BJNRD (2024), 11(1): 25-33
Bhutan Journal of Natural Resources & Development

Article

www.bjnrd.org

Open Access

ISSN 2409–2797 (Print)
ISSN 2409–5273 (Online)

DOI: https://doi.org/10.17102/cnr.2024.93

Current Distribution and Suitable Habitats of Asiatic Golden Cat (*Catopumma temminckii* Vigors and Horsfield) under Bumthang Territorial Division

Pema Yongdrup[1,*], Ngawang Chojey[2], Bala Ram Mafchan[3] and Karma Chorten Dhendup[4]

Abstract

Asiatic golden cat, *Catopumma temminckii* Vigors and Horsfield, is currently categorized as a Near Threatened species on IUCN Red List and is listed in Schedule II of the Forest and Nature Conservation Act of Bhutan, 2023. A total of 67 pairs of camera traps were strategically deployed within a grid measuring 5 km by 5 km between 1 October 2021 and 30 December 2021 to map habitat suitability and distribution of Asiatic golden cat. The probability distribution and suitable habitat were generated based on thirty five presence-only points and thirteen environmental variables using MaxEnt. Our study showed 56.14% (87,453 ha) as an unsuitable area, 35.18% (54,800 ha) as a moderately suitable area and 8.68% (13,511 ha) as a highly suitable area. The main environmental factors affecting the distribution were distance to the road (26.1%) followed by elevation (21.8%) and slope (15.4%). The most preferred habitat of Asiatic golden cat was broad-leaved forests followed by mixed-conifer forests. The findings underscore the importance of preserving landscapes beyond designated protected areas in order to safeguard critical wildlife species and their habitats.

Keywords: Asiatic golden cat, camera trap, distribution, maximum entropy modelling, suitable habitat

Introduction

The Asiatic golden cat, *Catopumma temminckii* Vigors and Horsfield, which is also known as the Temmincks cat, is a medium sized wild cat, and is categorized as Near Threatened in the IUCN Red list and in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (MaCarthy *et al.,* 2015). It is also listed in the Schedule II of the Forest and Nature Conservation Act of Bhutan, 2023 (FNCA, 2023) and is one of the least explored species in Bhutan. It is known for its elusive behavior with peculiar and distinctive markings (Jnawali *et al.,* 2011); exhibiting polymorphic coat colors and weighing between 8-16 kg (Suzuki *et al*., 2020). It is one of the 11 wild cat species recorded in Bhutan (Wangchuk *et al*., 2004) of which six different color morphs have been identified – cinnamon, golden, grey, melanistic, black with white lines running across its checks, and ocelot (BTC, 2021). As a forest dependent species, the

[1]Forestry Officer, Bumthang Territorial Division, Department of Forest and Park Services
[2]Assistant Research Officer, Jigme Namgyel Engineering College, Royal University of Bhutan
[3]Forestry Officer, Phrumsengla National Park, Department of Forest and Park Services
[4]Forestry Officer, Thimphu, Department of Forest and Park Services
*Corresponding author: pemaydup123@gmail.com
Received: January 10, 2024
Accepted: June 19, 2024
Published online: June 30, 2024
Editor: D.B.Gurung

global population of Asiatic golden cat is decreasing across its distribution ranges due to poaching for fur, habitat fragmentation and degradation (MaCarthy *et al.,* 2015). In Bhutan, an increasing number of hydropower projects, unintentional snaring set for musk deer and land use changes are major threats to the species (Dhendup, 2016; Yongdrup *et al.,* 2019).

The understanding of this charismatic species is limited, particularly in terms of its potential distribution range and ecological preferences beyond protected regions (Dhendup, 2016). Outside-protected areas (Territorial Divisions) have received limited scientific investigation and funding for surveys in comparison to the protected areas resulting in limited scientific reports from Territorial Divisions (Dhendup and Dorji, 2018). Thus, this research paper aims to contribute knowledge on Asiatic golden cat distribution and habitat preference under Bumthang Territorial Division. Also, we aim to create a predictive distribution map that highlights potential habitats for this near threatened felid. The result obtained will serve as a baseline data for the Bumthang Territorial Division as well as in filling the existing gap of Asiatic golden cat's information outside the protected areas. Such insights are vital for developing effective conservation strategies to protect Asiatic golden cat and its habitat in the study area.

In order to achieve these objectives, we used Species distribution modeling (SDM), which have become powerful tool in predicting potential distribution and suitable habitats of plants and animals (Merow *et al.,* 2013). Among these tools, MaxEnt (Maximum Entropy) has gained popularity and is considered a reliable approach for species distribution modelling due to its unique ability to use presence-only data including camera trap records along with other environmental variables to generate distribution maps with much accuracy (Phillips, 2005).

