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Application of mathematics play a key role in the lithosphere, hydrosphere, biosphere, cryosphere and atmospheric climate change causing natural disasters influencing fundamental aspects of life-supporting systems and other geological processes affecting 'Planet Earth'. Due to an increase in the complexity of the problems faced by the geoscientists, a common effort is required to establish innovative conceptual and numerical models to develop new paradigms. The transformation from descriptive stage to a more quantitative stage involves qualitative interpretations (i.e. conceptual models) complemented with quantitative interpretations (i.e. numerical models, fast dynamic geologic models, deterministic and stochastic models).

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Geostatistical and Geospatial Approaches for the Characterization of Natural Resources in the Environment: Challenges, Processes and Strategies

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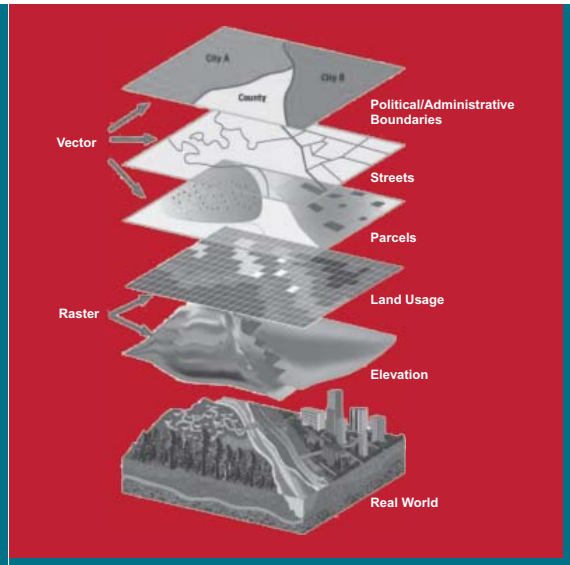

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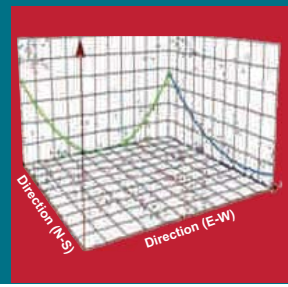

Geostatistical and Geospatial Approaches……Challenges, Processes & Strategies, N.J. Raju (ed),

Prediction of Crop Suitability of Certain Indian Spices –A GIS Approach

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Abstract: GIS technology is a computer-based data collection, storage, and analysis tool that combines previously unrelated information into easily understood maps. GIS can perform complicated analytical functions and then present the results visually as maps, tables or graphs. This allows decision-makers to virtually see the issues before them and then select the best course of action. The database prepared from existing field survey can be compiled using digital map for monitoring the availability of the species in the unknown locations through Ecocrop model of DIVA GIS. The spatial analysis thus helps in choosing the best location for the crop depending on the environmental parameters. The plotting of *Piper* species and *Garcinia* species collected from Western Ghats gave information of the species richness sites as well as the diversity of the species . Based on these results the prediction of the distribution of *piper* species and *Garcinia* species in North Eastern India was done and confirmed the availability with survey. The climatic parameters, important for crop suitability, The studies indicated that area under the natural habitat or the cultivation of the crop has a positive relation with the environmental suitability.

Keywords: GIS technology, Ecocrop model, prediction, *piper* species and *Garcinia* species.

1 INTRODUCTION

The genus *Piper*, the largest in the family Piperaceae consisting of more than 1000 species, occurs throughout the tropical and subtropical regions. The distribution of *Piper* ranges from sea level to the high ranges of Western Ghats and Sub Himalayas in India. The sub mountainous tracts of the Western Ghats are believed to be the centre of origin of black pepper, *Piper nigrum*L. *Piper* species occurring in India are economically Important.The genus *Garcinia*(Family: *Cluciaceae*) consists of over 200 species distributed in the tropics of the world, chiefly in Asia, Africa, and Polynesia. They are evergreen polygamous trees, shrubs and herbs. About 35 species are reported to exist in India, many of which are endemic and economically important, with immense medicinal properties (Roberts, 1984).*Garcinia*is the source for a natural diet ingredient (-) hydroxycitric acid, HCA which is an anti obesity compound.Geographical Information System (GIS) has been successfully used to study geographic distribution of cultivated species as well as pests of agricultural crops 10,11. Hence the present study was undertaken to investigate morphological grouping of the species and species richness of *Piper* and *Garcinia*using GIS, to describe the geographic distribution of the *species*. This study will provide baseline data for further analysis on exploration, conservation and use of germplasm of wild crop relatives as well as for studies on the factors that explain the geographic distribution of species.

