capacity to simultaneously generate and test a range of types of models, including categorical, range-type and logistic models. One of the main purposes of this paper is find out the suitable sites of Rauwolfia serpentine for suggest to conserve and cultivate it.

Study Area

Dehradun valley is situated in lesser Himalaya of Uttarakhand State, India. The Dun Valley occupies an area of 1277 km2, and is bounded by Shivalik hills in the south and Lesser Himalayas in the north. It receives a mean annual rainfall of 2051 mm. The temperature ranges from 2°C in winter to 42°C in summer. Dun valley is a forested landscape with forests, agriculture, settlements, orchards and tea gardens. The principal forest types are: (i) Moist Bhabar-Dun Sal Forest (3C/C2bi), (ii) Lower Himalayan Moist Temperate Forest (12C1), (iii) Himalayan Subtropical Pine Forest (9/C1), and (iv) Northern Dry Mixed Deciduous Forest (5B/C2) (Champion and Seth, 1968). *Shroearobusta, Terminaliatomentosa, Anogeissuslatifolia, Mallotusphilippensis, Dalbergiasissoo, and Acacia catechu* are some of the important tree species in the Valley.

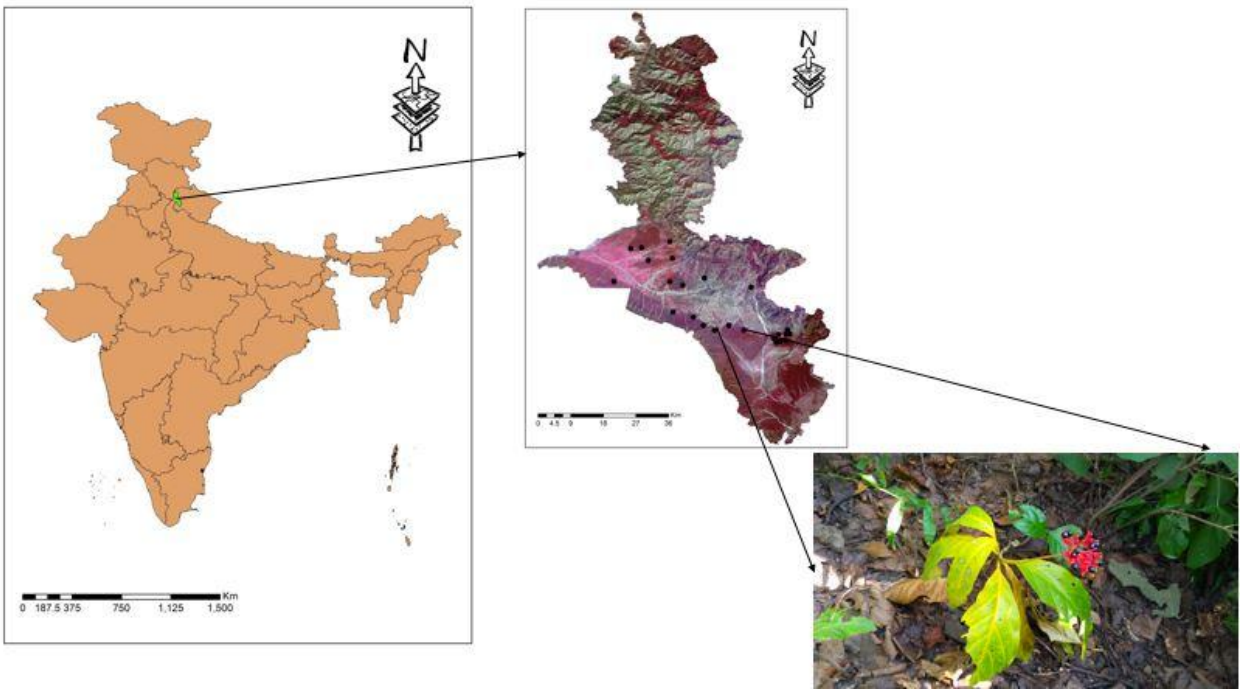

Fig 1: Location map of Dehradun District

Material & Method

The Cartosat-1 Digital elevation model (DEM) with 30m resolution, was used to generate slope, aspect and altitudinal zones.Linear Image Scanning Sensor (LISS) IV in four spectral bands with spatial resolution of 5.8 m of January 2017 and Cartosat-2 fused satellite data with 2.5m spatial resolution was used for deriving land use / land cover, Normalized Difference Vegetation Index (NDVI). Landsat 8 in 11 spectral band with spatial resolution 30 m for visible band and 60m for thermal bands was used for derive Soil Brightness Index (SBI). Supervised classification technique used for image classification for preparing land use/ land cover classes.Temperature and precipitation data with 30 arc second (1km) spatial resolution, downloaded from Worldclim dataset (www.worldclim.org) were used to find out suitable area for Rauwolfia serpentine. Soil depth map was taken from ICAR-National Bureau of soil survey and Land use planning for define the habitat potential.A hand-held Global Positioning System (GPS) receiver with ±5 m positional accuracy was used to acquire the species occurrence geocoordinates. Erdas 14 and ArcGIS 10.4.1 were used to create the spatial data layers. The metrological data, soil depth layer and others derived data from DEM processing are resampled into the spatial resolution of satellite imagery in order to facilitate raster analysis using nearest neighbor re-sampling technique.