Materials and Methods

Study area

Bumthang Territorial Division, which was established in April 1983, is located at about 27° 55'45.46"N 90°75'60.63"E in Bumthang district. Its jurisdiction extends over two districts of Bumthang and Trongsa with an area of approximately 1,557.55 km^2 (Figure 1). It lies at an altitudinal range of 666 m to more than 4,588 meters above sea level (m asl) comprising of cool temperate forests to sub-alpine and alpine scrub. The region receives 1,000 to 3,000 ml of rainfall annually and has warmer to temperate climatic conditions (FRMD, 2017). The Bumthang Forest Division is bordered by Wangchuck Centennial National Park in the northern part, Phrumsengla National Park and Biological Corridor (BC4) to the east, Jigme Singye Wangchuck National Park to the west, and Zhemgang Forest Division to the south with an area of 68.69 % under forest cover (FRMD, 2017). Despite its small size, the Bumthang Territorial Division is renowned for its abundant natural resources of national importance, including the national animal (Takin, *Burdorcas taxicolor* Hodgson), national bird (Ravin, *Corvus corax* Linnaeus), and national flower (Blue poppy, *Meconopsis gakyidiana* Yoshida, Yangzom & Long), and national tree (Bhutan cypress, *Cupressus tortulosa* Griff.) within its territorial boundaries (BFD, 2022).

Species occurrence data and environmental variables

We compiled Asiatic golden cat occurrence data (latitude and longitude) from the national tiger survey 2021-2022 that was carried out from 11 October 2021 to 31 January 2022. A total of 67 pairs of camera traps (ScoutGuard, Reconnyx HyperFire2, and Panthera) were systematically installed in 67 grids of 5 km by 5 km size, selected based on sign surveys, prey evidences, presence of wild ungulates, and human trails which were deemed as tiger dwelling areas (DoFPS, 2023). For this study, 35 of the 67 camera trap locations provided information on sightings of Asiatic golden cats. Thus, 35 species occurrence data were used for the analysis.

For reliable and unbiased model prediction, the Variance Inflation Factor (VIF) method was used to check multicollinearity among 19 bioclimatic variables in R version 4.3.1. We removed bioclimatic variables with VIF value of >10 as VIF value of greater than 10 is considered to be significantly related to other variables that affects model performance (Yoon and Lee, 2021). Following the multicollinearity test, a total of six bioclimatic variables with VIFs ≤ 10 were selected along with topographic and anthropogenic variables. Distance to water bodies and land cover map of Bhutan 2016 were also considered as they are the most critical factors influencing habitat selection by terrestrial animals and constitute major components of animal habitats. To identify how human activities affect the distribution of Asiatic golden cat, anthropogenic variables like human settlement and roads were also used as model input. The topographic variables such as slope, aspect, and elevation were derived from 30 m resolution digital elevation model (DEM) provided by Forest Planning and Resource Management Division. Finally, a total of 13 biologically meaningful variables were considered for modelling (Table 1).

