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COMMUNICATION

Species distribution modelling of Baya Weaver *Ploceus philippinus* in Nagaon District of Assam, India: a zoogeographical analysis

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Abstract: Identification and mapping of the spatial distribution of species is an important aspect of zoogeographical enquiry. The habitats of many species are facing the threat of depletion in increasingly human-influenced environments. This has already led to the extinction of many species in different localities, making understanding the linkages between anthropogenic threats and species distribution of utmost importance. A GIS-based model was applied to gain an overall picture of the potential distribution of *Ploceus philippinus* (Baya Weaver) in and around Nagaon District in Assam. The used maxent model in the GIS environment gives a highly significant Area Under Curve (AUC) validation statistic of 0.99. Out of the total area of 3,975 km^2, 596.86 km^2 (15%) is demarcated as a high-potential area. Such predictions are highly useful in assisting in the conservation of threatened species under current and future climatic conditions.

Keywords: AUC, birds, environment, GIS, habitat, mapping, Maxent, potential, northeastern India, spatial distribution.

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INTRODUCTION

The Baya Weaver *Ploceus philippinus*, is distributed throughout the Indian subcontinent and southeastern Asia. There are five species in the *Ploceus* clade: *P. philippinus*, *P. manyar*, *P. benghalensis*, *P. hypoxanthus*, and *P. megarhynchus* (De Silva et al. 2019*).* The Baya Weaver has a unique courtship display involving the nest-building that it is known for, and has multiple adaptations to its ecological niche. The male weaver bird puts a lot of effort and time into making a beautiful hanging nest and then invites a female bird by flapping its wings to choose it as their nesting place (Arigela et al. 2021). The weaver selects various trees, bushes, and other sites for building its nests, showing a preference for thorny acacias and specific palm species. The avian population in a particular region tends to favor a distinct type of nesting location (Davis 1974). Indian Baya Weavers have been observed to establish colonies on a remarkable range of plants. They have also been known to choose unconventional structures such as house eaves (Davis 1971), telegraph and power lines (Ambedkar 1970), and the sides of irrigation wells (Ali 1931; Crook 1960, 1963) as occasional sites for suspending their nests (Davis 1972). Over 84 percent of the colonies in the Assam region were on Areca palm (Davis 1972).

Maxent (Maximum entropy model) is a machine learning technique that can be used for SDM (Species distribution modelling) due to its use of maximum entropy to determine the probability of a species' presence and absence in each area. This method combines a variety of independent regional climate, land-use, topography, and other environmental and ecological variables into a single model of species' distributions. It then applies the principle of maximum entropy to the dataset. It is an increasingly popular machine learning algorithm used in SDM, which is a technique that can be used to predict the locations where species may occur, by examining the potential environmental, ecological, and socioeconomic factors associated with their distribution. Maxent is a machine learning algorithm that has become an increasingly popular choice for SDM (Phillips & Dudik 2008).

Several works have been done on species distribution model and habitat suitability analysis using Maxent model in India and across the world. The works of Reside et al. (2010), Syfert et al. (2013), Booth et al. (2014), Fourcade et al. (2014), Padalia et al. (2014), Jathar et al. (2015), Sarma et al. (2015), Moya et al. (2017), Bradie & Leung (2017), Rhoden et al. (2017), Palacio & Girini (2018), Nameer & Sanjo (2020) are worth mentioning as they have found the Maxent model has the ability to provide accurate predictions with different species and with different environmental variables .

The current paper analyzes the distribution or range of Baya Weaver in Nagaon District of Assam, India. Through the use of geographic information systems, species distribution modelling and remote sensing data, the habitat suitability classes like least potential, moderate potential, good potential and high potential classes for the Baya Weaver is identified. The Maxent (Phillips & Dudik 2008) model is popular among many scientists in investigating the potential distribution of floral and faunal species. Through this analysis we will gain insight into the bird's current and probable habitat and hopefully be able to provide recommendations for management and conservation efforts suitable for this species.

