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Contributing Environmental Factors of Habitat Suitability for the Great Argus (*Argusianus argus*) in Bukit Barisan Selatan National Park, Indonesia

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Abstract

The great argus (Argusianus argus)*, a key outstanding universal value* (*OUV*) *species in Bukit Barisan Selatan National Park* (*BBSNP*) *within the tropical rainforest heritage of Sumatra* (*TRHS*)*, is listed as vulnerable by the IUCN red list due to extensive deforestation and habitat fragmentation. Yet, its habitat preferences and spatial distribution remain poorly understood. This study aimed to model the potential distribution of the great argus and identify key environmental factors influencing its occurrence within the Way Canguk Research Station* (*WCRS*)*, BBSNP. We employed the Maximum Entropy* (*MaxEnt*) *algorithm using data from field surveys and camera traps combined with environmental variables including elevation, slope, distance to rivers, normalized difference moisture index* (*NDMI*)*, temperature, rainfall, distance to roads and settlements, NDVI, and land cover. The model exhibited high predictive performance* (*AUC = 0.846*)*. Distance to roads, rainfall intensity, and the presence of primary forest emerged as the most influential factors. The species showed a preference for primary forests located far from human disturbances and in areas with lower rainfall levels. These findings confirm WCRS as a suitable habitat for the great argus and underscore the urgency of preventing deforestation, restoring degraded lands, and mitigating road impacts to preserve BBSNP's ecological integrity and sustain TRHS's world heritage status.*

Keywords: *AUC, MaxEnt, model, remote sensing*

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Introduction

The great argus (*Argusianus argus*) is a terrestrial bird species from the Phasianidae family, predominantly found in the forests of Sumatra and Kalimantan at altitudes below 1,200 m (Clink et al., 2021; Laneng et al., 2021). Known for its elaborate mating dance performed by males during the breeding season, the species is highly sensitive to human presence (Azahar et al., 2023), restricting its distribution to undisturbed habitats with sparse understory (Laneng et al., 2021; Valley et al., 2022). This loss of habitat not only endangers the great argus but also impacts local cultural practices that rely on its presence. Among the Dayak tribes, the feathers of the great argus are integral to crafting traditional warrior and dance costumes, symbolizing cultural heritage and artistry (Trisnawati et al., 2023). Similarly, the *Anak Dalam* tribes regard the bird as their equivalent of domestic chickens, highlighting its importance in their daily lives and cultural identity (Prastio et al., 2023).

The great argus's dependence on pristine habitats, coupled with habitat destruction and declining populations, led to its reclassification as vulnerable on the IUCN Red List in 2020 following a long period of being listed as near threatened (BirdLife International, 2020). It has been legally protected under Indonesia's Ministry of Environment and Forestry since 2018. As one of the outstanding universal values (OUV) of Bukit Barisan Selatan National Park (BBSNP), part of the tropical rainforest heritage of Sumatra (TRHS), the great argus holds significant ecological and cultural importance. BBSNP, a UNESCO world heritage site since 2004, remains a critical refuge for the species (United Nations Educational, Scientific and Cultural Organization, 2004). However, habitat degradation from deforestation and road construction threatens biodiversity in this area (Setyawati et al., 2021; Ascensão et al., 2022). BBSNP's extensive lowland forest and protected status make it a vital refuge for the great argus, particularly in the face of habitat fragmentation elsewhere in Sumatra.

Despite its ecological and cultural significance, the great argus remains poorly studied in terms of its spatial distribution, limiting the development of targeted conservation strategies. Recognizing its status as an OUV species within TRHS underscores the urgency of addressing these research gaps. Previous research has mainly focused on its ecology, such as dispersal, behavior, and habitat preferences (Nijman, 1998; Winarni et al., 2009; Laneng et al., 2021; Savini et al., 2021), but studies on spatial

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distribution and habitat suitability remain scarce. This is because the species' solitary and cryptic behavior leads to low detection rates, dense canopy and understory vegetation restrict visual surveys, and field conditions in BBSNP limit access and survey coverage. These constraints reduce the feasibility of obtaining spatially comprehensive occurrence data necessary for robust species distribution models (SDMs).

Addressing this gap, this study employs MaxEnt (Phillips & Dudík, 2008), a robust presence-only SDM, to model habitat suitability for the great argus within the Way Canguk Research Station (WCRS), BBSNP. By integrating systematically collected field survey data, camera trap records, and diverse environmental variables, this research provides the first spatially explicit habitat suitability model for the species in this landscape. The findings aim to guide habitat restoration efforts and prioritize conservation areas in BBSNP, particularly the WCRS. These insights are critical for habitat management, land-use planning, and developing targeted conservation strategies to mitigate deforestation impacts and ensure the long-term survival of this vulnerable species. Ultimately, these insights contribute to maintaining the ecological integrity of BBSNP and safeguarding the TRHS's UNESCO world heritage status.

Methods

Study area BBSNP spans the southern tip of Sumatra, stretching from the western part of Lampung Province to the southern part of Bengkulu Province, encompassing approximately 355,511 ha (Figure 1). The research was conducted from March to April 2021 at the WCRS, a lowland forest located in the southwestern region of BBSNP. The research station covers an area of approximately 800 ha, with an elevation range of 0–100 m above sea level, and is geographically positioned at S5°39'32" and E104°24'21" (Winarni et al., 2009).

Procedures *Data of the great argus presence* Presence data for the great argus were collected using a combination of the transect line technique with the call count method, a widely utilized approach in avian surveys (Pérez-Granados & Traba, 2021), and camera traps installed at five locations (Palencia et al., 2021). Transects were purposively placed across different ecosystem types within the study area, which included primary forest, secondary forest (a regenerating forest that succeeded the 1997 fire), and riparian ecosystems. A total transect length of 10 km was established, comprising 5 km in primary forest, 3 km in secondary forest, and 2 km in riparian areas. The number of transects in each ecosystem type was determined based on a 10% sampling intensity (Naiheli et al., 2022).

Camera traps were installed 30–40 cm above ground level, positioned along suspected animal paths, and without the use of bait. The traps were purposefully placed in areas believed to serve as great argus activity hotspots, such as potential dancing grounds. Each camera trap was operational for a minimum of 25 days per installation (Figure 2).