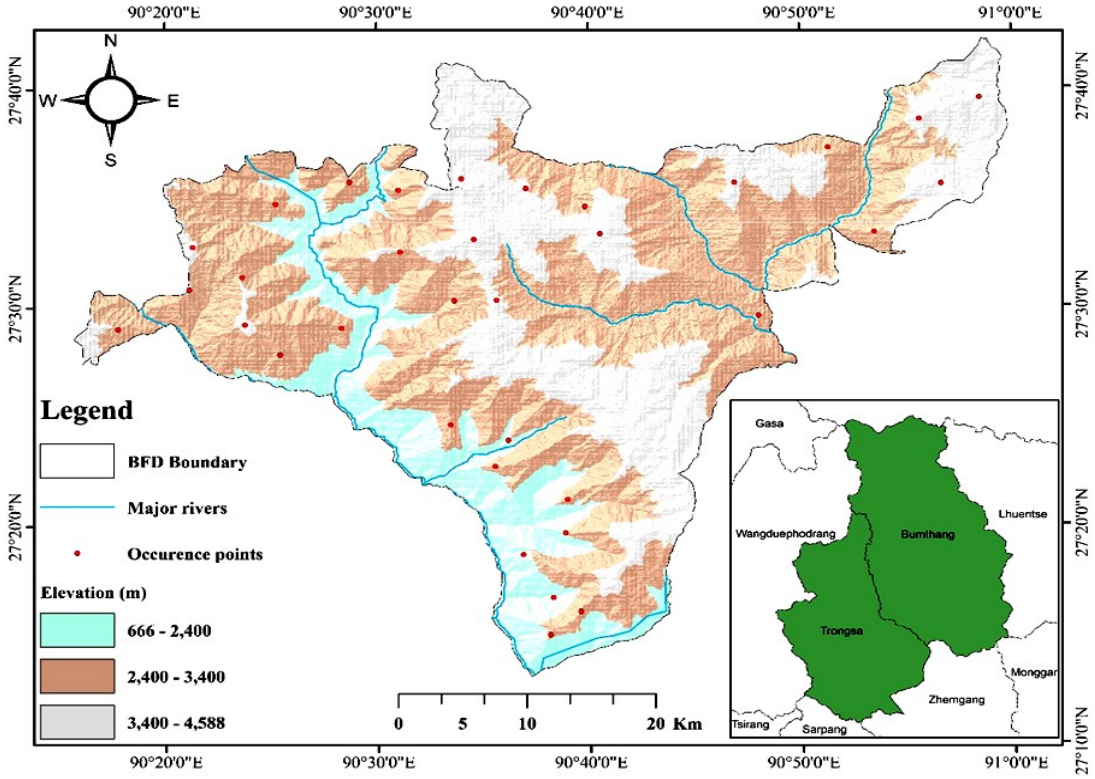


Figure 1: Map showing study area and Asiatic golden cat distribution locations

Data processing and MaxEnt setting

The overall arrangement of species occurrence data was conducted according to the methodology outlined by Young *et al.* (2011), which involved modification of environmental layers and execution of MaxEnt. A comma-delimitated .csv file was created from an Excel spreadsheet containing species occurrence data. All 13 bioclimatic variables were first extracted for Bhutan and then to the present study area using extract by mask features using spatial analyst tool in ArcGis version 10.8, and modified into same extent and cell size followed by resampling them into 30 m spatial resolution. Subsequently, all the layers were converted into ASCII format. We used MaxEnt version 3.4.4 for modelling.

Model validation

Approximately 75% of the presence data were used as training data and 25% as model validation data, and a 10-percentile threshold rule was applied. In order to avoid over or under-predict relationships, 10,000 background points with a maximum of 5,000 iterations and 15 replicate subsamples were adopted to provide ample time for convergence to build models (Young *et al.,* 2011). Following Thinley *et al.* (2021), the resulting map generated by MaxEnt was imported to ArcGis and reclassified into probabilities of Asiatic golden cat occurrence (highly suitable, moderately suitable, and unsuitable) areas based on the average 10-percentile logistic threshold value of 0.308. The values between 0-0.308 represent unsuitable area, between 0.308-0.654 as moderately suitable area, and values >0.654 as highly suitable area.

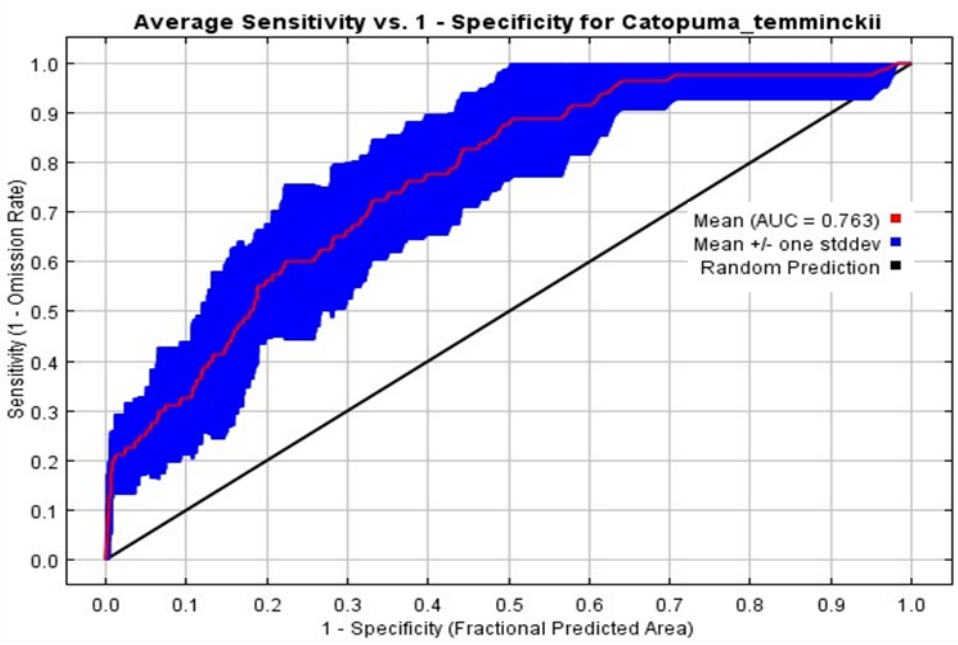


Figure 2. The mean ROC curve for Asiatic golden cat

Results and Discussion

Model performance and accuracy

The Receiver Operating Characteristic (ROC) Curve or area under curve (AUC) approach is considered the standard approach to assess the accuracy of predictive distribution model. An AUC, value closer to 1 demonstrates better model performance and a value of 0.5 indicates random model performance (Young *et al.,* 2011). Phillips and Dudik (2008) also reported that model with AUC scores above 0.75 are considered potentially useful. Hence, in this study, the mean AUC value for 15 replicates run obtained was 0.763 with standard deviation of 0.054 indicating better model performance (Figure 2).