MATERIALS AND METHODS

Study Area

The present Nagaon and Hojai districts (Figure 1) are situated in the middle part of Assam between 25.72 & 26.75 ^{0}N and 93.42 & 93.33 ^{0} E. It is surrounded by Sonitpur District in the north, Karbi Anglong and North Cachar hills in the south, Karbi Anglong and Golaghat districts in the east, and Morigaon District in the west. The mighty river Brahmaputra flows along the northern periphery of the district. Three Important Bird Areas (IBA) fall within Nagaon District: Deobali Jalah (IN-AS-11), Kaziranga National Park and Tiger Reserve (IN-AS-25) and Laokhowa-Burhachapori WS (IN-AS-28) (Rahmani et al. 2016). Nagaon District also falls under the range state of central Asian flyway.

Methods

The field survey was conducted randomly at several locations in Nagaon District of Assam to cover both summer (March to August) and winter seasons (January to February) and GPS points were collected using handheld GPS devices. While surveying the locations, local residents were interacted with to gather information about nesting sites of Baya Weaver. During the surveys, opportunistic sightings of nesting sites of Baya Weaver were also recorded. After that, the maxent model (Phillips & Dudik 2008) was used for predicting the habitat suitability of Baya Weaver in Nagaon District of Assam. During the run, six presence records were used for training and two for testing, 10,006 points were used to determine the Maxent distribution (background

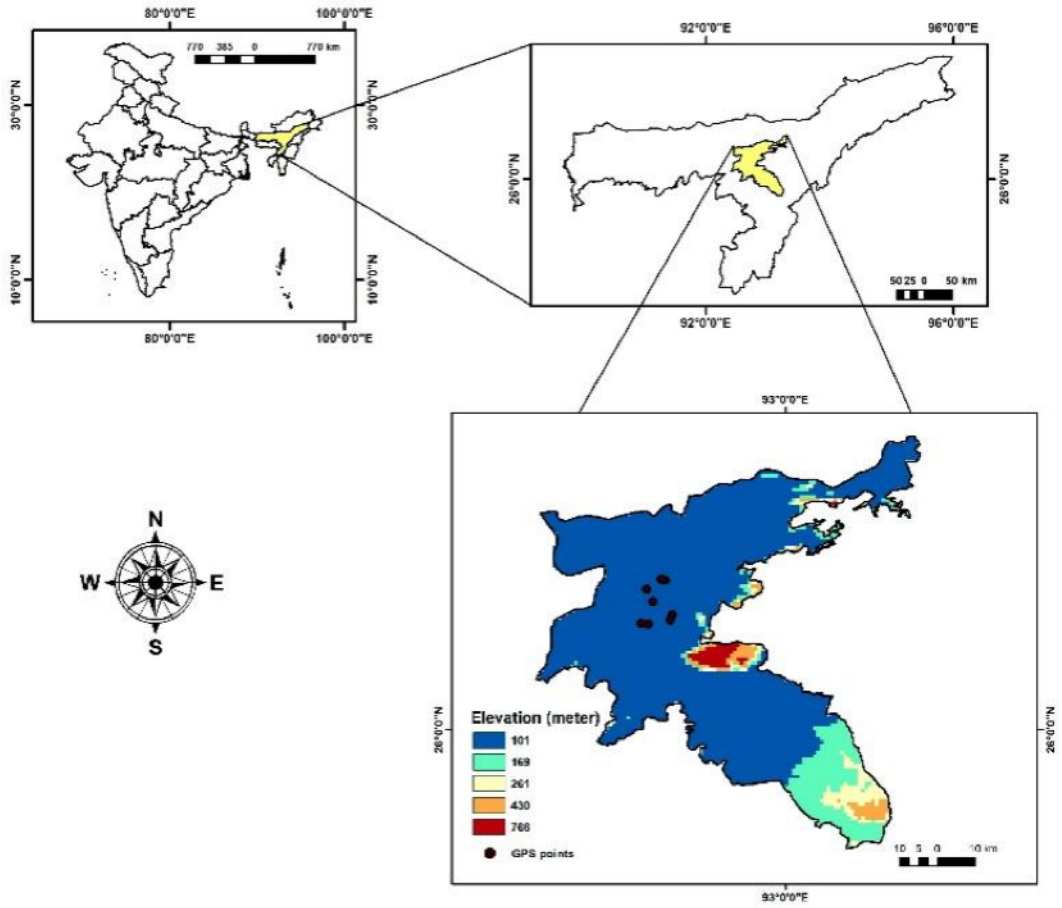

Figure 1. Location of the study area showing GPS points of Nagaon district of Assam, India.

