International Journal of Research in Engineering, Science and Management
Volume-1, Issue-10, October-2018
www.ijresm.com | ISSN (Online): 2581-5782

Modelling Potential of Maxent Model in Predicting Geographic Distributions of Medicinal Plants

Mamita Kalita[1], P. L. N. Raju[2], Nilakshee Devi[3]
[1]*JRF, Department of Space, North Eastern Space Applications Centre (NESAC), Umiam, India*
[2]*Director, Department of Space, North Eastern Space Applications Centre (NESAC), Umiam, India*
[3]*Professor, Department of Botany, Gauhati University, Guwahati, India*

***Abstract*—Plants have been used medicinally since pre-historic times. The pharmacological activity of chemical compounds present in medicinal plants gives them their scientific basis to be used as modern drugs. Investigations of such compounds in plants have been done by the science of ethno botany. Ethno botany limits itself in mining traditional uses of medicinal plants in drug discovery effects. Field work for plant investigation is time consuming and difficult because it needs high cost and extensive labor. However overall geographic distribution of particular medicinal plant species is of growing interest. The maximum entropy distribution modelling or Maxent model can be used to study the probability distribution of medicinal plant species over a geographical range. Provided with detailed environmental data, endangered and threatened medicinal plant species can also be studied as well as protected with help of such models. The present study is based on use of Maxent model for prediction of species based on presence only data. Maxent model helps in determining spread and explore complex relationships of environment as well as species. Accurate modelling not only helps in study the distribution pattern but also provides a platform to study the ecological as well as conservation status.**

***Index Terms*—pharmacological, ethno botany, maxent, endangered, threatened**

I. Introduction

Remote sensing and geographic information system (RS and GIS) is a powerful technology in species distribution models. They can be used to study habitat distribution of species as well as their suitability in a particular area. The present study is an introduction to species distribution model (SDM) also known as niche modelling, habitat modelling, climate envelope-modelling etc. A common application of SDM is to predict species ranges with other factors as predictors. Remotely sensed data cannot readily identify the plant species, it needs existing environmental and spatial data to identify the potential distribution sites. Many factors would be considered, although the exact choice depends on data availability (Walker & Cocks 1991). For plant investigations various Climatic (temperature, humidity, rainfall), Edaphic (fertility, drainage), Landform (slope, aspect) factors are important for more robust analysis. Further biotic information of land cover and distribution of predators and competitors can be used (Leathwick 2002).Such distribution models are based on:

1) Locations of occurrence of species.
2) Environmental data (climatic, edaphic) etc.
3) Environmental values used along with locations to fit the model.
4) Model is finally used to predict the distribution of species over an area of interest (for past as well future also).

Earlier distribution models were based on relationships with environmental gradient (Murray1866, Schimper 1903, Grinnell 1904). Many models like DIVA, BIOMAPPER (Hirzel and Guisan 2002), GAM (Yee and Mitchell 1991), GARP (Stockwell, 1999) GLM (Lehmann et al., 2002), DOMAIN (Carpenter et al., 1993BIOCLIM (Busby 1991), Maxent (Phillips et al., 2004) have been used as SDM's

(Kriticos and Randall. 2001; Philips et al., 2004; Guisan and Thuiller., 2005; Elith et al., 2006; Sun and Liu., 2010). Several studies indicated that Maxent modeling performed well or better than the other models (Phillips et al., 2006; Elith et al., 2006; Hernandez et al., 2006). It is the least biased estimate possible on the given information (Jaynes., 1957) and also estimates the probability of presence of a plant or animal species based on occurrence records and randomly generated background points by finding the maximum entropy distribution (Phillips et al., 2006).