2. MATERIAL AND METHODS

The geographical information (altitude, longitude and latitude) of the collection sites of *Piper* and *Garcinia* species were obtained by GPS, imported and was converted to shape file in which each spots representing the geographical location of the collection, using DIVA-GIS tool.The grid maps of temperature, rainfall and elevation were superimposed on the shape file to analyse the temperature, rainfall and altitude of all the sample collection locations.The diversity of *Garcinia* and *Piper* species were determined using tool Shannon's Diversity index method (Shannon and Weaver, 1949)and species richness in the collection area was determined by method of DIVA-GIS.Using 'ECOCROP' model,and the climatic information the domain of the two crops in India was predicted and confirmed by survey.

2.2. RESULTS AND DISCUSSIONS

Systematic surveys were conducted in 483 sites to collect *Piper* species in the Western Ghats, the major centre ofdiversity for the species in India. Live specimens were collected and established in the black pepper germplasm conservatory of the Indian Institute of Spices Research, Calicut. The altitude, longitude and latitude of the collection site were recorded using GPS. The data were plotted using DIVA-GIS software to study the distribution, diversity and richness of *Piper* species. Altitude map and rainfall map were prepared with the help of point-to-grid cells of the climatic data map optionof DIVA-GIS, using a grid size of 18′ x18′ km cells and superimposed with the species distribution map (Fig-1) to compare with the cluster groups and study the possibility of any specific pattern. For the rainfall map BIOCLIM model of annual precipitation was used. Altitude and rainfall are considered to be the most important aspects influencing the distribution of *Piper* [1] Species diversity and richness map was prepared with the help of point-to-grid analysis option of DIVA-GIS, using circular neighbourhood method with a radius of 50 km. The superimposed map of BIOCLIM annual precipitation and species distribution indicates that *P.longum*naturally occurs in the high-rainfall zones (morethan 4000 mm), while the rest of the species is presentwithin 1500–3000 mm rainfall zone. A well-distributed rainfall within the range of 1000–3000 mm is best suitedfor proper growth and development of pepper. [2] The annual rainfall in all the collection sites ranged from 1500 to4000 mm. Species such as *P. babubudani, P. thomsoni*, *P. longum*and *P. galeatum*are found in areas receiving rainfall over 2000 and up to 4000 mm.

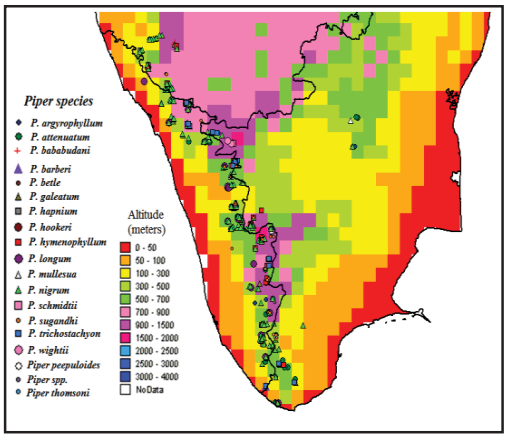

Fig.-1.Altitude map of southern India and *piper* species distribution

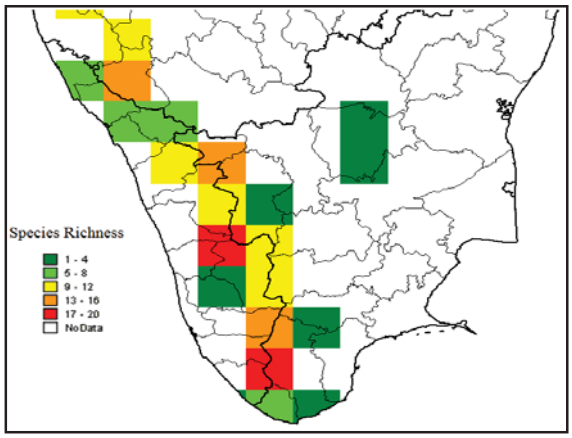

Fig-2.*piper* species Richness map at S. India

Species richness map (Figure 2) shows two hot spot areas. One is between 75°92¢–77°06¢E long. and 10°95¢–11°03¢N lat., consisting of Achankovil, Kulathapuzha, Silent Valley and Tiunelly, Kerala, and Nilgiris, Tamil Nadu. Another is in the extreme south, between 76°92¢–77°45¢E long. and 8°07¢–9°10¢N lat., consisting of Neyyar andPoovanathmodu, Kerala and Brymore, Kanyakumari district and Kodayar; Kariardam and Kannikatty; Tirunelvelydistrict, Tamil Nadu, where 7–8 species are available in the same site.

