

Predicting Habitat Suitability for the Endangered Green Peafowl (*Pavo muticus* L., 1766) in Thailand's Western Stronghold under Future Climate Scenarios

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ABSTRACT

The green peafowl (*Pavo muticus* L., 1766) is endangered globally. This study evaluates environmental factors shaping its habitat in key Thai strongholds to identify current habitat suitability and predict future changes under climate scenarios. Current and projected climate data from 2020 to 2100 were analyzed under four scenarios of 20 years each: at present, in the near future, mid future and far future, using species distribution modelling with MaxEnt and SSP2-4.5 to assess potential impacts. The results show that the key green peafowl habitat factors included elevation, slope, streams, isothermality and annual precipitation. Mixed deciduous forests were the most critical forest types for the species. Moderately and highly suitable habitats for the green peafowl covered approximately 5% of the sanctuary. However, well suitable habitat is projected to decrease markedly, representing a 21.25% decline. Strict management of these crucial areas is essential. Moreover, expanding protected areas, networks, and conservation strategies are vital for addressing challenges arising from rapid global environmental change.

HIGHLIGHTS

Camera traps captured twenty-nine ground bird species in Huai Kha Khaeng Wildlife Sanctuary. The green peafowl was the most abundant species. Topography and climate factors strongly influenced green peafowl habitat suitability. The suitable habitat is projected to decrease markedly representing a 21.25% decline. Conservation efforts must focus on the key habitats and climate impacts to conserve the species and their stronghold habitat.

1. INTRODUCTION

The green peafowl, *Pavo muticus* L., 1766, is native to the tropical and subtropical forests of Southern and Southeast Asia, including Northeast India, southern China, Myanmar, Laos, Cambodia, Thailand, Vietnam and Java (IUCN, 2025). The species is classified into three subspecies: the Burmese green peafowl (*P. muticus spicifer*), the Indochinese green peafowl (*P. muticus imperator*), and the Javan green peafowl (*P. muticus muticus*) (Patil and Vijay,

2024). Two subspecies occur in Thailand: the Javan green peafowl (also known as the Southern green peafowl), and the Indochinese green peafowl (or Northern green peafowl). Overall, the green peafowl is extinct across several countries while surviving in fragmented, small populations in others (Saridnirun et al., 2023). Major threats include habitat loss (Kong et al., 2018) as well as environmental changes (Weiskopf et al., 2020; Shwe et al., 2021). Thus, environmental studies are an urgent priority for conservation.

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Sukumal et al. (2022) identified six green peafowl strongholds in Southeast Asia: eastern Cambodia, south-central Vietnam, northeastern Cambodia, western Thailand, northern Thailand, and Myanmar's Bago Yoma range. In Thailand, scattered populations have been reported in several National Parks and Wildlife Sanctuaries (Sukumal et al., 2020; Nasoongnern et al., 2024). The most critical habitat of green peafowl in Thailand is Huai Kha Khaeng Wildlife Sanctuary (HKKWS) because there is a large population of green peafowl living naturally without overlapping with agricultural areas. (Sukumal et al., 2017).

In the case of climate factors, climate markedly influences species' habitats and distribution patterns (Odeny et al., 2019). Rising temperatures have raised concerns about declining bird populations (Bhagarathi et al., 2024). In recent years, studies have shown that >20% of bird species face extinction due to climate change (Pacifici et al., 2017; Yu et al., 2022; Halupka et al., 2023; Lawer, 2024; Mota et al., 2024; Weinhäupl and Devenish-Nelson, 2024). Climate also determines the availability of suitable habitat, making it the most critical factor in predicting future distribution (Singh et al., 2021). Understanding and forecasting range shifts and habitat changes due to climate are essential for effective conservation management (Holbrook et al., 2017; Bhasin et al., 2024). Protected areas remain central to conservation strategies for long-term biodiversity preservation (Vimal et al., 2021; Williams et al., 2022). Species distribution models play a key role in conservation by bridging research and policymaking (Coreau et al., 2018), offering hope for sustaining bird populations despite climate challenges (Bernath-Plaisted et al., 2024).

However, studies predicting habitat ranges at varying conservation hotspot levels are lacking in Thailand. Understanding and identifying suitable habitats are critical for long-term conservation. This study aims to examine the relationship between the occurrence of green peafowl and key environmental factors, including climate, topography, and vegetation cover, and to assess the suitability of habitat under these conditions.

This study aimed to investigate the environmental factors that affected the occurrence of peafowl in an area that had never been studied before, despite its significance as a conservation area. MaxEnt and the SSP2-4.5 scenario were used to predict changes in peafowl distribution every 20 years from 2020 to 2100 at four intervals. The results of the study

provided insights into how peafowl habitats have changed due to climate change. These findings contributed to a better understanding that could be applied to develop management guidelines for the conservation of green peafowls and other ground-dwelling wildlife in the area, enhancing ecosystem integrity and future conservation benefits.

2. METHODOLOGY

2.1 Study area

The study was conducted in HKKWS (Figure 1). The area is primarily covered by mixed deciduous (MDF) and dry evergreen forests (DEF), with patches of dry deciduous forest (DDF). Elevation in HKKWS ranges from 200 to 1,600 m, characterized by low-slope alluvial valleys along major rivers and rugged hills. The dominant vegetation includes MDF (48.3%), DEF (24.7%), hill evergreen forest (13.4%), and DDF (6.9%) (Saisamorn et al., 2024). The sanctuary is home to threatened species (Charaspet et al., 2021). Annual temperatures fall within the 8-38°C range, with mean annual rainfall of 1,375 mm (Simcharoen et al., 2014).