Additionally, secondary data from camera traps installed

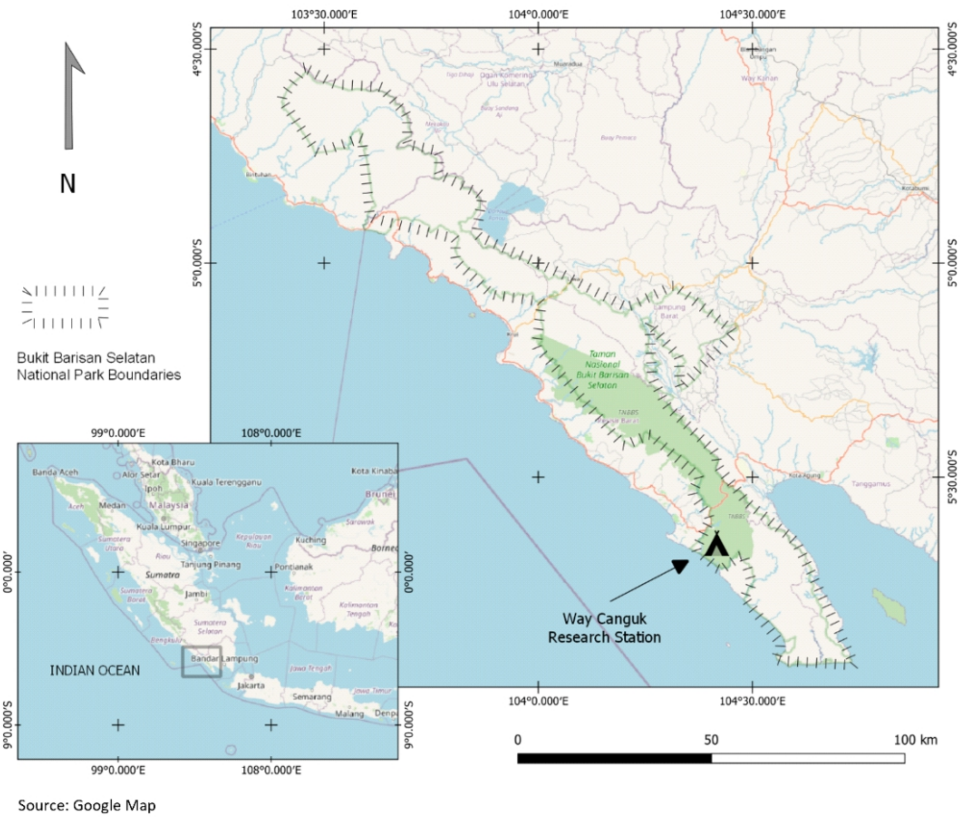

Figure 1 Map of the study area located in the Way Canguk Research Station, Bukit Barisan Selatan National Park, Indonesia.

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by the Tropical Ecology Assessment and Monitoring Program (TEAM) WCS-IP from 2010 to 2019 were utilized. This data provided supplementary presence records (Figure 2) and was collected using 10 cameras distributed at a density of one camera per 2 km², each operational for at least 30 days. Vegetation analysis was conducted using the grid line method to assess the diversity of plant species that serve as the great argus's food sources at the research location (Hilwan & Anggoro, 2023). Predictor variables for the SDM included physical and biological attributes, climate data, and human disturbance proxies, as outlined in Table 1.

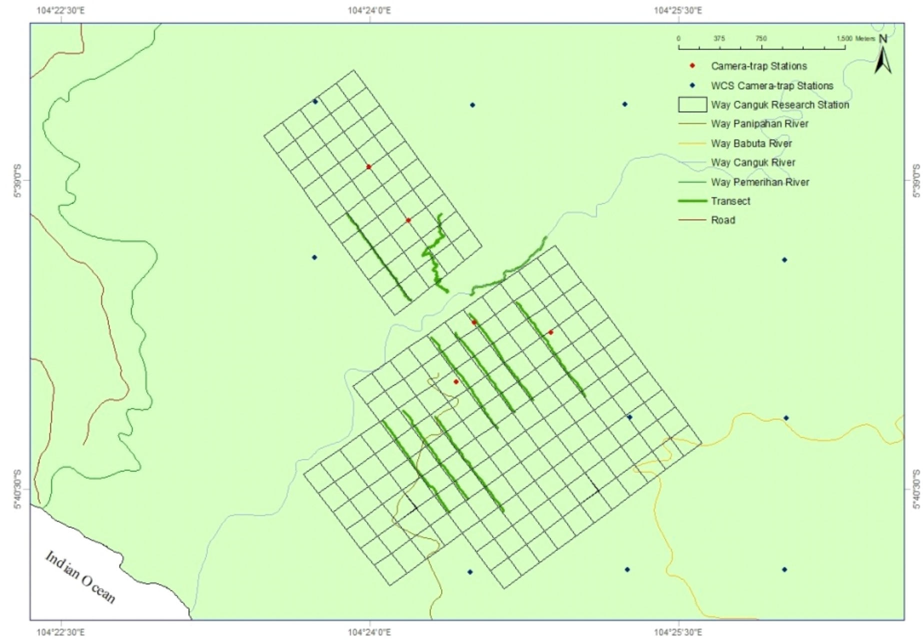

Figure 2 Location of camera trap installation.

Table 1 Environmental variables (Predictor variables)

Feature	Variable	Units	Source	Acquisition Year	Spatial resolution
Physical	Elevation	m	Earthexplorer.usgs.gov	2021	30 m × 30 m
	Slope	degree	Earthexplorer.usgs.gov	2021	30 m × 30 m
	Normalized Difference Moisture Index (NDMI)	-	Lpdaac.earthexplorer.usgs.gov	Mar–Apr 2021	30 m × 30 m
	Distance to river	m	Indonesia geospatial portal	2021	Vector data (converted to 30 m raster)
Climatic	Rainfall	mm	www.worldclim.org/bioclim	1970–2020 average	30 arc-sec (~1 km)
	Air temperature	ºC	www.worldclim.org/bioclim	1970–2020 average	30 arc-sec (~1 km)
Proxy to Human Disturbance	Distance to road	m	Indonesia geospatial portal	2021	Vector data (converted to 30 m raster)
	Distance to settlement	m	Indonesia geospatial portal	2021	Vector data (converted to 30 m raster)
Biology	Primary forests	-	Google Earth Engine	Mar–Apr 2021	~30 m
	Secondary forests	-	Google Earth Engine		~30 m
	Riparian ecosystem	-	Google Earth Engine		~30 m
	Agricultural land	-	Google Earth Engine		~30 m
	Normalized difference vegetation index (NDVI)	-	Lpdaac.earthexplorer.usgs.gov		30 m × 30 m

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Environmental variables: *Physical variables* 1) Elevation: Habitat occupancy of the ground-dwelling bird is influenced by variations in altitude, as noted in previous studies (Jean-Pierre et al., 2022). Elevation data were obtained from ASTER/DEM (Advanced Spaceborne Thermal Emission and Reflection Radiometer/Digital Elevation Model) datasets provided by the United States Geological Survey (USGS); 2) Slope: Slopes are negatively correlated with the abundance of the great argus (Ong-In & Savini, 2021). Slope maps were generated from ASTER/DEM data processed through the slope analysis tool in the ArcGIS application; 3) Distance to the river: The great argus is more frequently found in areas farther from main rivers (Nijman, 1998). Distance-to-river values were calculated using a river network map from the Indonesia Geospatial Portal (RBI) and analyzed using the Euclidean Distance method in a Geographic Information System (GIS) environment; and 4) NDMI: NDMI reflects water content and air humidity in vegetation or land cover (Taloor et al., 2021). While the effect of moisture on great argus habitat preferences has not been studied extensively (Nijman, 1998), the NDMI provides insights into habitat quality related to moisture conditions. NDMI values were calculated using Landsat 8 Operational Land Imager (OLI) satellite imagery and the formula as shown in Equation *[1]*.

$$NDMI = \frac{NIR-SWIR}{NIR+SWIR} \qquad [1]$$

note: *NIR* = near infra-red band (band 5), *SWIR* = short wave infra-red band (band 6).

Climatic variables 1) Rainfall: Average rainfall data were extracted for the study area using the "Extract by Mask" tool in GIS software, based on the research location boundaries. The spatial resolution was resampled to 30 m × 30 m (Alam & Ahamed, 2023), and the data were exported in ASCII format for use in modeling; and 2) Air temperature: Air temperature data were processed similarly to rainfall data. After extracting the study area boundaries using the "Extract by Mask" tool, the spatial resolution was adjusted to 30 m × 30 m (Alam & Ahamed, 2023). Temperature values were then converted from Kelvin to Celsius (°C) using the raster calculator feature. The final dataset was saved in ASCII format for further analysis.