II. Materials and Methods

The datasets for distribution studies include Satellite images and DEM (digital elevation model) obtained from USGS (United States Geological Survey) source. Maximum entropy model (Maxent) uses precise Geographic coordinates (Latitude and longitude) of species occurrence. The geographic locations of a particular medicinal plant are determined using GPS (Global positioning system). Precise geographic locations with 10 to 15 reference points are to be taken for an effective evaluation. The climatic data including minimum, maximum and mean temperatures, annual rainfall representing long term

TABLE I
POTENTIAL APPLICATION OF SPECIES DISTRIBUTION MODEL
(MANEL 2001) & (GUISAN 2005)

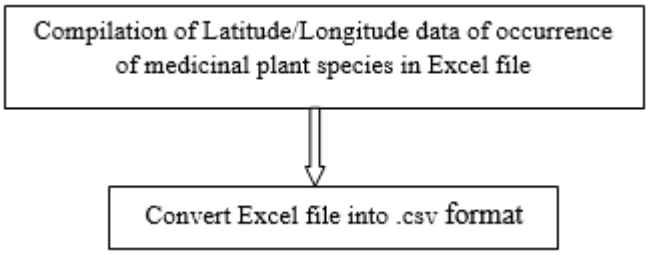
Field of application	Usage	References
Applied Ecology	Predict distributional change in response to changing climate or land use.	(Buckland, 1993)
Conservation Biology	Identifying core habitats for reintroducing species as well. Identifying the effective variables in influencing species distribution. Predicting habitat suitability for the area.	(Anderson, 2009; Beaumont, 2005; Chefaoui, 2005; Rotenberry, 2006; Yáñez, 2000)
Landscape Ecology	Incorporating habitat quality in to models of wildlife population viability. Incorporate landscape structure and composition variables such as habitat patch size, edge effects and juxtaposition and interspersion of habitat requisites.	(Larson, 2004)
Invasive Ecology	Predict sensitive habitat to invasive species. Model negative effect of non-indigenous species on native biota.	(Strubbe, 2009)
Marine Ecology	Mapping coral habitat and determining the effective factors in distribution. Supporting the implementation of environmental legislation, integrated coastal zone management, ecosystem-based fisheries management, marine protected areas, habitat identification	(Davies et al., 2008; Dolan, 2008; Galparsoro et al., 2009; Praca, 2008;Skov, 2008)

will be more effective for defining species ecophysiological tolerances (Nix, 1986; Kumar et al., 2009). The software for Maxent model can be downloaded from website http://biodiversityinformatics.amnh.org/open_source/maxent/ (Version 3.4.1). Maxent modelling need a thorough understanding of software like ESRI ArcGIS©, Microsoft Excel© and Notepad©. The reference points along with bioclimatic and landform factors are used for mapping potential distribution of medicinal plants. One particular species geographic distribution can be determined at a particular time. Default settings can be used to minimize the complexity of model. The statistical analysis of the model can be tested using goodness of fit and accuracy can be determined through defined thresholds and receiver operating characteristic (ROC) plots.

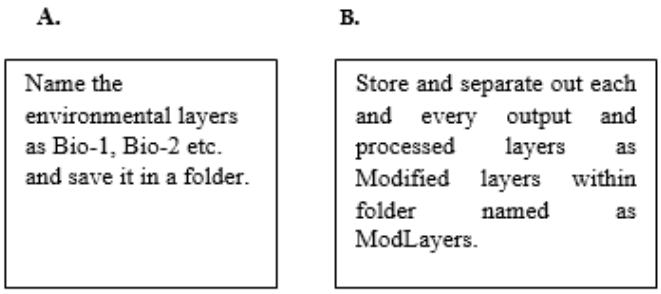
A. Methodology to be adopted during modelling process

1) Loading layers in ArcGIS and opening extract by mask tool

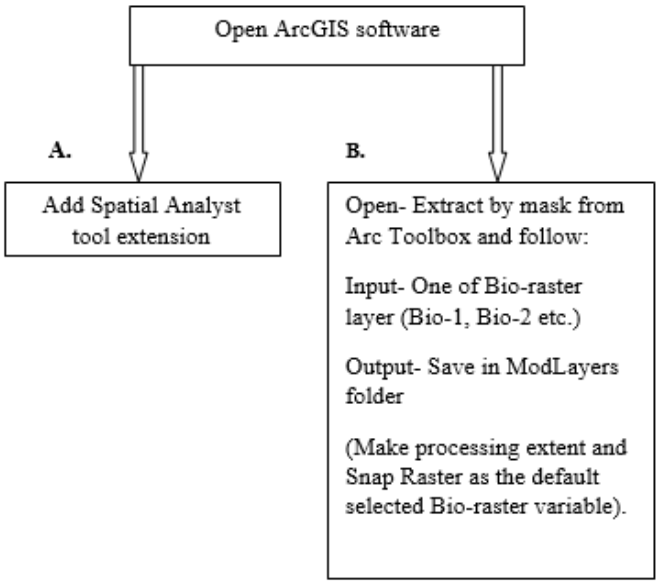
Step-1:



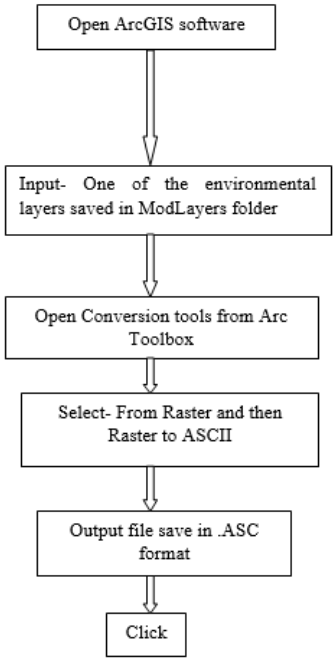
Step-2:



Step-3:

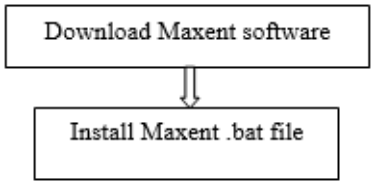


2) Converting environmental raster to ASCII format

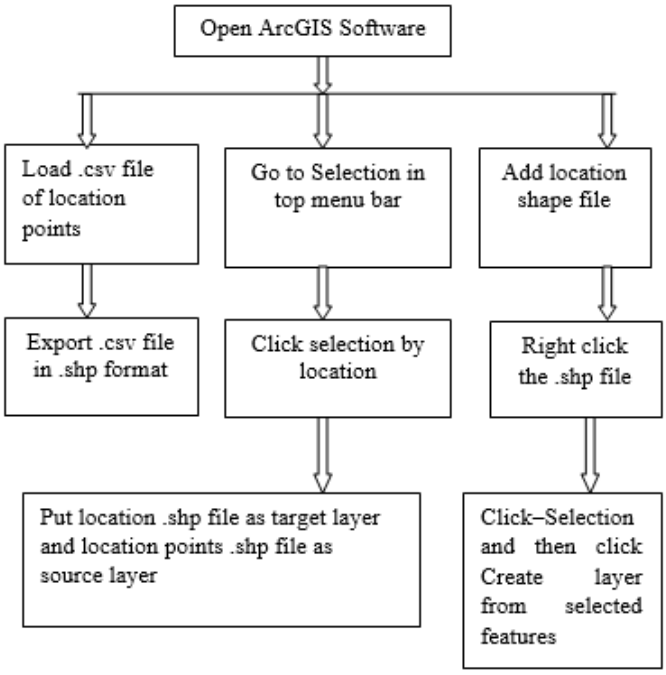


3) Running the Maxent model

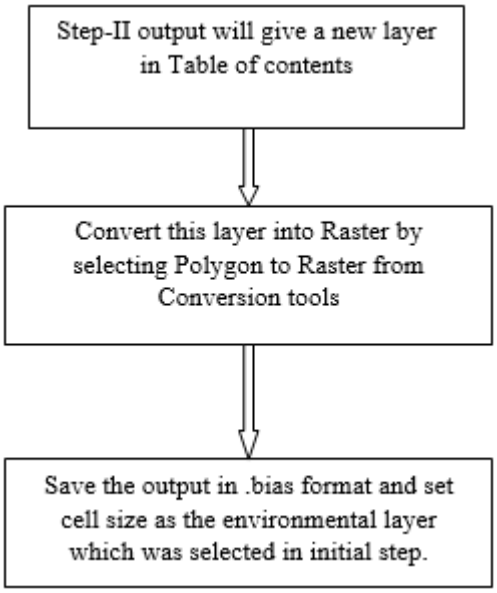
Step-1:



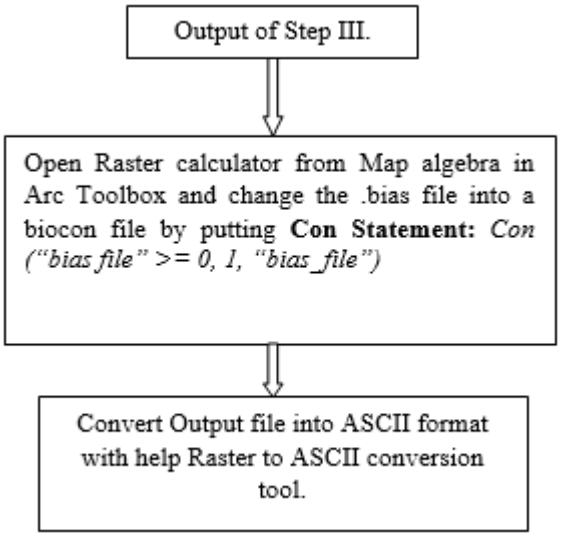
Step-2:



Step-3:



Step-4:

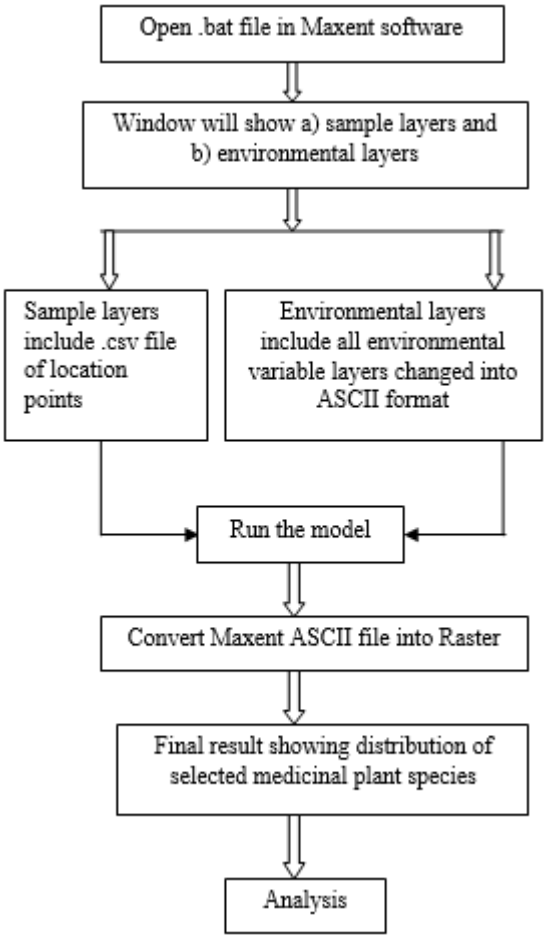


III. Results

The overall distribution of a particular medicinal species can be determined easily with Maxent model. Also the habitat suitability of same species over an area of interest can be obtained provided environmental and other data are available. Area wise distribution and suitability can be obtained based on need. The geographical ranges can be obtained based on existence probability and can be divided into categories such as excellent area, Optimum area, Suitable area, less suitable area and Unsuitable area. In this way one can generate the potential regions for introducing and cultivating the medicinal species. The climate suitability map will be useful to know the detailed species occurrence as well as helps in adopting conservation

strategies.

Step-5:



IV. Conclusion

A habitat distribution model can be obtained from theory based on Maxent model to evaluate and predict the existence and potential habitat quality of medicinal plants. Whether the suitability area will increase or decrease can be determined with help of Maxent model system. The potential habitat of a species from conservation point of view can also be obtained. Further such distribution model helps in showing habitat distribution of threatened and endangered plant species using environment variables and occurrence records. Mapping through Maxent helps in determining the potential threat of medicinal plant species and helps in setting priorities to restore its natural habitat for more effective conservation. The methodology presented here in this study could be used to quantify habitat distribution and may aid restoration efforts. Maxent modelling provides researchers and managers to understand the potential extent of medicinal plant as well as other species in India.

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