Influential climatic variable and response curves

While comparing, predictive percent contribution of each environmental variables was used in this model. Distance to the road with 26.1% emerged as the main factor influencing spatial distribution of Asiatic golden cat. It was followed by elevation with 21.8%, slope with 15.4% and precipitation of the wettest month Bio13 with 13.9%. The variables like distance to settlement (4.4%), Bio15 (4.2%), river (3.2%), and land use land cover (3.2%) had moderate model prediction, and the least was Bio2 (0.6%) (Table 2). However, results from the Jackknife test revealed that the precipitation of the wettest month (Bio13) was the most influential factor followed by road when used individually (Figure 3).

Distribution of Asiatic golden cat

Asiatic golden cat were distributed across the whole study area from low land (1452 m asl) of Trongsa district to high elevation meadows (3998 m asl) of Bumthang district. However, more than 50% of Asiatic golden cat occurred in mid-elevation zone that is between 2400 m asl to 3400 m asl (Figure 1). Also, results from

the elevation response curve showed Asiatic golden cats were distributed across the entire elevation gradient of the current study area, more occurring between 2000 m to 4000 m asl (Figure 4 a). Our result agrees with the findings from southern foothills of the Royal Manas National Park, where the Asiatic golden cats are recorded at elevation as low as 80 m asl (Tempa *et al.,* 2011; 2013) to the montane forest of Wangchuck Centennial National Park at elevations of 4282 masl (Dendup *et al.,* 2016). However, similar other studies indicated that the species is found inhabiting mid-elevation zone mainly, particularly between 1800 m to 3900 m asl (Wang, 2007; Jigme, 2011; Thinley *et al.,* 2015; Vernes *et al.,* 2015: Yongdrup *et al.,* 2019).

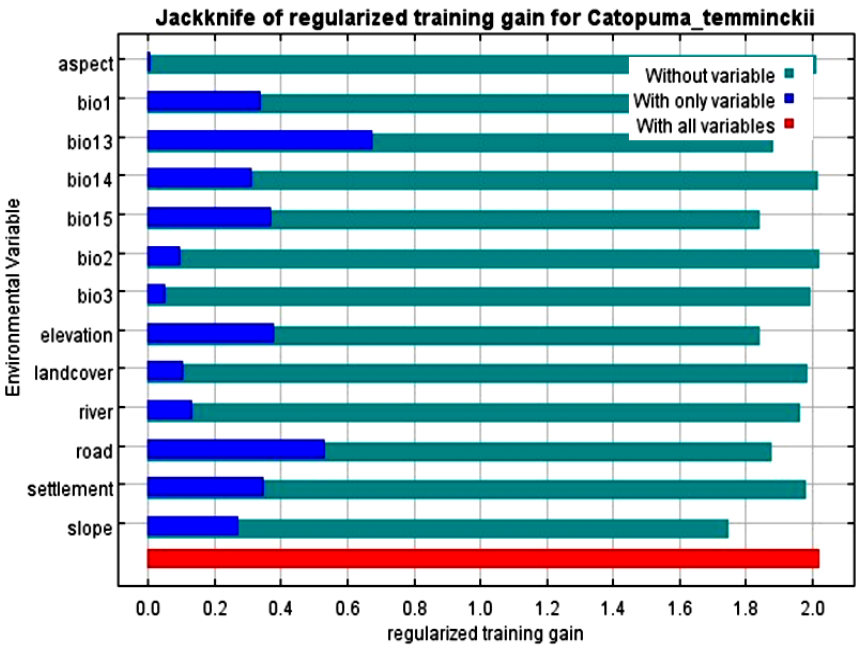


Figure 3: Jackknife test result of variable importance for Asiatic golden cat under Bumthang Territorial Division