Proxy variables for human disturbance Given the great argus's sensitivity to human presence, proxy variables representing human disturbance, specifically distance to roads and distance to settlements, were included as environmental predictors (Brocardo et al., 2023). These variables were derived from the Indonesian Geospatial Information Agency's (RBI) road and settlement maps. Distances (in meters) were calculated using the Euclidean Distance method in GIS software, producing continuous spatial layers for use in species distribution modeling.

Biology variables 1) Land cover: Land cover data were derived from the interpretation of Landsat 8 imagery captured between March and April 2021. Image processing and classification were conducted using Google Earth Engine (GEE) with the supervised classification method (Hasan et al., 2022). The study area was classified into four land cover types: primary forest, secondary forest and shrubs, agricultural land, and water bodies. Classification accuracy was assessed using the confusion matrix method, with results deemed acceptable if the overall accuracy exceeded 85% (Mijwil & Aljanabi, 2024). The final land cover classification map was exported in ASCII format for further analysis; and 2) Normalized difference vegetation index (NDVI): Vegetation density, which influences bird activity, was assessed using the NDVI, a standard indicator of vegetation density and forest degradation (Debataraja et al., 2021; Balata et al., 2022). NDVI values were calculated from Landsat 8/OLI satellite imagery using the formula as shown in Equation *[2]*.

$$NDVI = \frac{NIR-Red}{NIR+Red} \qquad [2]$$

note: *NIR* = near infrared band (band 5), *Red* = red band (band 4).

Data analysis *Variable selection and multicollinearity analysis* Variable selection was conducted through multicollinearity analysis to ensure the reliability of the model (Etaga et al., 2021). Multicollinearity occurs when two or more predictor variables are highly correlated, leading to increased standard errors and reduced model accuracy. The test assesses the correlation between predictor variables (Chan et al., 2022) and was performed using Pearson correlation coefficients (Mishra et al., 2022). Analyses were conducted using R Studio. Variables with absolute correlation coefficients ($|r|$) > 0.75 and a p-value < 0.05 were considered collinear and excluded from the final model. Eliminating multicollinearity among variables improves model reliability, reduces redundancy, and enhances predictive power (Chan et al., 2022; Cheng et al., 2022). This threshold is widely used in studies involving high-dimensional data to maintain model integrity (Chan et al., 2022; Mili et al., 2022).

Data processing The SDM used in this research was Maximum Entropy (MaxEnt) (Phillips & Dudík, 2008). The encounter response data for the great argus was saved in a comma-separated value (CSV) format, while the environmental variables (predictors) were converted into an ASCII (ASC) format to ensure compatibility with MaxEnt. MaxEnt's analysis produced spatial probability data for the great argus's presence, ranging from a minimum value of 0 to a maximum value of 1 (Javidan et al., 2021).

The results were further classified into three habitat suitability classes based on the calculated mean (μ) and standard deviation (σ) values (Table 2). This classification

Table 2 Classification of habitat suitability

Class	A range of value	Opportunity of species existence	Habitat suitability
1	Minimum < $x \le \mu - \sigma$	Low	Low Suitable
2	$\mu - \sigma < x \le \mu + \sigma$	High	Moderately Suitable
3	$\mu + \sigma < x \le$ Maximum	Very high	Highly Suitable

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aimed to identify areas with low, moderate, and high suitability for the species. The transformation and classification processes were conducted using Erdas Modeler within the Erdas Imagine 2014 software. The performance of the model in this study was evaluated using the Area Under the Receiver Operating Characteristics Curve (AUC), which ranges from 0 to 1. An AUC value closer to 1 indicates a more accurate and reliable model (Phillips & Dudík, 2008; Lah et al., 2021; Mafuwe et al., 2022). For this study, the modeling results were deemed acceptable if the AUC value exceeded 0.75, as suggested by Wang et al. (2023). The AUC values provide a robust metric for assessing model performance and predictive accuracy. The evaluation of model performance based on AUC values is summarized in Table 3 (Robinson et al., 2021).

Results

Multicollinearity analysis of predictor variables The correlation analysis conducted on 12 predictor variables revealed several positive correlations. Specifically, the distance to settlement variable was positively correlated with the distance to road variable. Similarly, agricultural land showed positive correlations with both air temperature and the NDMI variable, while the NDMI variable was also positively correlated with air temperature. These relationships are illustrated in Figure 3.

The multicollinearity analysis identified a correlation between the distance to settlement and the distance to the road. Based on practical considerations, the distance to a road variable was selected for inclusion in the model. This decision was influenced by the planned construction of a new highway that will traverse the National Park, as well as the lack of prior research addressing the road's impact on the great argus. Additionally, the NDMI variable was chosen over other related variables because it better captures the variability of landscape conditions in the study area. After accounting for multicollinearity, nine variables were ultimately selected from the initial twelve. These included physical factors (elevation, slope, NDMI, and distance to river), climatic factors (rainfall), biological factors (primary forest, secondary forest, and NDVI), and a proxy for human disturbance (distance to road).

Table 3 Modeling performance based on AUC values

AUC value range	Model performance
> 0.9	Excellent
0.7 – 0.9	Good
< 0.7	Low

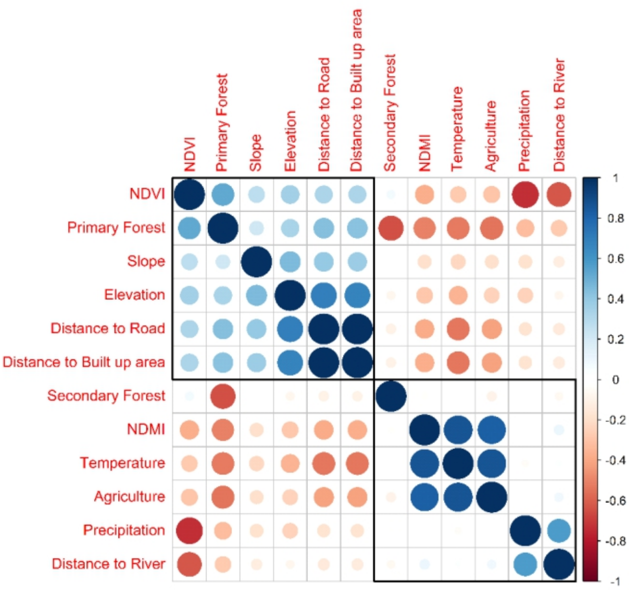

Figure 3 Correlation plot between environmental variables.

Encounter of the great argus in the study area The presence of the great argus was recorded by all five installed cameras, as well as by all 10 cameras from secondary data. Observations conducted using the line transect method detected 49 encounter points. Among these, three were direct encounters, five were indirect encounters (e.g., feathers and dancing grounds), and 41 were detections via vocalizations. Combining data from all methods, a total of 64 presence points were used for species distribution modeling. Notably, all encounters were recorded within the primary forest, underscoring its importance as the primary habitat for the great argus. This finding corresponds with the availability of vegetation that serves as a food source for the species.

Potential food sources in the study area Findings from this study highlight the critical role of primary forests in providing essential resources for the great argus. While direct foraging observations were not conducted, the species is known to consume fruits, seeds, flowers, leaf buds, and invertebrates. Vegetation surveys revealed that primary forests support a greater diversity of potential food plants compared to secondary and riparian forests (Table 4). Several plant families, including Annonaceae, Arecaceae, and Fabaceae, were identified in the study area, and previous research suggests that species within these families are part of the great argus's diet. Although direct consumption of these plants was not observed, their presence indicates that primary forests likely provide a richer and more diverse potential food supply of this species.