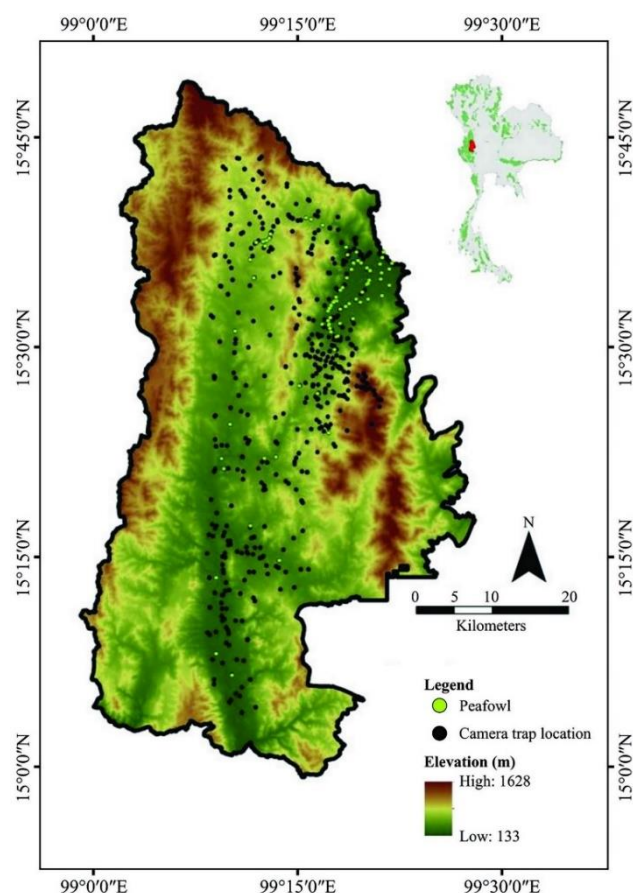


Figure 1. Study area and occurrence locations of green peafowl in HKKWS (646 locations)

2.2 Data collection

Camera traps were deployed in HKKWS from November 2017 to March 2019 across 646 locations, totaling 9,640 trap nights, with green peafowl photographed at 106 locations. In total, 40 Bushnell Trophy Cam HD Essential E2 12MP Trail Cameras were used. The study divided a 1:50,000 geographic map into 1-km² grid cells, 646 grid cells totally, placing a camera in each grid, with 15-20 grids surveyed per field trip. Cameras were spaced at least 500-m apart to ensure independent detections and reduce the probability of photographing the same animal with multiple cameras (Charaspet et al., 2019a; Charaspet et al., 2019b; Charaspet et al., 2020). Deployment locations were selected based on habitat suitability and the likelihood of green peafowl presence, especially along the main streams (Sukumal et al., 2017; Penjor et al., 2021).

Cameras were secured with metal casings and python locks, mounted on trees at 40-50 cm above ground level to capture terrestrial bird species, and positioned 3-4 m from target points or according to site suitability (Fontúrbel et al., 2020). They were set to hybrid mode (photo and video) with 24-h activation, three-photo capture per trigger, 10-s video length, and 10-s intervals, operating continuously (Leo et al., 2024). After each 30-day period, cameras were relocated.

All photographs were imported into a computer and organized using Camera Trap Manager (Zaragozí et al., 2015). Data was transferred to Microsoft Excel for analysis. Terrestrial bird species in photographs were identified by common name, scientific name, and family following IUCN (2025). Only clear photographs with date and time stamps were used. The recorded photographs were selected using independent event criteria according to Choo et al. (2020) for further abundance calculations. The relative abundance index was calculated as the number of independent event detections per one hundred camera-days or camera-nights (Zhao et al., 2020).

2.3 Species distribution model

Variable selection enhances model accuracy by reducing multicollinearity and minimizing the number of required predictors (Yi et al., 2016). The variance inflation factors (VIFs) of 22 environmental variables were tested using the “usdm” package in R studio (Naimi et al., 2014; R Core Team, 2018). VIFs, based on correlation coefficients (Shrestha, 2022), were used to eliminate variables with VIFs >5 (Akinwande et al.,

2015), except for elevation, which is a key predictor of green peafowl habitat suitability (Chatterjee and Hadi, 2006). Ultimately, 12 variables were selected: percent tree cover, forest type, elevation, slope, distance to a stream, distance to a ranger station, mean diurnal range, isothermality, annual precipitation, precipitation of driest month, and precipitation of coldest quarter. These variables were used to model both present and future habitat scenarios (Abdelaal et al., 2019). The present model used bioclimatic data from 1970 to 2020, whereas future models incorporated projections from the IPSLCM6A-LR model, one of the best-performing models for HKKWS (Kamworapan et al., 2021), developed by the Institut Pierre Simon Laplace, France (Boucher et al., 2020). Future scenarios were based on Shared Socioeconomic Pathways (SSP2-4.5), which assume medium greenhouse gas emission stabilization (Lovino et al., 2021). All environmental variables were resampled using the bilinear resampling technique (Ren et al., 2016), clipped to a 30-arcsecond (~1 km) resolution in ASCII format, and processed using R studio. The environmental variables used in the analysis are listed in Appendix Table 1.

To further minimize multicollinearity among continuous environmental variables (topographic variables, land cover variables, anthropogenic variables and bioclimatic variables) and mitigate potential model uncertainty or overfitting, a threshold correlation value of 0.7 was applied (Dormann et al., 2013). Highly correlated variables were identified and removed using the “vifcor” function in the “sdm” package in R (Naimi and Araújo, 2016). The final variable sets minimized redundancy in modeling green peafowl habitat suitability (Table 1).