points and presence points). Regularized training gain is 5.245, training AUC is 0.999, unregularized training gain is 6.310. Unregularized test gain is 5.668. Test AUC is 0.999.

Nineteen environmental variables (BIO1 = Annual Mean Temperature, BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp)), BIO3 = Isothermality (BIO2/BIO7) (×100), BIO4 = Temperature Seasonality (standard deviation ×100), BIO5 = Max Temperature of Warmest Month, BIO6 = Min Temperature of Coldest Month, BIO7 = Temperature Annual Range (BIO5-BIO6), BIO8 = Mean Temperature of Wettest Quarter, BIO9 = Mean Temperature of Driest Quarter, BIO10 = Mean Temperature of Warmest Quarter, BIO11 = Mean Temperature of Coldest Quarter, BIO12 = Annual Precipitation, BIO13 = Precipitation of Wettest Month, BIO14 = Precipitation of Driest Month, BIO15 = Precipitation Seasonality (Coefficient of Variation), BIO16 = Precipitation of Wettest Quarter, BIO17 = Precipitation of Driest Quarter, BIO18 = Precipitation of Warmest Quarter, BIO19 = Precipitation of Coldest Quarter) with a spatial resolution of 30 arc second (Fick & Hijmans 2017) were downloaded from worldclim.org along with slope, elevation and aspects raster and a multicolinearity test was conducted (Mehmud et al. 2022). Variables with a cross correlation of ±8 or more were excluded from the model to reduce the data redundancy and improve the performance of the model (Figure 2). The Shuttle Radar Topography Mission (SRTM) (Rodrıguez et al. 2005) elevation raster and the Terra and Aqua combined Moderate Resolution Imaging Spectroradiometer (MODIS), MCD12Q1 (Friedl & Sulla-Menashe 2019) land cover type was also used in the study and LULC map is prepared. The products give yearly intervals of global land cover categories (2001-2018). In the study, a classification scheme based on the leaf area index (Friedl & Sulla-Menashe 2019) was applied. Leaf area index in a classification scheme for categorizing land cover types based on the amount of leaf area per unit ground area. It also measures the density and structure of vegetation which affects the exchange of energy, water and carbon between the land surface and the atmosphere.

RESULTS AND DISCUSSION

Habitat

In our study, it was observed that the Baya Weaver prefers to make nests in trees located near grasslands and wet plains where there is standing water or small pools to forage for food. They also thrive in wetlands and cultivated areas. During the field visits, it was observed that this species mostly occupies trees in agricultural fields and even few pockets of urban settings (Figure 3). It is common to observe the bird creating huge loosely woven, roof-like nests made of dried leaves, grass, and coconut fronds out of its environment (Davis 1974). The nests are usually located in shrubs, trees, and other tall vegetation. These nests (Image 1) provide ideal shelter for them and also help in attracting a mate. The Baya Weaver also has a preference for nesting near other birds, which helps in its defense if it comes under attack by predators (Street et al. 2022). They are also found in large flocks during migratory season, due to their go-it-alone personalities.