Table 1: Variables selected for modelling

Category	Variables	Abbreviation	Unit
Bioclimatic variables	Annual Mean Temperature	Bio1	Degree Celsius(C)
	Mean Diurnal Range (Mean of monthly (max temp - min temp))	Bio2	
	Isothermality (BIO2/BIO7) × 100	Bio3	Percentage (%)
	Precipitation of wettest month	Bio13	mm
	Precipitation of driest month	Bio14	mm
	Precipitation Seasonality (Coefficient of Variation)	Bio15	mm
Topographic	Elevation	Ele	m
	Slope	Slo	Degree
	Aspect	Asp	Degree
Anthropogenic	Distance to water	Dis-water	m
	Distance to settlement	Dis-settlement	m
	Distance to roads	Dis-road	m
Land Cover	Land Use Land Cover	LuLc	-

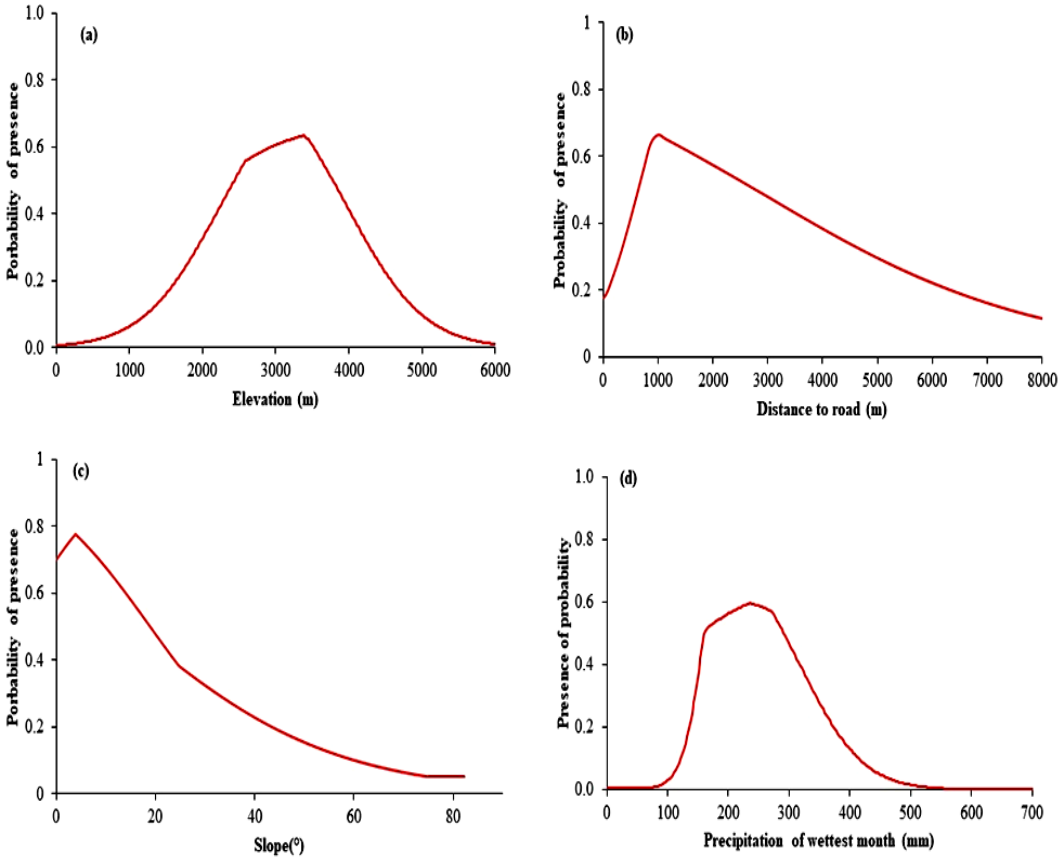
Habitat preferences for Asiatic golden cat

Out of 155,755.35 ha of the study area, MaxEnt model predicted 56.14% (87,453 ha) as unsuitable area, 35.18% (54,800 ha) as suitable area, and 8.68% (13,511 ha) as highly suitable area for Asiatic golden cat under Bumthang Territorial Division (Figure 5). Our finding revealed that this species occurs in almost all the forest types. The most preferred habitat by Asiatic golden cat was broad-leaved forests followed by mixed-conifer forests (Figure 4 f). However, there was no significant difference in habitat types preferred by Asiatic golden cat indicating this species as

Table 2. Variable contribution and permutation importance of predictor variable used for modelling