Species distribution modeling was performed using MaxEnt version 3.4.4 (Phillips et al., 2017). The model was run with default settings unless otherwise specified. Specifically, we used the default feature classes (linear, quadratic, product, and hinge) and the regularization multiplier was set to the default value of 1.0. These settings help control model complexity and reduce the risk of overfitting. These choices align with standard practices commonly adopted in species distribution modeling literature (e.g., Phillips et al., 2006; Elith et al., 2011). By using these default configurations, we ensured that the model was comparable with a wide range of previous studies and maintained a balance between model performance and interpretability.

Table 1. Predictor bioclimatic variables used after removing highly correlated variables to minimize multicollinearity in species distribution models.

Label	Variable	Scaling factor	Unit	Note
BIO2	Mean diurnal range	10	°C	Two effects are at play: one influencing BIO2 and one influenced by BIO2. Diurnal range impacts frost occurrence, whereas maritimity affects BIO2, i.e., proximity to the ocean increases temperature range.
BIO3	Isothermality	100	%	Isothermality is strongly affected by distance from the equator. In the tropics, temperatures are relatively stable year-round, whereas at the poles, winters and summers are distinctly different.
BIO12	Annual precipitation	1	mm	This variable reflects a region's aridity and wetness but represents total annual water availability. If precipitation varies markedly throughout the year, this may not be the most suitable variable.
BIO14	Precipitation of driest month	1	mm	
BIO19	Precipitation of coldest quarter	1	mm	

Models were trained and tested with 10 simulations and a maximum of 500 iterations, using an initial background dataset of 10,000 units. A sub-sample approach allocated 75% of the data for training and 25% for testing. Model results were expressed in log-log (clog-log) format (Trisurat et al., 2014; Bai et al., 2018; Mcgarvey et al., 2021; Khan et al., 2022). The AUC (area under the receiver operating characteristic curve) values vary from 0 to 1; values <0.5 indicate that the model performance is worse than random, 0.5 indicates performance that is not better than random, 0.5-0.7 indicates poor performance, 0.7-0.9 indicates reasonable or moderate performance, and >0.9 indicates high performance (Jiang et al., 2018). The future habitat suitability model incorporated projected changes in bioclimatic variables to assess green peafowl habitat suitability may shift under different climate conditions (Table 1). The model was used to identify suitable habitat areas in HKKWS while accounting for potential environmental changes.

The models were calibrated to produce suitability scores on a scale from 0 to 1, where 0 indicates the least suitable and 1 the most suitable. These scores were categorized into four suitability classes: unsuitable (0.00-0.25), poorly suited (0.25-0.50), moderately suited (0.50-0.75), and well suited (0.75-1.00) (Ab Lah et al., 2021; Luo et al., 2025).

3. RESULTS AND DISCUSSION

3.1 Green peafowl abundance

In total, 29 bird species from 18 families were photographed using camera traps. The most frequently

captured species was the green peafowl, with 506 images recorded across 9,690 trap nights, representing 5.22% of all recorded terrestrial bird detections. These images were obtained from 95 of 646 camera locations. Focusing on species from the pheasant family (Phasianidae), six species were identified: green peafowl, red junglefowl, kalij pheasant (*Lophura leucomelanos*), grey peacock-pheasant (*Polyplectron bicalcaratum*), Siamese fireback (*Lophura diardi*), and silver pheasant (*Lophura nycthemera*). Collectively, these species accounted for 8.68% RAI of all recorded terrestrial bird detections, comprising most of the 10.16% RAI of total wildlife captured (Table 2).

Table 3 summarizes the environmental factors influencing the habitat suitability of green peafowl in HKKWS under present (2020) and near-future (2021-2040), medium-future (2041-2060), and far future (2081-2100) scenarios. The assessment considered topographic, bioclimatic, and anthropogenic variables. On average, topography was the most influential factor, accounting for 67.50% of green peafowl habitat suitability based on % relative contribution (%RC), with elevation (54.52%) being the dominant variable, followed by slope (12.45%). Bioclimatic variables also played a role (29.07%), particularly isothermality (21.55%), annual precipitation (4.82%) and mean diurnal range (2.35%), while land cover variables (1.87%), tree cover (0.01%), forest type (1.86%) and anthropogenic variables (1.65%) were of little influence on green peafowl.

Table 2. Ground-dwelling bird species photographed in HKKWS (November 2017-March 2019) using camera traps at 646 locations (9,690 trap nights), comparing Phasianidae and non-Phasianidae species.