The great argus distribution modeling MaxEnt was applied with nine selected variables to predict the spatial distribution of the great argus in the study area. The model demonstrated outstanding performance, with an AUC value of 0.864. Predictions indicated that areas with a high probability of great argus encounters were predominantly located in the central part of the study area (Figure 4). When probability values were reclassified into suitability classes (Table 2), medium and high suitability areas accounted for a combined 82% of the total study area (Table 5). An overlay analysis of land cover and suitability classes showed that most of the highly suitable areas were located within primary forest (Figure 5).

Key environmental predictors contribute to habitat suitability The jackknife test analysis indicated that the predictor variable distance to road yielded the best modeling performance when used independently, followed by elevation and rainfall (Figure 6). The distance to the road

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Table 4 Identified feed plants of the great argus at the research station

No	Family name/type	Land cover		
		Primary forests	Secondary forest	Riparian
Magnoliales: Annonaceae				
1	*Monoon lateriflorum* (Blume) Miq.	v	v	-
2	*Polyalthia cauliflora* Hook.f. & Thomson	-	-	v
3	*Polyalthia* sp.	v	-	v
4	*Popowia bancana* Scheff.	v	v	v
Malpighiales: Euphorbiaceae				
5	*Mallotus floribundus* (Blume) Müll.Arg.	-	v	-
	Ericales: Ebenaceae			
6	*Diospyros cauliflora Blume*	v	-	-
Fabales: Fabaceae				
7	*Cheniella glauca* (Benth.) R.Clark & Mackinder.	v	v	v
Myrtales: Melastomataceae				
8	*Miconia crenata* (Vahl) Michelang.	-	v	-
9	*Pternandra coerulescens* Jack	v	-	-
Ericales: Sapotaceae				
10	*Palaquium* sp.	-	v	-
Urticales: Moraceae				
11	*Ficus crassiramea* subsp. *stupenda* (Miq.) C.C.Berg.	v	-	-

Table 5 Habitat suitability classes of the great argus

Habitat suitability	Area (ha)	Proportion (%)
Low suitable	844.92	23.75
Moderately suitable	1,883.07	52.94
Highly suitable	828.90	23.30

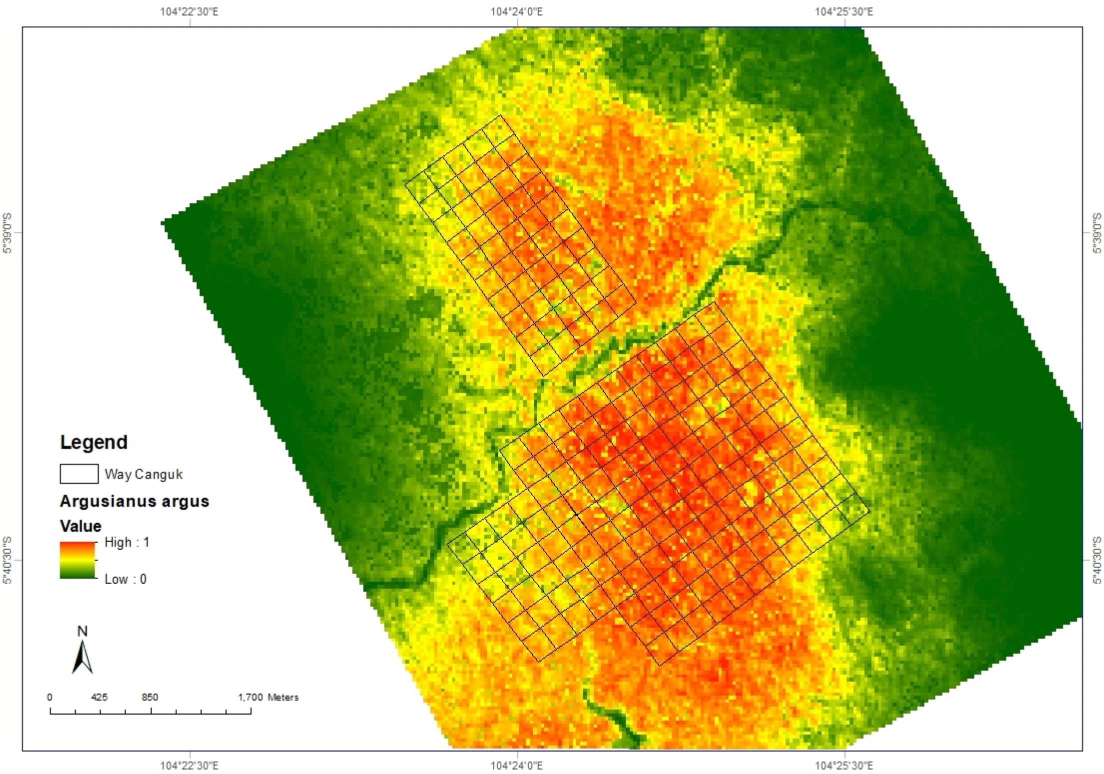

Figure 4 Distribution model of the great argus.

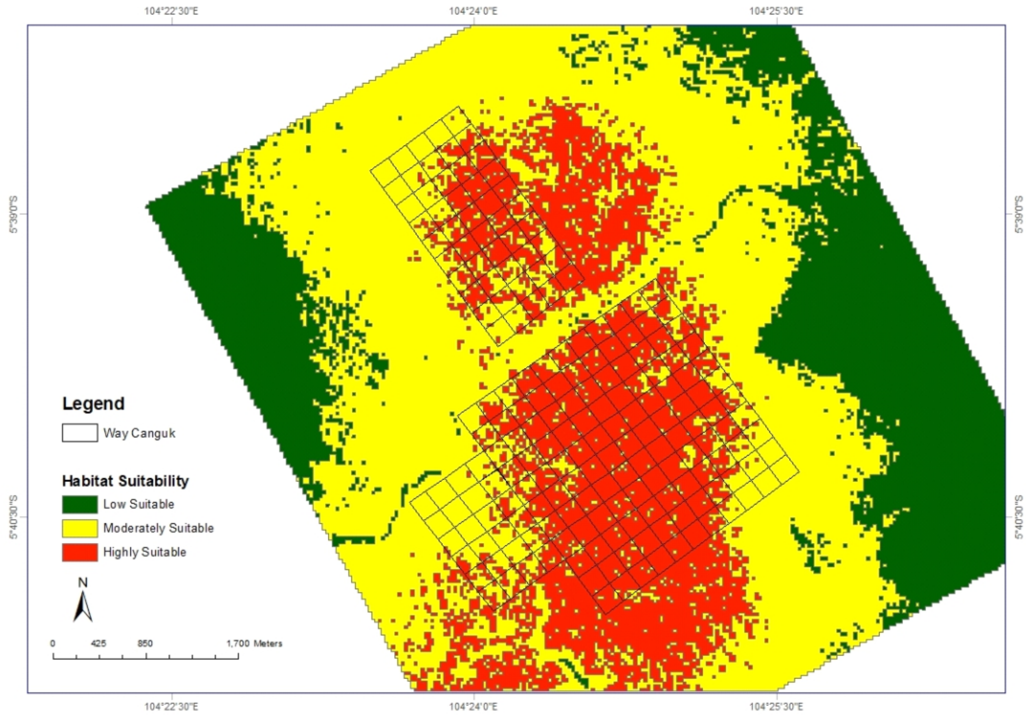

Figure 5 Habitat suitability map for the great argus in the research area.