Spatial modelling

Identifying and charting the spatial distribution of species is a critical element of any zoogeographical investigation. It gives us a great insight into the current habitats of species many of which are now facing severe threats from a human-altered harsh environment. Owing to human activities and the growing pressure of human populations put on habitats, many species are becoming threatened. As such, a GIS based study has been applied to gain an understanding of the potential distribution of species in and around the Nagaon District of Assam. The habitat suitability map generated by Maxent in GIS was based on selected environmental parameters. The results showed by the maxent model suggest that among these environmental variable number 17 (Precipitation of Driest Quarter), 14 (Precipitation of Driest Month), slope and land use have 38.3,21.6, 24.7, and 5.7 percent contribution. Pearson's correlation coefficient (r) was used to conduct multicollinearity test (Mehmud et al. 2022) for the region of Assam. The test AUC and training AUC of the maxent model is 0.99. The importance of environmental variable can be identified by looking at the Jackknife test (Figure 4). Maximum iteration was set to 1,000 for the analysis.

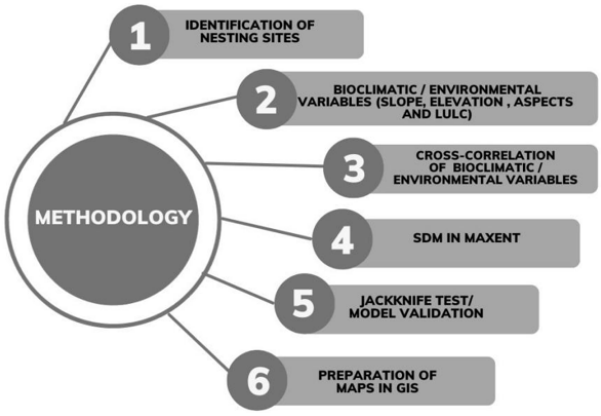

Figure 2. Methodology used in species distribution modelling of Baya Weaver..

The potential habitat (Figure 3) suitable for the nesting sites of Baya Weaver is estimated from the model within the periphery of the availability of water sources. The model also suggests that the rainfall in the driest quarter and rainfall in the driest month are a significant role in the spatial distribution of the said bird species. Out of the total area of 3,975 km^2, 596.86 km^2 (15%) area is demarcated as a good and high-potential area. Using the map as a guide, another field visit was conducted and discovered a few colonies in and around the areas identified as suitable. One of the observations was that, in one location, it was found nesting in banyan trees, rather than the more common tree species of *Areca* Palm.

CONCLUSION

The zoogeographical analysis of Baya Weaver in Nagaon District of Assam was aimed to detect the optimum environment for its favorable distribution and viable long-term conservation. The study showed that anthropogenic land-cover such as agriculture, water bodies and infrastructure play significant roles in determining the potential range of the bird species. In addition, precipitation of driest quarter (bio 17) and precipitation of driest month (bio 14) were also found to be suitable for the species. The associated vegetation cover of the habitat played an important role in the increased number of individuals and their distribution area as observed from the Land use and land cover map and field visits. These findings clearly demonstrate the importance of robust species conservation models for Baya Weaver in Nagaon. Therefore, this study provides a useful perspective on determining landscape features in order to conserve this species in the future. This study represents the first zoogeographical investigation into habitat suitability mapping of Baya Weaver in the Nagaon region of Assam. It provides researchers with valuable insights into the potential locations of said

Image 1. Nesting sites of Baya Weaver in various locations of Nagaon district of Assam, India. © N. Bora.