Family/Common name	Scientific name	NIP	RAI	LOF	Naïve occupancy	IUCN 2025
Phasianidae						
Green peafowl	<i>Pavo muticus</i>	506	5.22	95	14.71	EN
Red junglefowl	<i>Gallus gallus</i>	327	3.37	123	19.04	LC
Kalij pheasant	<i>Lophura leucomelanos</i>	6	0.06	6	0.93	LC
Grey peacock-pheasant	<i>Polyplectron bicalcaratum</i>	1	0.01	1	0.15	LC
Siamese fireback	<i>Lophura diardi</i>	1	0.01	1	0.15	LC
Silver pheasant	<i>Lophura nycthemera</i>	1	0.01	1	0.15	LC
		842	8.68	227	35.13	
Charadriidae						
Red-wattled lapwing	<i>Vanellus indicus</i>	73	0.75	7	1.08	LC
Ardeidae						
Chinese pond heron	<i>Ardeola bacchus</i>	7	0.07	7	1.08	LC
Columbidae						
Grey-capped emerald dove	<i>Chalcophaps indica</i>	7	0.07	5	0.77	LC
Eastern spotted dove	<i>Spilopelia chinensis</i>	7	0.07	6	0.93	LC
Zebra dove	<i>Geopelia striata</i>	1	0.01	1	0.15	LC
Strigidae						
Brown fish-owl	<i>Ketupa zeylonensis</i>	7	0.07	2	0.31	LC
Bucerotidae						
Oriental pied hornbill	<i>Anthraceroceros albirostris</i>	6	0.06	3	0.46	LC
Pittidae						
Blue-winged pitta	<i>Pitta moluccensis</i>	5	0.05	5	0.77	LC
Blue pitta	<i>Hydornis cyaneus</i>	3	0.03	1	0.15	LC
Corvidae						
Red-billed blue magpie	<i>Urocissa erythroryncha</i>	5	0.05	5	0.77	LC
Caprimulgidae						
Large-tailed nightjar	<i>Caprimulgus macrurus</i>	4	0.04	4	0.61	LC
Accipitridae						
Crested serpent-eagle	<i>Spilornis cheela</i>	3	0.03	3	0.46	LC
Unidentified eagle species	-	6	0.06	6	0.93	-
Muscicapidae						
White-rumped shama	<i>Copsychus malabaricus</i>	2	0.02	2	0.31	LC
Oriental magpie-robin	<i>Copsychus saularis</i>	1	0.01	1	0.15	LC
Picidae						
Black-headed woodpecker	<i>Picus erythropygius</i>	2	0.02	2	0.31	LC
Grey-faced woodpecker	<i>Picus canus</i>	1	0.01	1	0.15	LC
Turdidae						
Blue rock-thrush	<i>Monticola solitarius</i>	1	0.01	1	0.15	LC
Coraciidae						
Indian roller	<i>Coracias benghalensis</i>	1	0.01	1	0.15	LC
Caprimulgidae						
Large-tailed nightjar	<i>Caprimulgus macrurus</i>	1	0.01	1	0.15	LC
Alcedinidae						
White-throated kingfisher	<i>Halcyon smyrnensis</i>	1	0.01	1	0.15	LC
Pycnonotidae						
White-throated bulbul	<i>Alophoixus flaveolus</i>	1	0.01	1	0.15	LC
Turnicidae						
Yellow-legged buttonquail	<i>Turnix tanki</i>	1	0.01	1	0.15	LC
	Total	988	10.16	294	45.42	

Note: NIP: number of independent photographs; RAI: relative abundance index; LOF: location found; IUCN (2025): The International Union for Conservation of Nature.

3.2 Factors affecting green peafowl occurrence

All habitat suitability models demonstrated robust predictive performance, with high mean area under the curve (AUC) values for present model=0.92; near-future model=0.91; mid-future=0.91; far-future=0.91. The overall mean AUC value across all scenarios was 0.920 ± 0.001 , indicating strong model accuracy. Analysis results showed that environmental factors influencing green peafowl occurrence were primarily related to topography, with an average relative contribution (RC) of $67.50 \pm 2.05\%$. Altitude above sea level was the primary factor (average $RC = 54.52 \pm 2.06\%$), with the average altitude of green peafowl occurrence being 307.40 m above sea level. Slope was the second most important topographic factor (average $RC = 12.45 \pm 0.13\%$) (Table 4). Climate was the second most influential factor after topography, contributing an average RC of $29.07 \pm 2.12\%$ to habitat suitability. Five key bioclimatic variables were identified: mean diurnal range, isothermality, annual precipitation, precipitation of the driest month, and precipitation of the coldest quarter. Temperature consistency demonstrated the most significant effect

($RC = 21.55 \pm 2.47\%$), with a mean temperature consistency value of $56.00 \pm 0.12\%$ across all scenarios, because the appearance of green peafowl was a response to temperature levels. Vegetation-related variables, including percentage tree cover and forest type (MD), contributed 1.87% to the total RC that played a minor role in green peafowl occurrence (Table 3). From examining trends from the present to 2100, the relative influence of environmental factors on green peafowl occurrence remained largely stable, except for annual precipitation, which showed a consistent increase in importance (Figure 2). Precipitation enhances environmental productivity and habitat complexity, which directly supports the ecological requirements of the green peafowl, thereby increasing their likelihood of presence in such areas. The changes in the mean values of key environmental variables across different time periods for green peafowl habitat are presented in Figure 3. Figure 4 displays the Jackknife test results, which assess the relative importance of individual environmental variables in determining green peafowl habitat suitability, which confirmed climatic and topographic conditions as the most informative variable.