Eight map layers were used in the GARP analysis representing parameters that's influence to the species. These layers were all obtained from various online sources including elevation, Slope, aspect, soil type, soil brightness, NDVI, Temperature, precipitation (Table 1). All data layer were clipped in arcgis10.4.1 using a mask of the study area. Most environmental layers were obtained as raster format and some layers were obtained as vector format, these vector layers converted to raster format using Feature to raster tool using arcgis. An executable ,clip to ASCII format, was submitted to project all layers to the Universal Transverse Mercator coordinate system WGS Datum 1984 and equalize the cell sizes toone arc-second resolution (approximately 30 m^2), as well asconvert all layers to ASCII format — all prerequisites for GARP. We set GARP to perform 20 runs for Rauwolifia serpentine with a convergence limit 0.01 and 1000 minimum iteration. All four ruletypes (atomic, range, negated range, and logistic regression) wereemployed as well as the best subset feature of GARP. Then used the summation feature in

the raster calculator of ARCGIS to make a final predictive map, which range varies from 0 to 1 and categorized into three classes of potential habitats viz., 'Highly suitable', 'Moderate suitable', 'Not Suitable'.

Sr. No.	GIS data layer	Source
1	Elevation	NRSC
2	Aspect	Derived from DEM in arcgis
3	Slope	Derived from DEM in arcgis
4	Soil Type	National Bureau of Soil Survey and Land use Planning
5	Soil Brightness Temperature	Derived from Landsat 8 satellite Data
6	NDVI	Derived From LISS IV satellite data
7	Average Temperature	Worldclim
8	Rainfall	Worldclim

Table 1: Layer data used in GARP analysis

Result and Discussion

The availability of Rauwolfia serpentine is recorded through random transacts using GPS. The transact survey is carried out mainly in Sal forest and Teek forest along the roads.Rauwolfia serpentine was found mainly in Horawala Sal forest, Thano Sal forest, Lacchiwala range, Asarori range, Timlirange,Langha range, Chandpurkhurd, Jhanjhra range, and Nalapani. The model result showed that an area of total 442.43 km² has highly suitable area including 394.56 km for agriculture area and 47.87 km² for forest area. Approximately 721.89 km² has moderate suitable area including 522.21 km for agriculture area and 199.68 km² for forest area (figure 2). Negligible area is found above 1100m it was observed that maximum species area lies between elevation range of 500-1100m.