Variable	Percent contribution	Permutation importance
Distance to road	26.1	22.3
Elevation	21.8	27.8
Slope	15.4	3
Bio13	13.9	18.8
Distance to settlement	4.4	1
Bio15	4.2	2.5
River	3.2	0.7
Land use land cover	3.2	0.7
Bio1	3.1	22.1
Bio3	2.1	0.7
Bio14	1.2	0.1
Aspect	0.8	0.3
Bio2	0.6	0

habitat generalist. Earlier studies also indicated that the Asiatic golden cat occurs in a wide range of habitats including tropical, subtropical, warm broad-leaved, cool broad-leaved, mixed conifer, and dwarf rhododendron forests of Bhutan (Wangchuk *et al.,* 2004; Wang, 2007; Tempa *et al.,* 2013; Yongdrup *et al.,* 2019). It has also been reported in high elevation grasslands and shrubs (Wang, 2007). Recently, Wangyel *et al.* (2020) also reported the Asiatic golden cat from Bhutan fir dominated forests. Furthermore, our results revealed that Asiatic golden cats prefer flatter areas with slopes below 60º as well as areas away from human settlements and roads, receiving precipitation between 100 to 500 mm annually (Figure 4 a c d). Only few studies have recorded Asiatic golden cat at 2 km away from nearest settlement (Wangyel *et al.,* 2020).



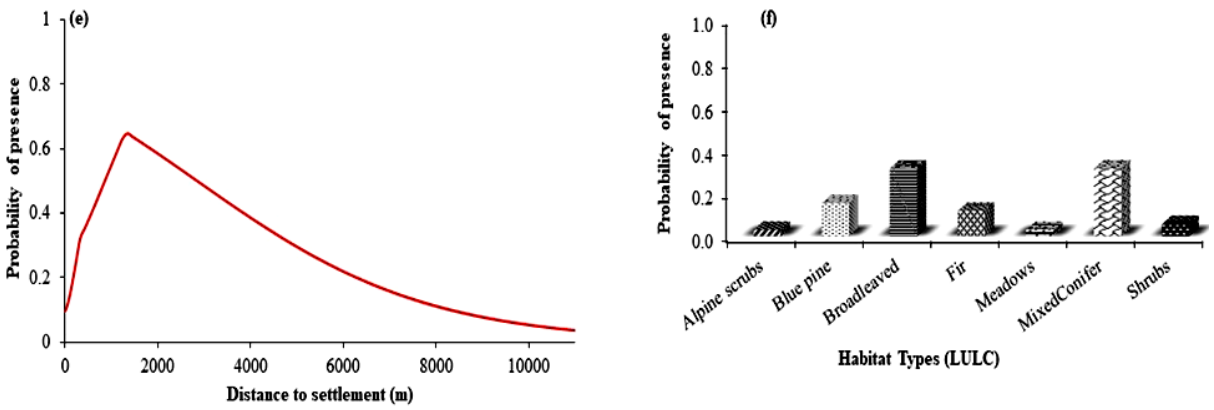


Figure 4: Response curves of six environmental variables **a)** elevation, **b)** distance to road, **c)** slope, **d)** precipitation seasonality, **e)** distance to settlement, **f)** habitat types