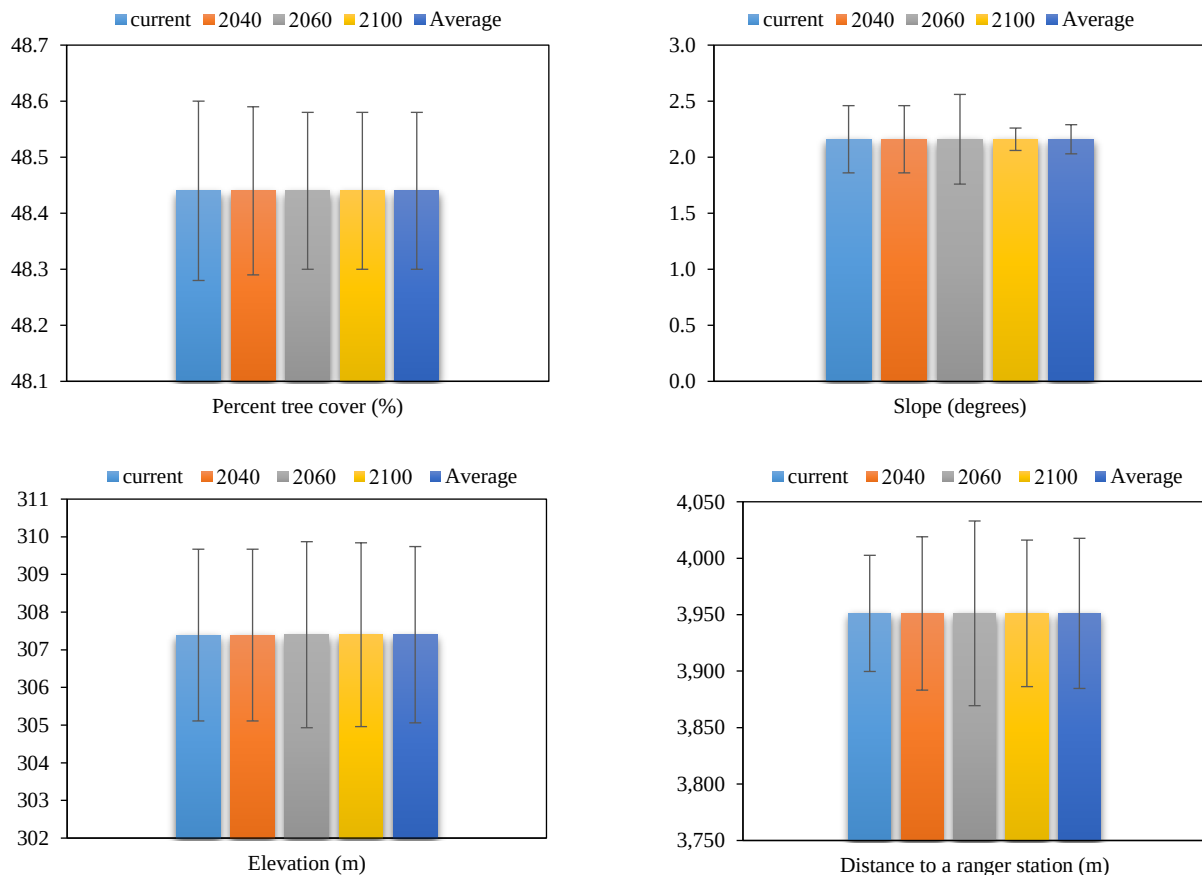


Figure 2. Change in the mean values of some key environmental variables across different time periods (2020-2100) for green peafowl habitat in HKKWS. Error bars indicate standard deviations.

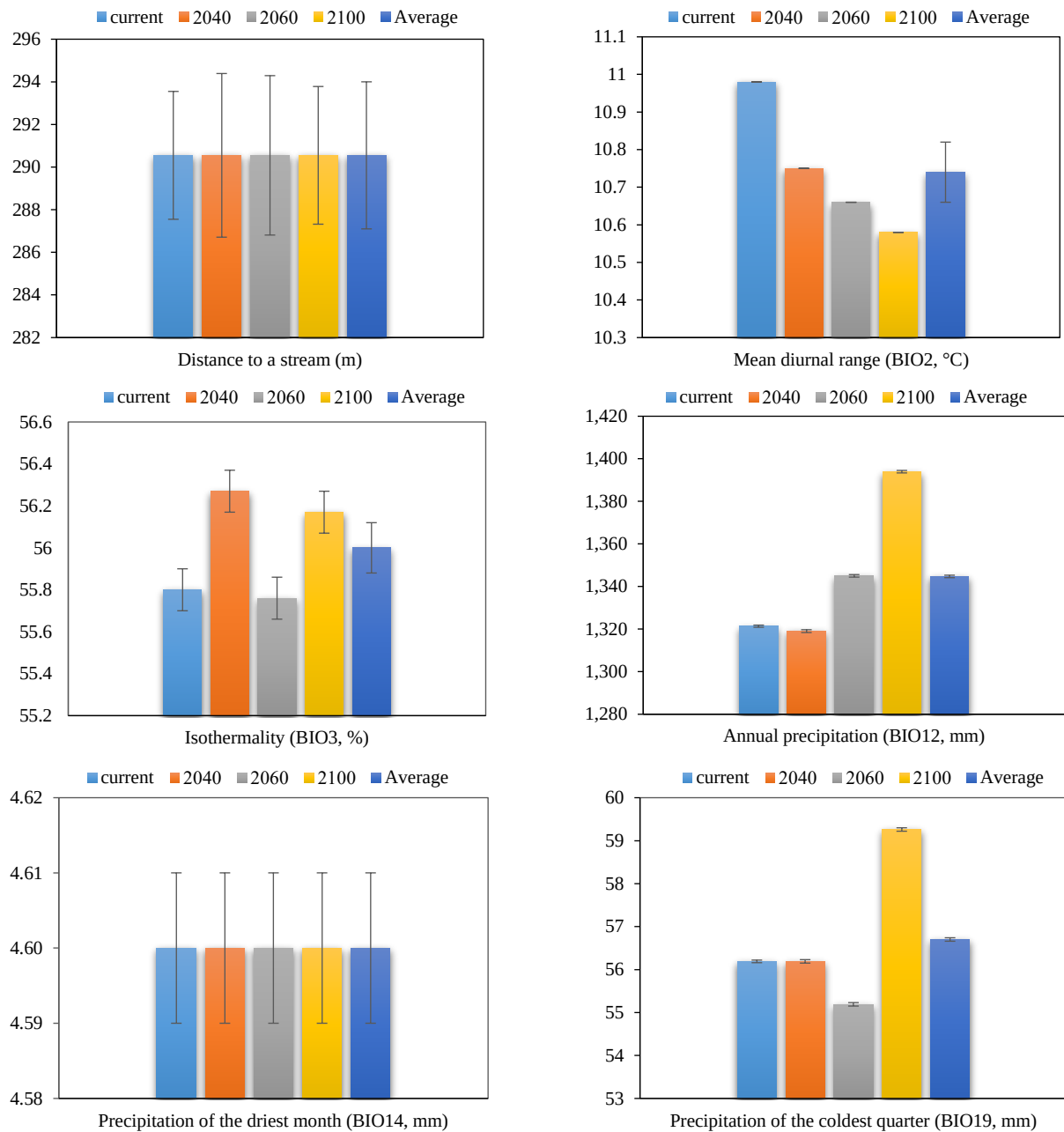


Figure 2. Change in the mean values of some key environmental variables across different time periods (2020-2100) for green peafowl habitat in HKKWS. Error bars indicate standard deviations (cont.).

