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Integrating Multi-Sensors Data for Species Distribution Mapping Using Deep Learning and Envelope Models

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Abstract: The integration of ecological and atmospheric characteristics for biodiversity management is fundamental for long-term ecosystem conservation and drafting forest management strategies, especially in the current era of climate change. The explicit modelling of regional ecological responses and their impact on individual species is a significant prerequisite for any adaptation strategy. The present study focuses on predicting the regional distribution of *Rhododendron arboreum*, a medicinal plant species found in the Himalayan region. Advanced Species Distribution Models (SDM) based on the principle of predefined hypothesis, namely BIOCLIM, was used to model the potential distribution of *Rhododendron arboreum*. This hypothesis tends to vary with the change in locations, and thus, robust models are required to establish nonlinear complex relations between the input parameters. To address this nonlinear relation, a class of deep neural networks, Convolutional Neural Network (CNN) architecture is proposed, designed, and tested, which eventually gave much better accuracy than the BIOCLIM model. Both of the models were given 16 input parameters, including ecological and atmospheric variables, which were statistically resampled and were then utilized in establishing the linear and nonlinear relationship to better fit the occurrence scenarios of the species. The input parameters were mostly acquired from the recent satellite missions, including MODIS, Sentinel-2, Sentinel-5p, the Shuttle Radar Topography Mission (SRTM), and ECOSTRESS. The performance across all the thresholds was evaluated using the value of the Area Under Curve (AUC) evaluation metrics. The AUC value was found to be 0.917 with CNN, whereas it was 0.68 with BIOCLIM, respectively. The performance evaluation metrics indicate the superiority of CNN for species distribution over BIOCLIM.

Keywords: spatial distribution modelling; convolutional neural network; *Rhododendron arboreum*; biodiversity management; ecological responses

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1. Introduction

The Himalayan ecosystem is experiencing a continuous temperature rise, and the impact of climate change can be seen very clearly in the Himalayas, which demonstrates the need to monitor the Himalayan ecosystem even more [1,2]. The Himalayas are home to several medicinally and economically important plant species, *Rhododendron* species with botanical name *Rhododendron arboreum Sm.* from the family Ericaceae is among one of them [3–5]. It is widely spread in Himalayas, South India, and Sri Lanka [4]. With tremendous biological significance, it can sustain itself in the fragile ecotone between the alpine and subalpine biomes. Despite being identified as a medicinally important plant species, the geographical distribution and geospatial modelling of *Rhododendron arboreum* have not been explored to its fullest and needs to be deciphered, which will further benefit the formulation of conservation strategies [6]. The literature review of past