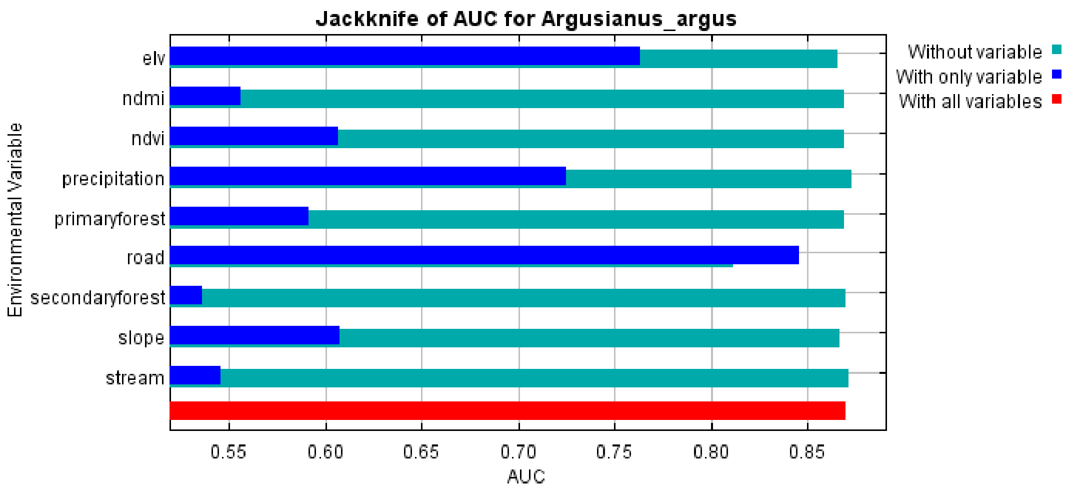

Figure 6 AUC jackknife test results.

variable also significantly reduced the model's performance when excluded, whereas other variables did not show substantial differences. Each predictor variable's contribution to the model was quantified, with distance to road contributing 39.7%, rainfall 26.8%, primary forest 17.7%, elevation 8.4%, and NDVI 6%. The remaining variables contributed less than 1%. These variables highlight the interaction between human disturbance, climate, and biological factors in shaping habitat preferences. The strong negative association between habitat suitability and proximity to roads underscores the great argus's sensitivity to human disturbance (Figure 7a), as evidenced by the response curve for the distance-to-road variable.

The presence of primary forests was another critical factor influencing habitat suitability for the great argus (Figure 7c). As an interior species, the great argus relies on intact habitats with dense vegetation, which provide essential resources such as food, cover, and suitable courtship/dancing grounds free of undergrowth, as indicated by the NDVI response curve (Figure 7e). Beyond forest characteristics, physical features of the landscape, particularly elevation and slope, significantly influence habitat suitability for the great argus. The response curve indicates a declining probability of the species' presence as elevation increases (Figure 7d) and slopes become steeper (Figure 7f).

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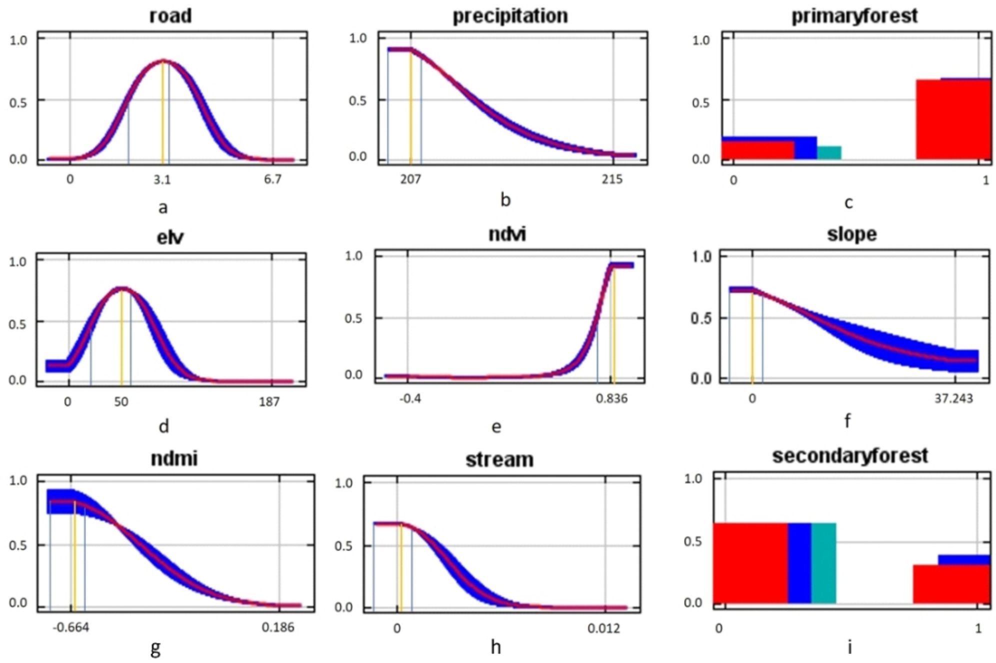

Figure 7 Variable response curves: (a) distance to road, (b) rainfall, (c) primary forest, (d) elevation, (e) NDVI, (f) slope, (g) NDMI, (h) distance to river, (i) secondary forest

Discussion

Past ecological studies on the great argus have provided valuable insights, but research on its spatial distribution remains limited. This study fills this gap by integrating key environmental variables into a predictive model, offering a more comprehensive understanding of the factors driving habitat suitability. Previous work by Winarni et al. (2009) used radio telemetry and the Minimum Convex Polygon (MCP) method to map home range size, territory, and daily travel. However, this approach did not account for environmental variables influencing the species' presence, which are critical for developing effective conservation strategies. In contrast, Species Distribution Models (SDMs) such as MaxEnt have become popular for estimating the relationship between species presence and environmental factors (Valavi et al., 2022; L. Wang & Jackson, 2023). Among various SDMs, MaxEnt is preferred due to its high predictive accuracy, ease of use, and ability to handle presence-only data (Campos et al., 2023), making it a reliable tool for habitat predictions.

MaxEnt was applied with nine selected variables to predict the spatial distribution of the great argus in the study area. The model demonstrated satisfactory performance, with an AUC value of 0.864, following the criteria of Phillips and Dudík (2008). This value indicates strong model performance, where the selected environmental variables effectively explain the spatial patterns of the great argus's habitat suitability. The majority of highly suitable areas were located within primary forest. This finding underscores the species' reliance on undisturbed forest landscapes, in line with previous studies (Davison, 1981a; Laneng et al., 2021; Simamora et al., 2021).

Three key environmental variables, including distance to road, rainfall intensity, and the presence of the primary forest, were identified as the most influential factors shaping habitat suitability. These variables highlight the interaction between human disturbance, climate conditions, and biological factors in shaping species distribution. The strong preference for interior forests and avoidance of disturbed areas further confirms the great argus's sensitivity to habitat fragmentation. These findings are consistent with previous studies, which indicate that the great argus is an interior species dependent on undisturbed primary forests (Hamirul et al., 2021; Laneng et al., 2021; Simamora et al., 2021).