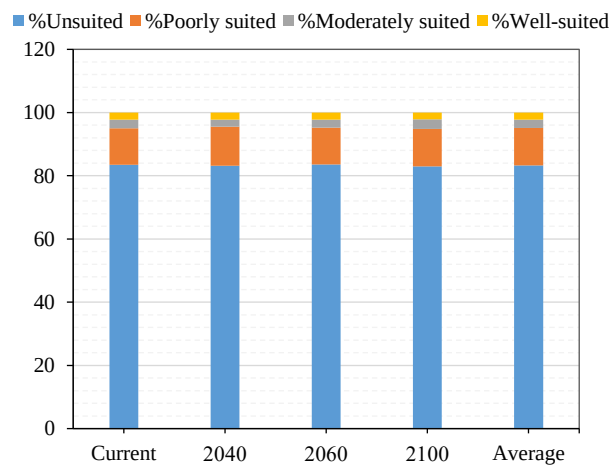


Figure 3. Predicted percentage changes in potential habitat suitability for green peafowl based on current and future environmental conditions.

Table 3. Percentage relative contributions (RCs) and mean values of key environmental variables used in habitat suitability models for green peafowl in HKKWS.

Environmental variables	Present (2020) AUC=0.922		Near-future (2021-2040) AUC=0.915		Mid-future (2041-2060) AUC=0.916		Far-future (2081-2100) AUC=0.916		Average Present-2100 AUC=0.92 ± 0.001	
	RC (%)	Sample average (±SD)	RC (%)	Sample average (±SD)	RC (%)	Sample average (±SD)	RC (%)	Sample average (±SD)	RC (%)	Sample average (±SD)
Land cover variables	1.7		1.9		1.7		2.2		1.87±0.11	
Percent tree cover (%)	0	48.44±0.16	0.1	48.44±0.15	0.1	48.44±0.14	0.1	48.44±0.14	0.01±0.00	48.44±0.14
Forest type	1.7	MDF	1.8	MDF	1.6	MDF	2.1	MDF	1.86±0.10	MDF
Topographic variables	62.7		71.5		65.5		70.3		67.50±2.05	
Elevation (m)	50	307.39±2.28	58.5	307.39±2.45	52.1	307.4±2.47	57.5	307.4±2.44	54.52±2.06	307.40±2.34
Slope (degrees)	12.2	2.16±0.03	12.5	2.16±0.03	12.8	2.16±0.04	12.3	2.16±0.04	12.45±0.13	2.16±0.00
Distance to a stream (m)	0.5	290.55±3.00	0.5	290.55±3.84	0.6	290.55±3.74	0.5	290.55±3.23	0.52±0.02	290.55±3.45
Anthropogenic variables	1.8		1.5		1.7		1.6		1.65±0.06	
Distance to a ranger station (m)	1.8	3,951.15±51.43	1.5	3,951.08±67.92	1.7	3,951.21±81.79	1.6	3,951.19±64.89	1.65±0.06	3,951.15±66.50
Biodimatic variables	34		25.1		31.2		26		29.07±2.12	
Mean diurnal range (BIO2, °C)	2.6	10.98±0.00	1.9	10.75±0.00	2.5	10.66±0.00	2.4	10.58±0.00	2.35±0.15	10.74±0.08
Isothermality (BIO3, %)	27.4	55.8±0.01	17.6	56.27±0.01	23.9	55.76±0.01	17.3	56.17±0.01	21.55±2.47	56.00±0.12
Annual precipitation (BIO12, mm)	3.8	1,321.37±0.5	5.4	1,319.05±0.66	4.6	1,345.02±0.59	5.5	1,393.95±0.58	4.82±0.39	1,344.74±0.58
Precipitation of the driest month (BIO14, mm)	0.1	4.6±0.01	0.1	4.6±0.01	0.1	4.6±0.01	0.2	4.6±0.01	0.12±0.02	4.60±0.01
Precipitation of the coldest quarter (BIO19, mm)	0.1	56.19±0.03	0.1	56.19±0.04	0.1	55.19±0.04	0.6	59.26±0.04	0.22±0.12	56.70±0.04