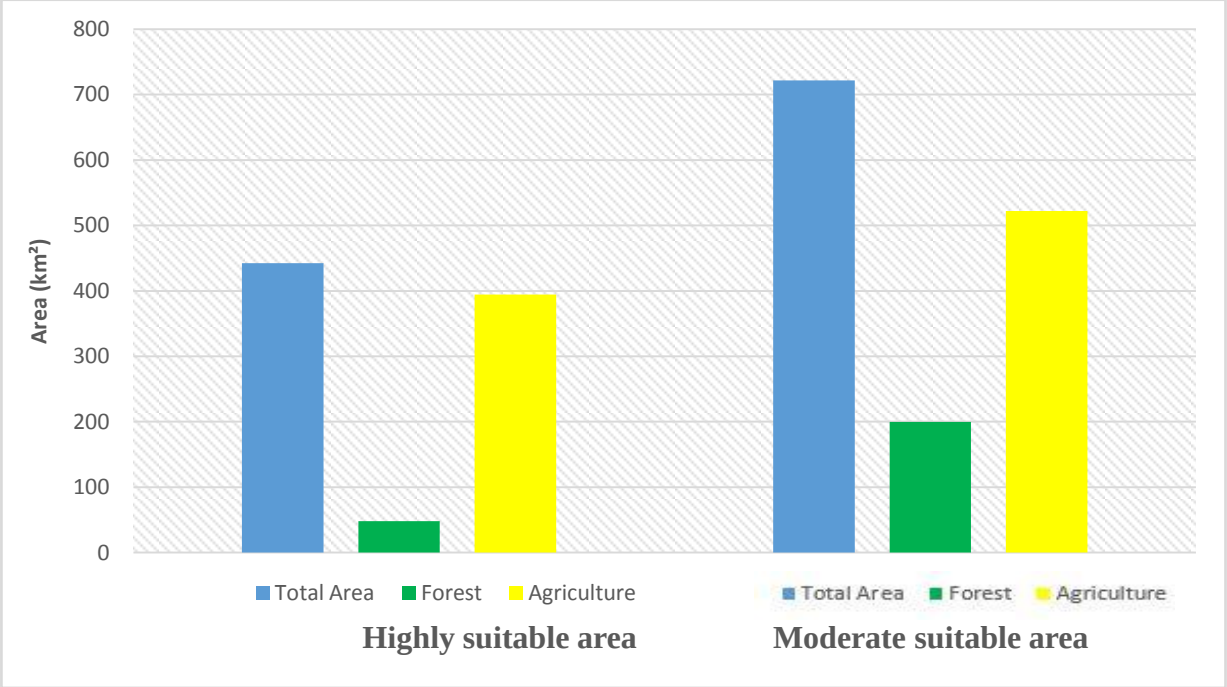

Fig 2: Highly and Moderate suitable areas including Forest and agriculture

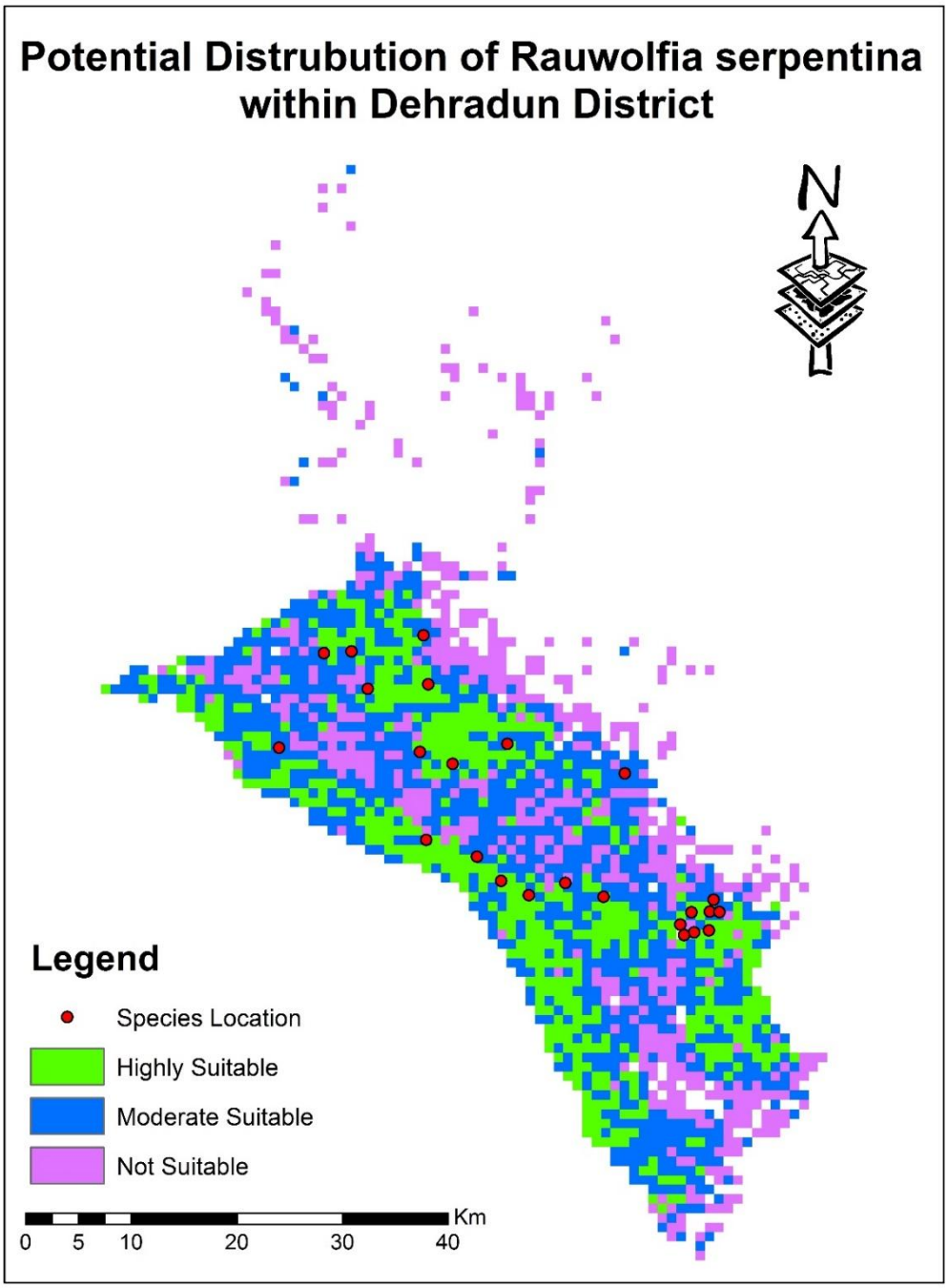

Figure 3: Predicted potential distribution of Rauwolfia serpentina within Dehradun District

The GARP modeling can be helpful in distribution of any species for any study area quickly and effective if the required data area fed as input. A total of 25 GPS points of Rauwolfia serpentine was recorded in the above mentioned areas of Dehradun district. The model output provided satisfactory result with the given set of training and test data. The final model had high accuracy is 86.9%.

Acknowledgement

We are thankful to NMPB (National Medicinal Plant Board) for sponsoring the Project.

References

Adhikari, D., Barik, S. K., Upadhaya, K., 2012. Habitat distribution modelling for reintroduction of Ilex khasianaPurk, a critically endangered tree species of northeastern India. Ecological Engineering, 40, pp.37-43

Barik, S., Adhikari, D., 2011. Predicting geographic distribution of an invasive species Chromolaena odorata L. (King) and HE Robins in Indian subcontinent under climate change scenarios. In: Invasive alien plants: an ecological appraisal for the Indian subcontinent, Bhatt, J.R., Singh, J.S., Tripathi, R. S., Singh, S.P. and Kohli, R.K. (Eds.), pp.328.

Iverson, L.R., Prasad, A. & Schwartz, M.K. (1999) Modeling potential future individual tree-species distributions in the eastern United States under a climate change scenario: a case study with Pinus virginiana. Ecological Modelling, **115**, 77–93.

Guisan, A. and Zimmermann, N. E. 2000. Predictive habitat distribution models in ecology. Ecological Modelling, 135(2), pp.147-186.

Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G. and Jarvis, A. 2005. Very high resolution interpolated climate surface for global land areas. International Journal of Climatology, 25, pp.1965- 2198.

Kushwaha, S. P. S. 2011. Remote sensing of invasive alien plant species. In: Bhatt, J. R., Singh, J. S., Tripathi, R. S., Singh, S.P. and Kohli, R.K. (Eds.), Invasive Alien Plants – An Ecological Appraisal For the Indian Sub-continent. CABI, Oxfordshire, pp.131-138.