The model results indicate that the great argus strongly prefers inner forest habitats while avoiding roads and human activity, as shown by the response curve for the distance-to-road variable. A significant negative correlation between habitat suitability and proximity to roads suggests that even moderate human presence may disrupt the species' habitat selection. Roads not only fragment habitats but also increase the risk of human-wildlife conflicts (Gregory et al., 2021). These findings emphasize the need for conservation strategies that limit road expansion in key habitat areas or implement mitigation measures such as wildlife corridors. Such a result aligns with previous studies, including Ong-In and Savini (2021), which emphasize the importance of prioritizing conservation in areas distant from human infrastructure.

Rainfall intensity emerged as the second most influential variable in habitat suitability. The response curve showed a clear negative relationship, where increased rainfall reduced the likelihood of encountering the species. Climate variables, such as rainfall, play a crucial role in shaping bird abundance (de Albuquerque et al., 2021), although they are not directly manageable through conservation efforts. Excessive rainfall may alter soil conditions, potentially hindering the maintenance of dancing grounds used for courtship displays (Zhao et al., 2021). Similarly, the NDMI response curve revealed that high humidity further decreased habitat suitability (Figure 7g). These patterns may reflect the bio-ecological requirements of the great argus, particularly the males' reliance on clean, dry forest floors as dancing grounds for courtship displays (Guan et al., 2022).

The presence of primary forests was another critical factor influencing habitat suitability for the great argus. As an interior species, the great argus relies on intact habitats with dense vegetation, which provide essential resources such as food, cover, and dancing grounds free of undergrowth, as indicated by the NDVI response curve (Figure 7e). However, habitat suitability within primary forests varied across the study area, suggesting that additional factors such as microclimate variations and understory density may influence habitat preference. Fragmented primary forests, particularly in sloped or elevated areas, often form smaller patches surrounded by agricultural lands or shrubs. These conditions alter microclimate and reduce habitat quality, a trend also observed in Winarni's study (2004), which found a clear preference for larger forest patches.

Forest fragmentation and edge effects are potential contributors to habitat degradation. Edge effects caused by habitat fragmentation may lead to increased human presence, higher predation risks, and altered microclimates that reduce habitat quality for the great argus (Slater et al., 2024). Larger forest patches, with more extensive core areas, mitigate these effects and enhance habitat suitability (Morante-Filho et al., 2021). While this study did not include landscape fragmentation as a variable in habitat modeling, future research should address this factor due to its significant conservation implications (Villaseñor et al., 2021; Jambari et al., 2023).

The great argus's diet primarily consists of fruits, seeds, flowers, leaf buds, and invertebrates, with earlier studies highlighting the dominance of feed plants from families such as Annonaceae, Arecaceae, and Fabaceae (Davison, 1981b). Although direct observations of foraging activity were not made during this study, the presence of these plant families in the study area suggests that suitable food resources are available. These habitats provide not only essential food resources but also the microhabitat conditions necessary for this species' survival (Stark et al., 2023). However, habitat fragmentation and degradation may disrupt food availability (Navarro et al., 2021), potentially affecting population viability. Investigating seasonal variations in food abundance and their influence on habitat selection could provide valuable insights into the ecological requirements of the great argus. Given its omnivorous diet, further research into its feeding behaviors and habitat preferences is crucial for developing targeted conservation strategies.

Beyond these key variables, physical features of the landscape, particularly elevation and slope, significantly influence habitat suitability. The response curve indicated that the probability of species occurrence declined with increasing elevation and steeper slopes, suggesting that the great argus prefers flatter terrain. Although the great argus has been recorded at altitudes up to 1,200 (Clink et al., 2021), the flatter terrain in the study area appears to offer more favorable conditions for movement and the maintenance of dancing grounds (Rafi et al., 2017). This finding has implications for conservation planning, as it highlights the need to prioritize lower-elevation primary forests for protection.

Conclusion

The habitat suitability for the great argus (AUC = 0.864) can be accurately modeled using nine independent predictor variables, free of multicollinearity. The analysis revealed that distance to roads, rainfall intensity, and the presence of natural forests are the most significant factors affecting habitat suitability. The results underscore the critical importance of primary forests as the preferred habitat for the great argus. Human activity associated with roads leads to deforestation and habitat fragmentation, significantly reducing the likelihood of the great argus inhabiting these areas. Without immediate action, the great argus and the biodiversity it represents may face irreversible decline. Protecting key habitats within the TRHS is essential, not only to maintain its UNESCO World Heritage status but also to preserve its role as a vital biodiversity hotspot. By taking collective and decisive steps, including reducing habitat loss and integrating wildlife corridors into infrastructure planning, we can ensure a future where the great argus thrives alongside the rich biodiversity of Sumatra.

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References

Alam, K. F., & Ahamed, T. (2023). Climate-adaptive potential crops selection in vulnerable agricultural lands adjacent to the Jamuna River Basin of Bangladesh using remote sensing and a fuzzy expert system. *Remote Sensing*, *15*(8), Article 2201. https://doi.org/10.3390/rs15082201

Ascensão, F., D'Amico, M., Revilla, E., & Pereira, H. M. (2022). Road encroachment mediates species occupancy, trait filtering and dissimilarity of passerine communities. *Biological Conservation*, *270*, Article 109590. https://doi.org/10.1016/j.biocon.2022.109590

Azahar, M. A., Azman, M. S., Ahmad Ruzman, N. H., Appanan, M., Zam Beri, A. Z., Baharudin, M. S., Rosli, R., Samihon, S. A., Gara, S., Samihon, S., Eliah, A. E., & Kamaruzzaman, M. F. (2023). Observations on vertebrates at Padang Chong Forest Reserve, Perak. *BIO Web of Conferences*, *73*, Article 01006. https://doi.org/10.1051/bioconf/20237301006

Balata, D., Gama, I., Domingos, T., & Proença, V. (2022). Using satellite NDVI time-series to monitor grazing effects on vegetation productivity and phenology in heterogeneous Mediterranean forests. *Remote Sensing*, *14*(10), Article 2322. https://doi.org/10.3390/rs14102322

BirdLife International. (2020). *Argusianus argus*. The IUCN red list of threatened species 2020: e.T22725006A183255774. https://doi.org/10.2305/IUCN.UK.2020-3.RLTS.T22725006A183255774.en

Brocardo, C. R., Rosa, D. C. P., Castro, A. B., Rosa, C., Torralvo, K., Pequeno, P., Magnusson, W. E., & Fadini, R. F. (2023). Responses of ground-dwelling birds and mammals to local environmental variables and human pressure in an Amazonian protected area. *European Journal of Wildlife Research*, *69*(3), Article 48. https://doi.org/10.1007/s10344-023-01677-z

Campos, J. C., Garcia, N., Alírio, J., Arenas-Castro, S., Teodoro, A. C., & Sillero, N. (2023). Ecological niche models using MaxEnt in Google Earth Engine: Evaluation, guidelines and recommendations. *Ecological Informatics*, *76*, Article 102147. https://doi.org/10.1016/j.ecoinf.2023.102147

Chan, J. Y., Mun, S., Leow, H., Bea, K. T., Cheng, W. K., Phoong, S. W., Hong, Z., & Chen, Y. (2022). Mitigating the multicollinearity problem and its machine learning approach : A review. *Mathematics*, *10*(8), Article 1823. https://doi.org/10.3390/math10081283