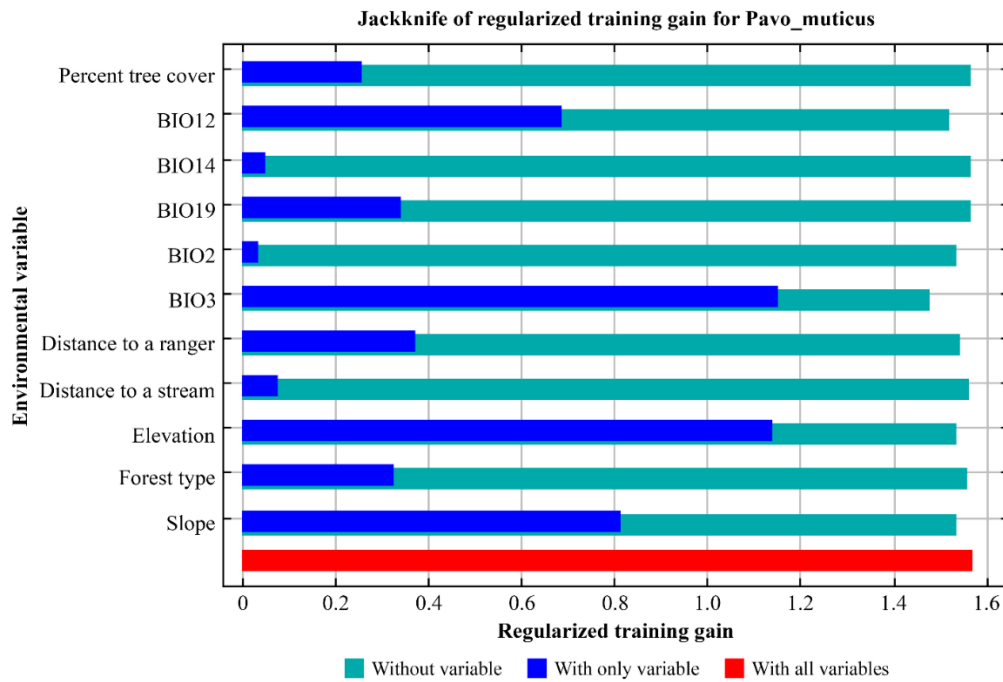


Figure 4. Jackknife test results assessing the relative importance of individual environmental variables in determining green peafowl habitat suitability under current conditions which confirmed Isothermality (BIO3, %) as the most informative variable

3.3 Habitat suitability

Results revealed that a highly suitable habitat is limited to 80 km², accounting for only 2.22% of the total area (Table 4 and Figure 5). Future projections suggest a slight decrease in unsuitable areas, with low-

and medium-suitability areas showing minor increases. However, the extent of highly suitable habitat is predicted to remain relatively lower, ranging from 63 to 80 km².

Table 4. Present and future habitat suitability for green peafowl in HKKWS.

Habitat suitability		Current (2020)	Near-future (2021-2040)	Mid-future (2041-2060)	Far-future (2081-2100)	Average
Unsuited	Area (km ²)	2,442	2,435	2,446	2,428	2,437.75
	% (of HKK)	83.46	83.22	83.60	82.98	83.32
Poorly suited	Area (km ²)	339	361	341	346	346.75
	% (of HKK)	11.59	12.34	11.65	11.83	11.85
Moderately suited	Area (km ²)	80	65	74	89	77.00
	% (of HKK)	2.73	2.22	2.53	3.04	2.63
Well-suited	Area (km ²)	80	65	65	63	68.25
	% (of HKK)	2.22	2.22	2.22	2.15	2.20
Total area of HKK (km ²)		2,926	2,926	2,926	2,926	

This study recorded 29 species of ground-dwelling birds from 18 families using camera traps in HKKWS, making it the second most diverse site after Khao Yai National Park, where Kanka et al. (2023) identified 36 species from 21 families. The pheasant family was prominent in HKKWS, with six species recorded. Notably, the occurrence of green peafowl has increased in the eastern part of HKKWS, particularly along Huai Thap Salao Stream, a trend

consistent with the findings of Suwanrat et al. (2015), who observed higher green peafowl numbers in forest-edge habitats near human settlements.

In addition to biological factors, especially food, water, roosting, shelter and nesting site that is essential to the species (Hernowo, 2017), this study showed that the key factors affecting green peafowl presence were topographic variables, followed in order of influence by climatic, anthropogenic and tree

cover factors. This contrasts with the findings of [Sukmasuang et al. \(2023\)](#) who demonstrated that the distribution of Siamese fireback and red junglefowl in

lowland regions was largely influenced by climatic factors, with biophysical and topographic factors playing secondary roles.