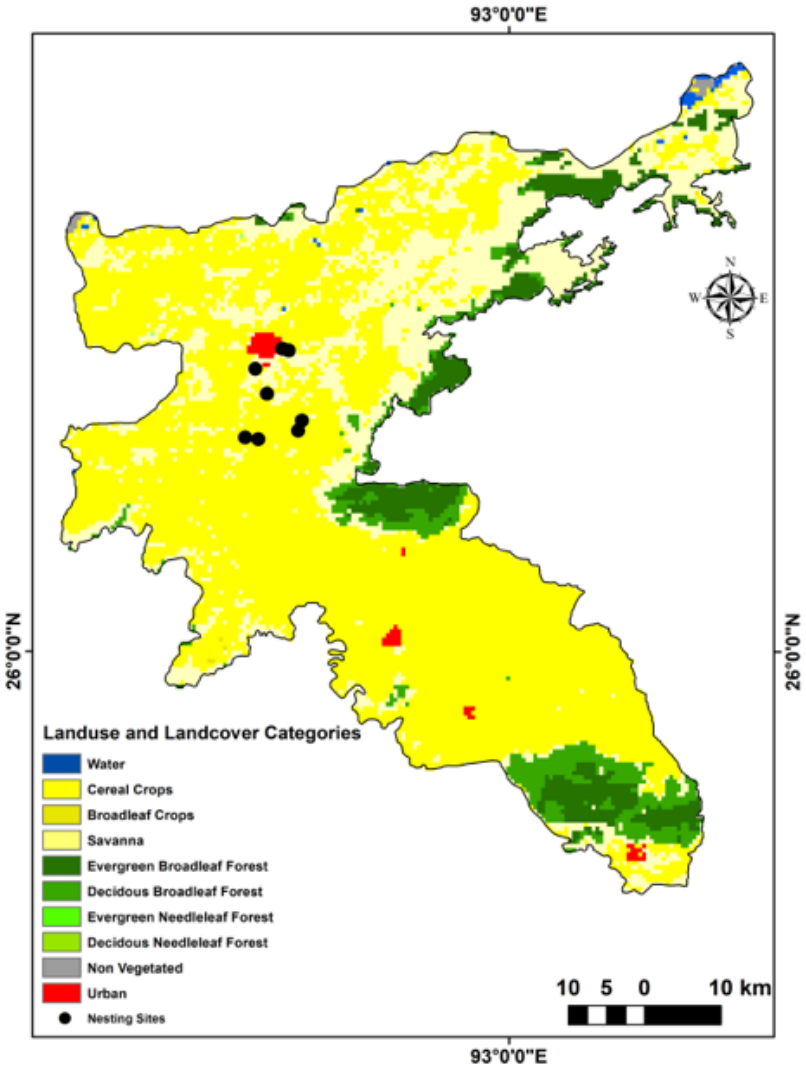

Figure 3. Land use and land cover map of the study area with location of nesting sites.