Based on our study, the species can be broadly divided into three groups. The first group occurs in high altitude (300–1000 m), the second group at medium altitude (100–500 m) and the third group at lower altitudes (50–150 m). About 15 qualitative characters were recorded from the 16 samples collected (both live specimen and herbarium). These were computerized using SPSS software for cluster analysis (15 characters of 16 species) by hierarchical clustering to spatially group the species based on similarity matrix (Figure 3). A scatter diagram was prepared using SPSS software to understand species distribution along the environmental gradients. The scatter diagram of species distribution (Figure 4) prepared with rainfall and altitude shows that the high altitude species are falling in comparatively low-rainfall grids of the BIOCLIM map. In southern India, coastal areas which received more rainfall are at low altitude areas. The species clustered in the same cluster are are showing same altitude and rainfall in the scattered diagram indicates that morphological characters are influenced by the environmental parameters.

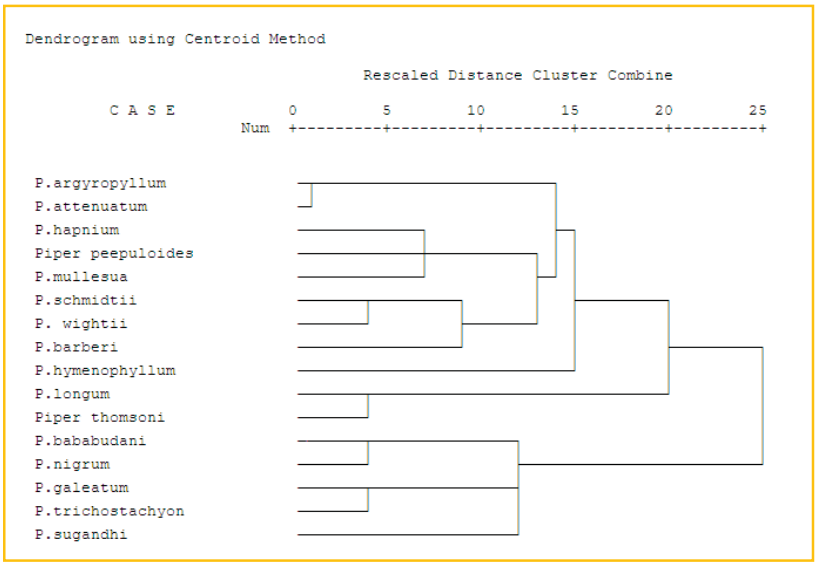

Fig-3 Hierarchical cluster of 16 species.

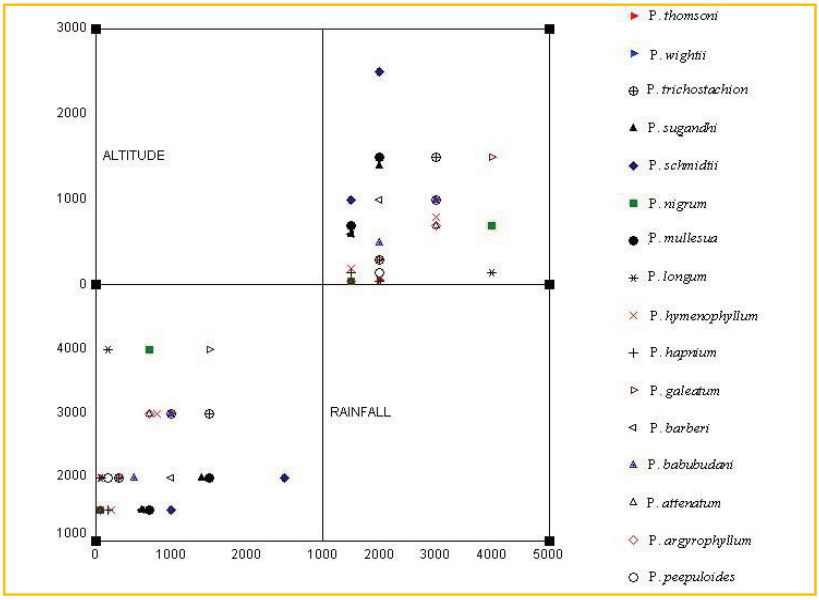

Fig-4.A scatter diagram

GARCINIA

The environmental information like altitude, temperature and precipitation information of the garcinia collection sites of westernGhats were plotted in the India map and with the help of Ecocrop model of DIVA GIS. The map predicted that North Eastern Himalayan foot hills are also excellent habitats for *Garcinia*.Survey in the states of North east was done based on the prediction and 5 species were collected which are all different from the Western Ghats species. A visit to the Herbarium of the Botanical Survey of India ,Shibpur, Kolkata , gave a very clear idea about the species identity. It is very interesting to report that these species were reported by Hooker and Kings from N.E.States on 17th century. Our survey recededthat these species are only known to the local people where it is available and by different local names.*Garcinia* is one among a few genus in the plant kingdom showing a great diversity in the morphology especially of leaves and flower[3]. Many species of *Garcinia* are threatened due to habitat destruction [4] and many species of *Garcinia* falls in IUCN red list. Another issue faced by the researchers is the synonymity of certain species[5] ..This study reported that though the two ecosystems like Western Ghats and Himalayan foot hills are wide apart from each other the weather