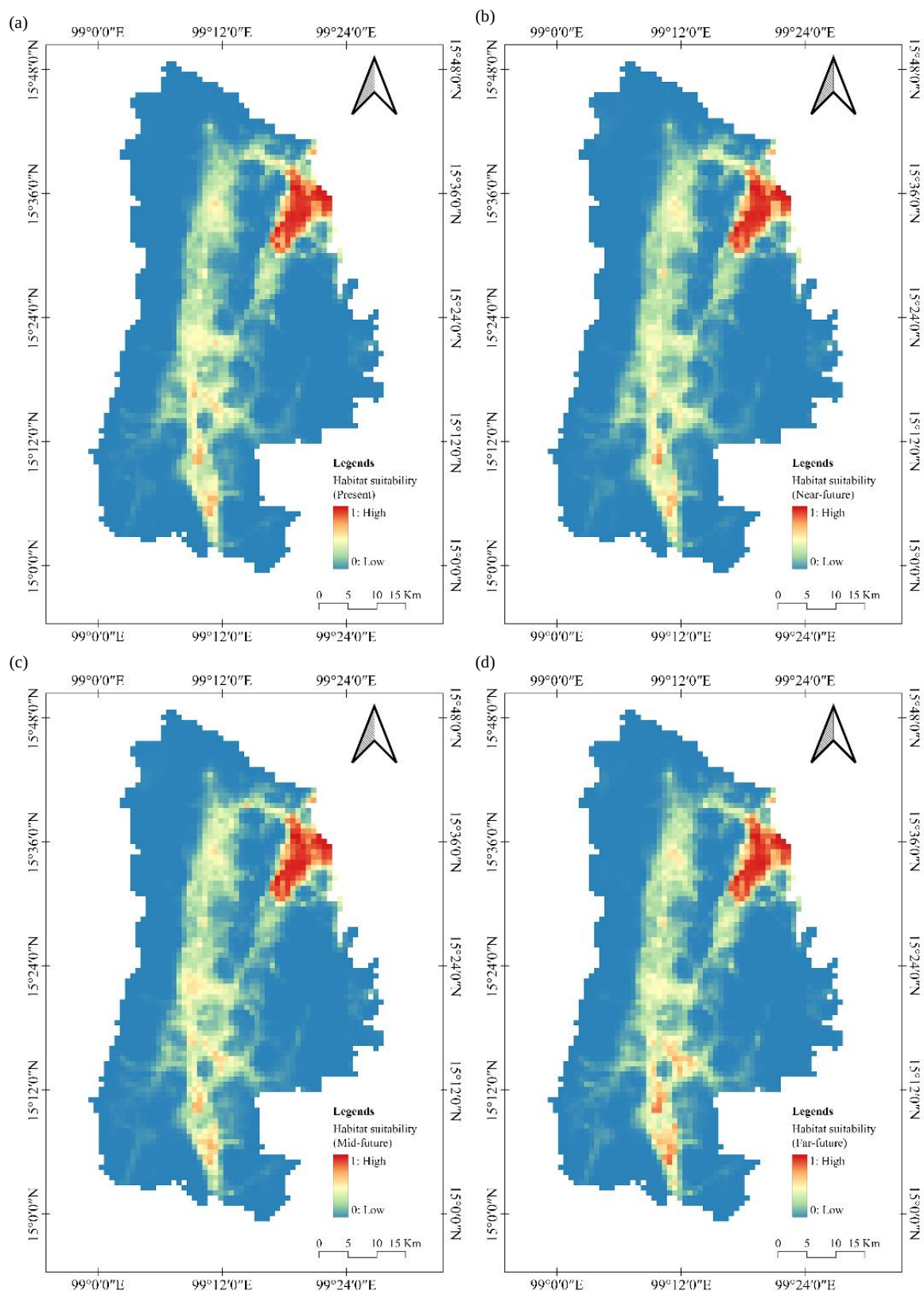


Figure 5. (a) Present, (b) near-future, (c) mid-future, and (d) far-future for green peafowl habitat suitability in HKKWS.

Topographic features, like slopes and terrain, influence where green peafowl can live and move around. They use these features to find food, shelter and avoid predators (Saridnirun et al., 2023). Different slopes and terrains affect their ability to forage, roost and care for their young. In essence, green peafowls adapt their behavior and movement patterns to the specific topographic conditions of their habitat, making use of the landscape to meet their daily needs, indicating that green peafowl prefer habitats with specific slope characteristics, because they offer a balance of safety, visibility, food availability, roosting and nesting sites (Hernowo, 2017). In the case of anthropogenic variables, there is no evidence of community habitation in this area, there is only a forest protection unit, so it has very little influence on the appearance of the green peafowl (Yan et al., 2021).

Additionally, percent tree cover, annual precipitation and elevation were key factors contributing to higher AUC values. Among climatic factors, isothermality had the strongest influence on green peafowl occurrence, followed by annual precipitation, mean diurnal range, precipitation of the driest month and precipitation of the coldest quarter. Isothermality represents the ratio of diurnal to annual temperature variations (O'Donnell and Ignizio, 2012), with values close to 100 indicating similar day-to-night and seasonal temperature fluctuations (Lu et al., 2022). Isothermality has previously been identified as a major determinant of species distribution (Xie et al., 2023). Additionally, the mean temperature of the wettest quarter has been shown to positively influence green peafowl habitat suitability, whereas the mean temperature of the driest quarter has a negative impact (Lawer, 2024). These findings align with those of Phipps et al. (2017) and Rehman et al. (2024) who reported isothermality being a key factor influencing habitat suitability. Given the projected long-term significance of isothermality (Xie et al., 2023), it remains a critical variable for future green peafowl conservation. Similarly, Nameer (2020) noted that temperature and precipitation seasonality during the driest quarter play a major role in determining the distribution of Indian peafowl (*Pavo cristatus*). The present findings underscore the need for green peafowl conservation strategies that prioritize habitats at specific elevations with stable climatic conditions.

Although highly suitable habitat will continue to decline, it comprises a small proportion of the total area, underscoring the challenges in green peafowl

conservation. These constraints may stem from climate change which is difficult to control directly. These findings suggest that habitat conservation and management efforts should prioritize landscape characteristics to ensure the long-term survival of green peafowl in the HKKWS, in addition to linking with large-scale forest conservation to counter climate change as essential for the long-term survival of this endangered species.

4. CONCLUSION

This study identified the green peafowl as the most recorded ground bird in the sanctuary, with its presence strongly influenced by topographic and bioclimatic factors such as elevation and isothermality. MDF was identified as the most critical factor for green peafowl survival. Currently, only 5% of HKKWS (143.25 km²) is classified as moderately to highly suitable habitat for green peafowl. Future projections indicate a decline in highly suitable habitat, from 80 km² at present to 63 km², representing a 21.25% decrease. This highlights the need for proactive conservation measures to ensure the long-term survival of green peafowl in HKKWS; conservation efforts should focus on protecting key habitats. Managing and expanding protected areas strategically are key for conserving green peafowl in the long term and addressing environmental issues like biodiversity loss, climate change, and habitat degradation through large-scale conservation landscapes.

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AUTHOR CONTRIBUTIONS

Conceptualization, Ronglarp Sukmasuang; Methodology, Ronglarp Sukmasuang and Saksit Simchareon; Software, Jedsada Noowong; Validation, Ronglarp Sukmasuang and Jedsada Noowong; Formal Analysis, Kornkanok Prommakul and Jedsada Noowong; Investigation, Kittiwara Siripattaranukul; Resources, Prateep Duengkae; Data Curation, Bunyatiporn Kaewdee; Writing-Original Draft Preparation, Ronglarp Sukmasuang; Writing-Review and Editing, Khwanrutai Charaspet and Kornkanok Prommakul; Visualization, Kornkanok Prommakul; Supervision, Saksit Simchareon and Prateep Duengkae; Project Administration, Ronglarp Sukmasuang; Funding Acquisition, Ronglarp Sukmasuang.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

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