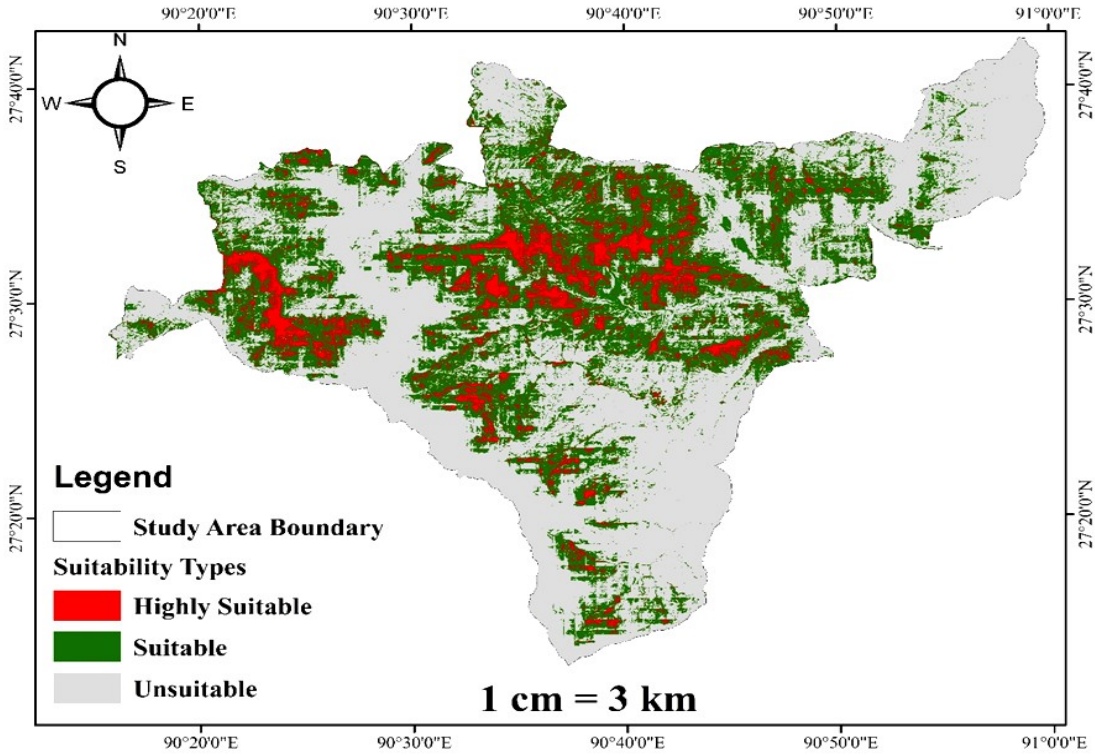


Figure 5: Suitability map of Asiatic golden cat.

Conclusion and Recommendation

This study stands as the first of its kind to create distribution and habitat suitability maps for the Asiatic golden cat within the Bumthang Territorial Division, utilizing the Maximum Entropy Modelling (MaxEnt) approach. The results provide insights on various aspects including distribution patterns, habitat preferences, and the impact of environmental factors on species distribution. Importantly, the findings confirmed that the Asiatic golden cats' distribution spans the entire study area without displaying any significant preferences for particular habitat types. Moreover, this study revealed the presence of Asiatic golden cats in the landscape beyond protected areas. As a source of baseline information, the study is valuable for future investigations concerning this near-threatened species in the current area. Based on the research outcomes and the findings of related studies, future researchers

should concentrate on acquiring more information regarding the population status and trends of the Asiatic golden cats in Bhutan. Such focused efforts will contribute to better conservation strategies for this magnificent species.

Limitations

A significant limitation noted in this study is the potential bias introduced by the selection of camera trap locations. Placing 67 pairs of camera traps across 5 x 5 km grids within the tiger's habitat and areas of high probability of presence, the projections of habitat suitability were restricted to the chosen coordinates that may have led to a potential bias in the distribution outcomes. For this, future researcher could adopt more systematic approach for grid selection based on Asiatic golden cat's home range to ensure full coverage of different habitat types, regardless of prior knowledge of species presence. This may help in capturing a more representative sample of the species' habitat use and distribution. Additionally, the data collection was conducted over a limited time frame, which might not have captured the full range of temporal variations in species presence and habitat use. Extending the duration of data collection to cover multiple seasons would provide a more comprehensive understanding of how environmental factors affect species presence and its habitat suitability. Thus, the present study result may not fully represent the overall distribution and habitat use of the species across the entire study area.

Acknowledgement

The authors express their appreciation to Mr. Pankey Dukpa, Chief Forestry Officer of Bumthang Territorial Division for according approval to use camera trap data from nationwide tiger survey 2021-2022. Also, we would sincerely like to thank Bumthang Territorial Division field colleagues who were involved in the intensive field work and data sorting which made our work easier. Lastly, we would like to thank all the reviewers who greatly helped in improving the quality of this manuscript.

References

BTC. (2021). *Wild Cats Atlasts of Bhutan*. Bhutan Tiger Centre, Department of Forest and Park Services, Gelephu.

BFD. (2022). *Bilogical Corridor 08 Management Plan (2022 - 2032)*. Bumthang Forest Division. Departmen of Forests and Park Services, Ministry of Agriculture and Forests. Royal Government of Bhutan.

Dhendup, T. (2016). Status of Asiatic Golden Cat Catopuma temminckii Vigors & Horsfield, 1827 (Carnivora: Felidae) in Bhutan. *Journal of Threatened Taxa*, *8*(4), Article 4. https://doi.org/10.11609/jott.2560.8.4.8698-8702

Dhendup, T., & Dorji, R. (2018). *Camera-trap records of small carnivores from Gedu Territorial Forest Divi sion, Bhutan*. https://doi.org/10.13140/RG.2.2.21570.43202

Dhendup, T., Tempa, T., & Norbu, N. (2016). Camera trap records of Asiatic golden cat at high altitudes in Bhutan. *Cat News*, *N 64*, 37–38.

Department of Forest and Park Services. (2023, August 24). The National Tiger Survey Report 2022 [Ministry of Energy and Natural Resources.]. *Bhutan for Life*. https://bfl.org.bt/the-national-tiger-survey-report-2022/

Forest and Nature Conservation Act of Bhutan. (2023). *Forest and Nature Conservation Act of Bhutan, 2023*. Department Forest and Park Services, Ministry of Energy and Natural Resources. Thimphu, Bhutan.