Mcpherson, J. M. and Jetz, W. 2007. Effects of species' ecology on the accuracy of distribution models. Ecography, 30, pp.135-151.

Pearson, R. G. 2007. Species' distribution modeling for conservation educators and practitioners. Synthesis - American Museum of Natural History, New York, USA, Available from: http://ncep.amnh.org.

Polak, T. and Saltz, D. 2011. Reintroduction as an ecosystem restoration. Conservation Biology, 25(3), pp.424-427.

Rawat, Neelam., Kandpal, Kishor., Purohit Saurabh., 2017. Predicting Potential Habitat Distribution of Rauwolfia serpentina an Important Medicinal Plant using Maxent Modeling in Doon Valley, Uttarakhand State, India. International Journal of Advanced Remote Sensing and GIS. ISSN 2320-0243(Volume-6, Issue-1)

Sastri, B. N., 1990. The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products; Raw Materials, Vol. II, and Industrial Products, Part II, covering letter "C." Publications and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India. pp.427.

Songer, M. A., (2006). Endangered dry deciduous forests of Upper Myanmar (Burma): a multi-scale approach for research and conservation (Doctoral dissertation).

Stockman, Amy K., David A. Beamer, and Jason E. Bond., 2006. An evaluation of a GARP model as an approach to predicting the spatial distribution of non-vagile invertebrate species. Diversity and Distributions 12.1.81-89.

Stockwell, David., The GARP modelling system: problems and solutions to automated spatial prediction.International journal of geographical information science. 13.2 (1999): 143-158.

Thuiller, W., Richardson, D. M., Pysek, P., Midgley, G. F., Hughs, G. O. and Rouget, M. 2005. Nichebased modeling as a tool for predicting the risk of alien plant invasions at a global scale. Global Change Biology, 11, pp.2234-2250.

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C. and Hughes, L. 2004. Extinction risk from climate change. Nature, 427(6970), pp.145-148.

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