patterns of Garcinia adobes is similar. The Garcinia species showed a wide range in the altitudes of occurrence (10 – 1500 m MSL); there was specificity in average annual temperature (17 - 23°C) and total rainfall (2000 – 4200 mm).After collecting 5 species from Western Ghats and 5 species from Himalayan foot hills the genetic set up of the species studied with the help of markers and the sequences of some specific genomic DNA region. In the phylogenetic similarity cluster two species appeared and it was very interesting to note that between them, one is from Western Ghats species and another from the Himalayan species.It shows that the morphological variation the species containing is due to the variation of the ecosystems otherwise the types of species recorded in the two different ecosystems are almost same and may have originated themselves in the two different ecosystems when they have found the same type of environmental conditions.

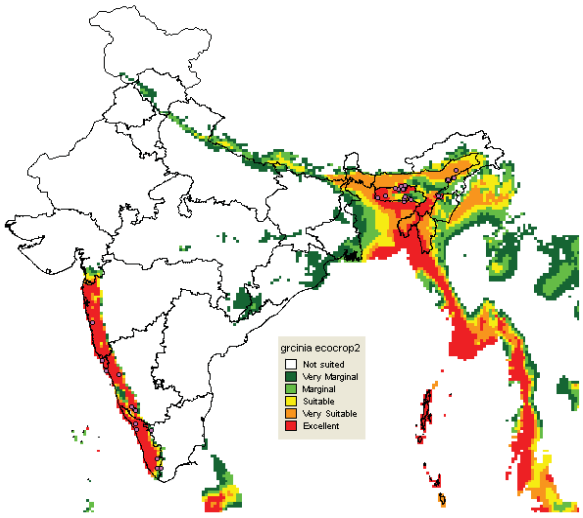

Fig 5:*Garcinia* domain prediction by ECOCROP model

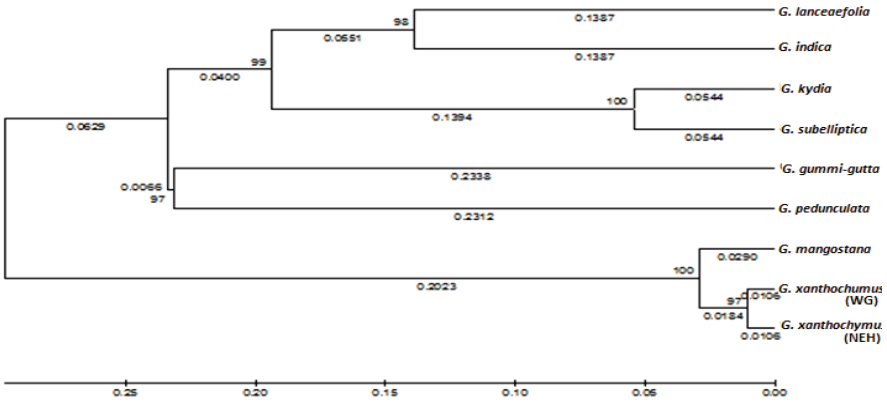

Fig. 6: Evolutionary relationship of selected *Garcinia* species using Neighbor-joining method

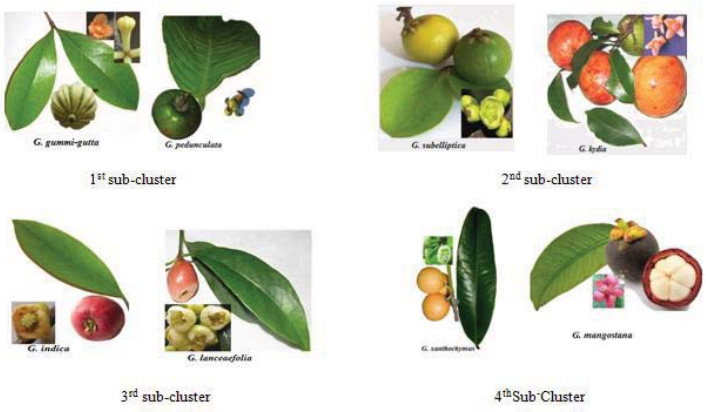

Fig. 7: Photographs of the species of the different sub clusters

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