FRMD. (2017). *Land use and land cover of Bhutan, 2016, Maps and Statistics*. Department Forest and Park Services. Ministry of Agriculture of Forests. Thimphu, Bhutan.

Jnawali, S.R., Baral, H., Lee, S., Acharya, K., Upadhyay, G., Pandey, M., & Griffiths, J. (2011). The status of Nepal mammals: the national red list series, Department of National Parks and Wildlife Conservation Kath mandu, Nepal. *Preface by Simon M. Stuart Chair IUCN Species Survival Commission. The Status of Nepal's Mammals: The National Red List Series*, *4*.

Merow, C., Smith, M. J., & Silander Jr, J. A. (2013). A practical guide to MaxEnt for modeling species' distri butions: What it does, and why inputs and settings matter. *Ecography*, *36*(10),1058–1069.https:// doi.org/10.1111/j.1600-0587.2013.07872.x

Mccarthy, J., Dahal, S., Dhendup, T., Gray, T., Mukherjee, S., Rahman, H., Riordan, P., Boontua, S., & Wil cox, D. (2016). *IUCN Redlist Assessment of Asiatic Golden Cat*. https://doi.org/10.13140/ RG.2.1.5104.1367

Phillips, S.J., Anderson, R.P., & Schapire, R.E. (2006). Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, *190*(3), 231–259. https://doi.org/10.1016/j.ecolmodel.2005.03.026

Suzuki, A., Kyaw, W. W. H., & Naing, K. M. (2019). The presence of Asiatic golden cat in human-modified landscape in Ayeyarwady region. In *Proceedings of the International Joint Symposium* (p. 235).

Tempa, T., Hebblewhite, M., Mills, L.S., Wangchuk, T.R., Norbu, N., Wangchuk, T., Nidup, T., Dendup, P., Wangchuk, D., Wangdi, Y., & Dorji, T. (2013). Royal Manas National Park, Bhutan: a hot spot for wild felids. Oryx, 47(2), 207-210.

Tempa, T., Norbu, N., Dhendup, P., & Nidup, T. (2011). Results from a camera trapping exercise for estimate ing tiger population size in the lower foothills of Royal Manas National Park. *Ugyen Wangchuck Institute for Conservation and Environment and Royal Manas National Park, Royal Government of Bhutan, Lamai Gompa*.

Thinley, P., Rajaratnam, R., Kamler, J.F., & Wangmo, C. (2021). Conserving an Endangered Canid: As sessing Distribution, Habitat Protection, and Connectivity for the Dhole (Cuon alpinus) in Bhutan. *Fron tiers in Conservation Science*, *2*. https://doi.org/10.3389/fcosc.2021.654976

Vernes, K., Sangay, T., Rajaratnam, R., & Singye, R. (2015). Social Interaction and co-occurrence of colour morphs of the Asiatic Golden Cat, Bhutan. *Cat News 62*: 18–20.

Wang, S.W. (2007). A rare morph of the Asiatic Golden Cat in Bhutan's Jigme Singye Wangchuck National Park. *Cat News* 47: 27–28.

Wangchuk, T., Thinley, P., Tshering, K., Tshering, C., Yonten., D & Pema, B. (2004). *Field Guide to the Mammals of Bhutan*. Royal Government of Bhutan, 59–60pp.

Wangyel, S., Dorji, K., Tobgay, S., & Yangdon, N. (2020). First photographic evidence of the Asiatic Golden Cat Catopuma temminckii Vigors & Horsfield, 1827 (Mammalia: Carnivora: Felidae) in Sakteng Wildlife Sanctuary, Bhutan. *Journal of Threatened Taxa*,*12*,15262–15266.https:// doi.org/10.11609jott.5089.12.2.15262-15266

Yongdrup, P., Sherub, K., Tshering, U., Chaida, L., & Chaten, C. (2019). Abundance and Distribution of Asi atic Golden Cat (Catopumma teminckii Vigors and Horsfield) and Clouded Leopard (Neofelis nebulosa Grifith) in Jomotsangkha Wildlife Sanctuary, Bhutan. *Bhutan Journal of Natural Resources and Develop ment*, *6*(1), 19–26.

Yoon, S., & Lee, W.H. (2021). Methodological analysis of bioclimatic variable selection in species distribu tion modeling with application to agricultural pests (Metcalfa pruinosa and Spodoptera litura). *Computers and Electronics in Agriculture*, *190*, 106430. https://doi.org/10.1016/j.compag.2021.106430

Young, N., Carter, L., & Evangelista, P. (2011). A MaxEnt model v3. 3.3 e tutorial (ArcGIS v10). *Natural Resource Ecology Laboratory, Colorado State University and the National Institute of Invasive Species Science*.