Cheng, J. H., Chen, Z. G., & Yi, S. J. (2022). Wavelength selection algorithm based on minimum correlation coefficient for multivariate calibration. *Guang Pu Xue Yu Guang Pu Fen Xi/Spectroscopy and Spectral Analysis*, *42*(3), 719–725. https://doi.org/10.3964/j.issn.1000-0593(2022)03-0719-07

Clink, D. J., Groves, T., Ahmad, A. H., & Klinck, H. (2021). Not by the light of the moon: Investigating circadian rhythms and environmental predictors of calling in Bornean great argus. *PLoS ONE*, *16*(2), Article e0246564. https://doi.org/10.1371/journal.pone.0246564

Davison, G. W. H. (1981a). Sexual selection and the mating system of *Argusianus argus* (Aves: Phasianidae). *Biological Journal of the Linnean Society*, *15*(2), 91–104. https://doi.org/10.1111/j.1095-8312.1981.tb00751.x

Davison, G. W. H. (1981b). Diet and dispersion of the great argus *Argusianus argus*. *Ibis*, *123*(4), 485–494. https://doi.org/10.1111/j.1474-919X.1981.tb04052.x

de Albuquerque, F. S., Bateman, H. L., Boehme, C., Allen, D. C., & Cayuela, L. (2021). Variation in temperature, precipitation, and vegetation greenness drive changes in seasonal variation of avian diversity in an urban desert landscape. *Land*, *10*(5), Article 0480. https://doi.org/10.3390/land10050480

Debataraja, I. B., Pradana, D. H., & Winarni, N. L. (2021). The impact of landuse and the relationship between NDVI on the bird species richness in Sukmajaya District, Depok. *IOP Conference Series: Earth and Environmental Science*, *846*(1), Article 012004. https://doi.org/10.1088/1755-1315/846/1/012004

Etaga, H. O., Ndubisi, R. C., & Oluebube, N. L. (2021). Effect of multicollinearity on variable selection in multiple regression. *Science Journal of Applied Mathematics and Statistics, 9*(6), 141–153. https://doi.org/10.11648/j.sjams.20210906.12

Gregory, A., Spence, E., Beier, P., & Garding, E. (2021). Toward best management practices for ecological corridors. *Land*, *10*(2), Article 140. https://doi.org/10.3390/land10020140

Guan, X., Rao, X., Song, G., & Wang, D. (2022). The evolution of courtship displays in Galliformes. *Avian Research*, *13*, Article 100008. https://doi.org/10.1016/j.avrs.2022.100008

Hamirul, S., Izereen, M., Azmin, H., Izzati, A., Ainur, B., Nabihah, M., Izyan, S., Syafiq, N., Izzat, N., Syafiq, S., Aainaa, A., Norashikin, F., Hizami, H., Azahar, A., Firdaus, K., Amal, N., Ai Yin, S., Lukman, I., Yusoff, S., & Kamarul, H. (2021). Camera trap survey of wildlife in State Land Forest, Merapoh, Pahang, Malaysia. *Malaysian Forester*, *84*(2), 283–295.

Hasan, S. H., AL-Hameedawi, A. N. M., & Ismael, H. S. (2022). Supervised classification model using Google Earth Engine development environment for Wasit Governorate. *IOP Conference Series: Earth and Environmental Science*, *961*(1), Article 012051. https://doi.org/10.1088/1755-1315/961/1/012051

Hilwan, I., & Anggoro, P. (2023). Studi populasi dan distribusi palahlar (*Dipterocarpus hasseltii* Blume) di Resort Gunung Salak I, Taman Nasional Gunung Halimun Salak. *Jurnal Silvikultur Tropika*, *14*(3), 229–235. https://doi.org/10.29244/j-siltrop.14.03.229-235

Jambari, A., Hosaka, T., Nakabayashi, M., Yahya, M. S., & Azhar, B. (2023). Conservation planning in national parks may benefit from site occupancy and detection estimates of native animal species. *Journal for Nature Conservation*, *75*, Article 126463. https://doi.org/10.1016/j.jnc.2023.126463

Javidan, N., Kavian, A., Pourghasemi, H. R., Conoscenti, C., Jafarian, Z., & Rodrigo-Comino, J. (2021). Evaluation of multi-hazard map produced using MaxEnt machine learning technique. *Scientific Reports*, *11*(1), Article 6496. https://doi.org/10.1038/s41598-021-85862-7

Jean-Pierre, A., Loranger-Merciris, G., & Cézilly, F. (2022). Spatial occupancy, local abundance and activity rhythm of three ground dwelling Columbid species in the forests of Guadeloupe in relation to environmental factors. *Diversity*, *14*(6), Article 0480. https://doi.org/10.3390/d14060480

Lah, N. Z. A., Yusop, Z., Hashim, M., Salim, J. M., & Numata, S. (2021). Predicting the habitat suitability of *Melaleuca cajuputi* based on the maxent species distribution model. *Forests*, *12*(11), Article 1449. https://doi.org/10.3390/f12111449

Laneng, L. A., Nakamura, F., Tachiki, Y., & Vairappan, C. S. (2021). Camera-trapping assessment of terrestrial mammals and birds in rehabilitated forest in INIKEA Project Area, Sabah, Malaysian Borneo. *Landscape and Ecological Engineering*, *17*(2), 135–146. https://doi.org/10.1007/s11355-020-00442-7

Mafuwe, K., Broadley, S., & Moyo, S. (2022). Use of maximum entropy (Maxent) niche modelling to predict the occurrence of threatened freshwater species in a biodiversity hotspot of Zimbabwe. *African Journal of Ecology*, *60*(3), 557–565. https://doi.org/10.1111/aje.12928

Mijwil, M. M., & Aljanabi, M. (2024). A comparative analysis of machine learning algorithms for classification of diabetes utilizing confusion matrix analysis. *Baghdad Science Journal*, *21*(5), Article 24. https://doi.org/10.21123/BSJ.2023.9010

Mili, S. A., Islam, M. S., Al Momen Sabuj, A., Haque, Z. F., Pondit, A., Hossain, M. G., Hassan, J., & Saha, S. (2022). A cross-sectional seroepidemiological study on infectious bursal disease in backyard chickens in the Mymensingh District of Bangladesh. *Veterinary Medicine International*, *2022*, Article 9076755. https://doi.org/10.1155/2022/9076755

Mishra, A., Nair, N. S., Harichandrakumar, K., Binu, V., & Satheesh, S. (2022). Application of principal component analysis in dealing with multicollinearity in modelling clinical data. *Journal of Clinical and Diagnostic Research*, *16*(7), YC15–YC19. https://doi.org/10.7860/jcdr/2022/55379.16629

Morante-Filho, J. C., Benchimol, M., & Faria, D. (2021). Landscape composition is the strongest determinant of bird occupancy patterns in tropical forest patches. *Landscape Ecology*, *36*(1), 105–117. https://doi.org/10.1007/s10980-020-01121-6

Naiheli, F. R., Seran, W., Pramatana, F., & Kaho, L. M. R. (2022). Struktur dan komposisi serta status regenerasi mamar Desa Beaneno, Kecamatan Sasitamean, Kabupaten Malaka. *Jurnal Kehutanan Papuasia*, *8*(2), 342–355. https://doi.org/10.46703/jurnalpapuasia.vol8.iss2.368