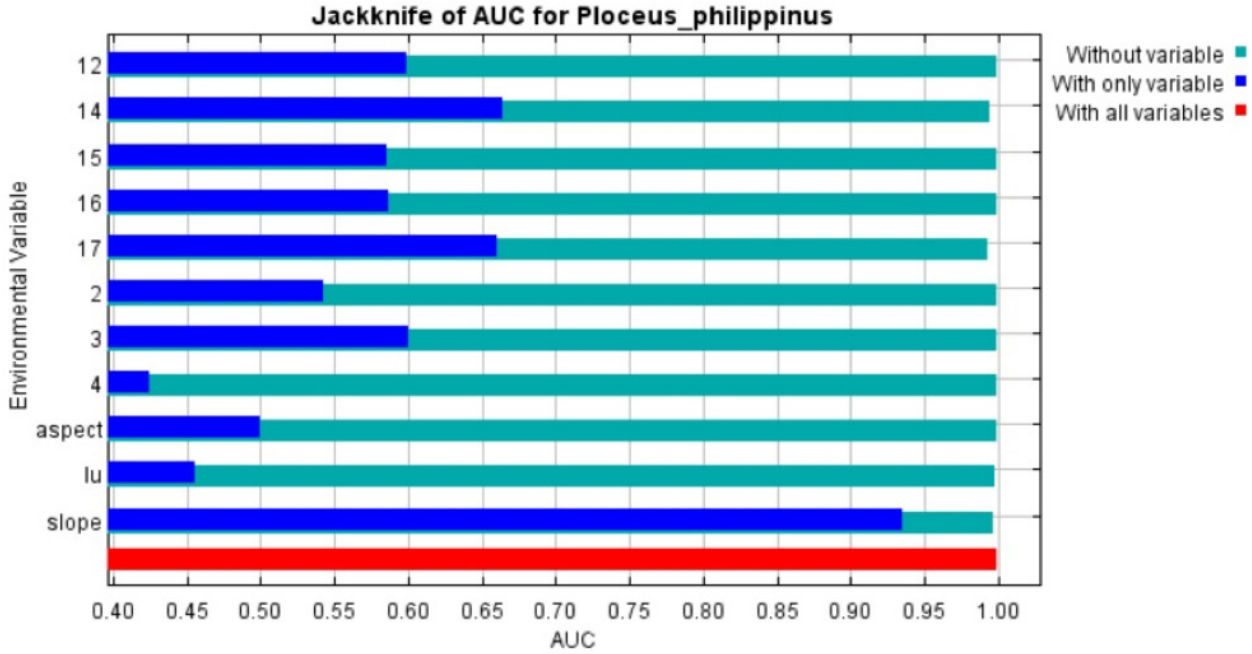

Figure 4. Jackknife test of environmental variables used in Maxent model.

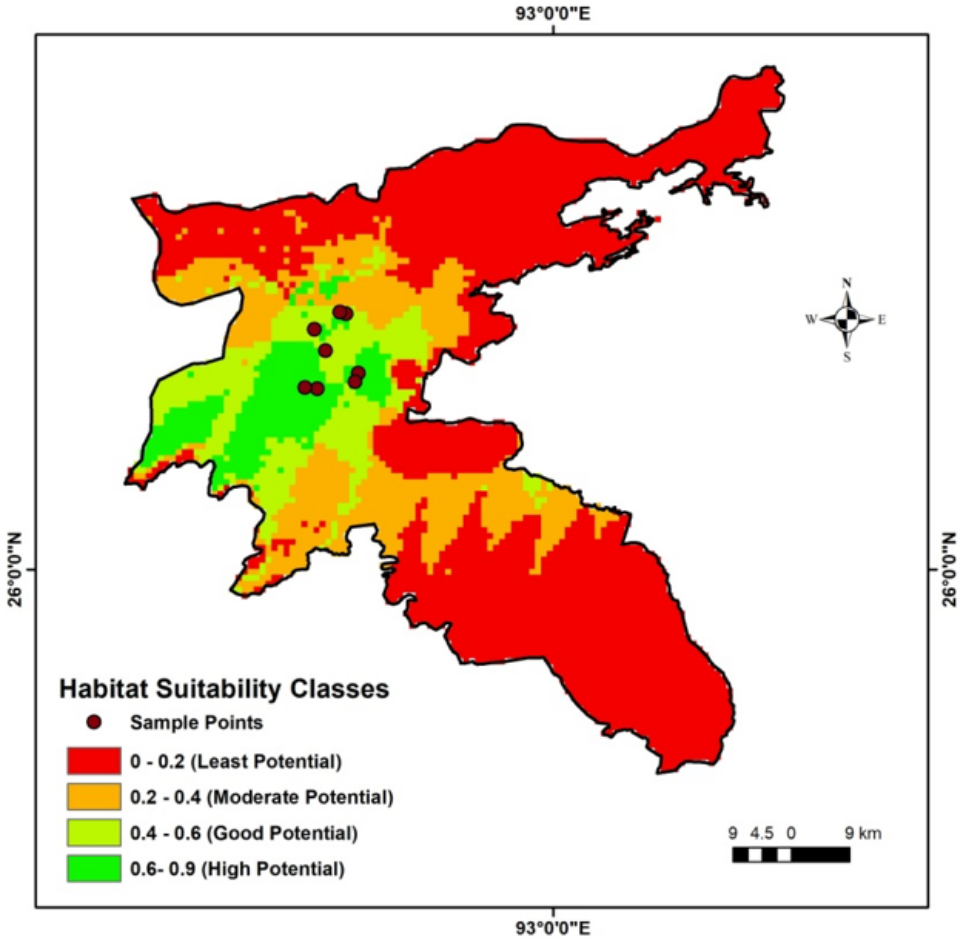

Figure 5. Habitat suitability map of Baya Weaver *Ploceus philippinus* in Nagaon District in Assam.

bird species in the area, utilizing bioclimatic variables. Subsequent research endeavors can build upon this habitat mapping to explore the reasons behind the low geographical coverage (15 % geographical area) of Baya Weaver population in the region.

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