Navarro, A. B., Magioli, M., Bogoni, J. A., Moreira, M. Z., Silveira, L. F., Alexandrino, E. R., da Luz, D. T. A., Pizo, M. A., Silva, W. R., de Oliveira, V. C., Donatelli, R. J., Christianini, A. V., Piratelli, A. J., & Ferraz, K. M. P. M. B. (2021). Human-modified landscapes narrow the isotopic niche of neotropical birds. *Oecologia*, *196*(1), 171–184. https://doi.org/10.1007/s00442-021-04908-9

Nijman, V. (1998). Habitat preference of great argus pheasant *Argusianus argus* in Kayan Mentarang National Park, East Kalimantan, Indonesia. *Journal fur Ornithologie*, *139*(3), 313–323. https://doi.org/10.1007/BF01653342

Ong-In, T. I. W. A., & Savini, T. (2021). Hydropower reservoir reduces great argus *Argusianus argus* density in proximity to its shore. *Bird Conservation International*, *33*, Article e3. https://doi.org/10.1017/S0959270921000368

Palencia, P., Rowcliffe, J. M., Vicente, J., & Acevedo, P. (2021). Assessing the camera trap methodologies used to estimate density of unmarked populations. *Journal of Applied Ecology*, *58*(8), 1583–1592. https://doi.org/10.1111/1365-2664.13913

Pérez-Granados, C., & Traba, J. (2021). Estimating bird density using passive acoustic monitoring: A review of methods and suggestions for further research. *Ibis*, *163*(3), 765–783. https://doi.org/10.1111/ibi.12944

Phillips, S. J., & Dudík, M. (2008). Modeling of species distributions with Maxent: New extensions and a comprehensive evaluation. *Ecography*, *31*(2), 161–175. https://doi.org/10.1111/j.0906-7590.2008.5203.x

Prastio, B., Santoso, A., Roekhan, Maulidina, A., Numertayasa, I. W., & Suardana, I. P. O. (2023). An ecolinguistic study: The representation of forest conservation practices in the discourse of *Anak Dalam Jambi* tribe, Indonesia. *Cogent Arts and Humanities*, *10*(1), Article 2262788. https://doi.org/10.1080/23311983.2023.2262788

Rafi, M., Novarino, W., Rizaldi, & Ardiyanto, A. (2017). Aktivitas kuau raja (*Argusianus argus* Linnaeus, 1766) pada *mating ring* di hutan konservasi Kalaweit Supayang, Solok, Sumatera Barat. *Metamorfosa: Journal of Biological Sciences*, *4*(1), 58–64. https://doi.org/10.24843/metamorfosa.2017.v04.i01.p10

Robinson, C. L. K., Proudfoot, B., Rooper, C. N., & Bertram, D. F. (2021). Comparison of spatial distribution models to predict subtidal burying habitat of the forage fish Ammodytes personatus in the Strait of Georgia, British Columbia, Canada. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*(10), 2856–2869. https://doi.org/10.1002/aqc.3593

Savini, T., Namkhan, M., & Sukumal, N. (2021). Conservation status of Southeast Asian natural habitat estimated using Galliformes spatio-temporal range decline. *Global Ecology and Conservation*, *29*, Article e01723. https://doi.org/10.1016/j.gecco.2021.e01723

Setyawati, T., Nando, S., Marthy, W., Andayani, N., Sheherazade, & Linkie, M. (2021). Planning to remove UNESCO World Heritage Sites in Sumatra from being 'In Danger.' *Animal Conservation*, *24*(2), 149–152. https://doi.org/10.1111/acv.12626

Simamora, T. I., Purbowo, S. D., & Laumonier, Y. (2021). Looking for indicator bird species in the context of forest fragmentation and isolation in West Kalimantan, Indonesia. *Global Ecology and Conservation*, *27*, Article e01610. https://doi.org/10.1016/j.gecco.2021.e01610

Slater, H. D., Gillingham, P. K., Pratt, V., Eaton, B., Fletcher, S., Abdullah, A., Supriadi, & Korstjens, A. H. (2024). Living on the edge: forest edge effects on microclimate and terrestrial mammal activity in disturbed lowland forest in Sumatra, Indonesia. *Oryx*, *58*(2), 228–239. https://doi.org/10.1017/S0030605323000212

Stark, G., Ma, L., Zeng, Z. G., Du, W. G., & Levy, O. (2023). Cool shade and not-so-cool shade: How habitat loss may accelerate thermal stress under current and future climate. *Global Change Biology*, *29*(22), 6201–6216.. https://doi.org/10.1111/gcb.16802

Taloor, A. K., Manhas, D. S., & Kothyari, G. C. (2021). Retrieval of land surface temperature, normalized difference moisture index, normalized difference water index of the Ravi basin using Landsat data. *Applied Computing and Geosciences*, *9*, Article 100051. https://doi.org/10.1016/j.acags.2020.100051

Trisnawati, J., Muharar, S., & Sugiarti, E. (2023). The hudoq mask works potential as a source of learning and moral based local wisdom of Dayak Bahau Busang tribe. *The International Journal of Politics and Sociology Research*, *10*(4), 176–193. https://doi.org/10.35335/ijopsor.v10i4.88

United Nations Educational, Scientific and Cultural Organization. (2004, Januari 9). *Tropical rainforest heritage of Sumatra*. Retrieved from https://whc.unesco.org/en/list/1167/

Valavi, R., Guillera-Arroita, G., Lahoz-Monfort, J. J., & Elith, J. (2022). Predictive performance of presence-only species distribution models: a benchmark study with reproducible code. *Ecological Monographs*, *92*(1), Article e01486. https://doi.org/10.1002/ecm.1486

Valley, P., Faisão, D., & Palas, V. (2022). Population and risk assessment of sympatric pheasant species. *Brazilian Journal of Biology*, *84*, Article e259582. https://doi.org/10.1590/1519-6984.259582

Villaseñor, N. R., Escobar, M. A. H., & Hernández, H. J. (2021). Can aggregated patterns of urban woody vegetation cover promote greater species diversity, richness and abundance of native birds? *Urban Forestry and Urban Greening*, *61*, Article 127102. https://doi.org/10.1016/j.ufug.2021.127102

Wang, L., & Jackson, D. A. (2023). Effects of sample size, data quality, and species response in environmental space on modeling species distributions. *Landscape Ecology*, *38*(12), 4009–4031. https://doi.org/10.1007/s10980-023-01771-2

Wang, Z., Ma, Q., Liang, S., Liu, Y. A., Liu, L., Huang, C., Chen, K., & Hou, W. (2023). Study on the distribution and habitat suitability of seagrass in the Northern Chinese Seas. *Frontiers in Marine Science*, *10*, Article 1297137. https://doi.org/10.3389/fmars.2023.1297137

Winarni, N. L., Nurcahyo, A., Hadiprakarsa, Y., & Iqbal, M. (2004, January). *Effects of forest patch size on Galliformes in Southern Sumatra, Indonesia* [Conference paper]. International Galliformes Symposium, Fordingbridge, United Kingdom.

Winarni, N. L., O'Brien, T. G., Carroll, J. P., & Kinnaird, M. F. (2009). Movements, distribution, and abundance of great argus pheasants (*Argusianus argus*) in a sumatran rainforest. *Auk*, *126*(2), 341–350. https://doi.org/10.1525/auk.2009.07162

Zhao, Y., Liao, J., Bao, X., & Ma, M. (2021). Soil seed bank dynamics are regulated by bird diversity and soil moisture during alpine wetland degradation. *Biological Conservation*, *263*, Article 109360. https://doi.org/10.1016/j.biocon.2021.109360