Research Article

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Pemodelan Distribusi Spesies pada Monyet Ekor Panjang (*Macaca fascicularis*) di Padang, Sumatera Barat

Species Distribution Modelling on Long-tailed Macaque (*Macaca fascicularis*) in Padang, West Sumatra

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A B S T R A C T

Human activity is a major factor in the decline of primate biodiversity, including long-tailed macaques, which thrive in varied habitats, even near human settlements. This overlap can lead to conflicts for both humans and macaques. The objective of this study is to determine the distribution of long-tailed macaques through direct observation and potential distribution based on habitat suitability modelling using MaxEnt. Six environmental variables were selected based on the ecological traits of long-tailed macaques, including forest cover, population density, distance to roads, distance to forests, distance to conservation areas, and land use type. Moreover, 32 coordinate points were identified in Padang for locating long-tailed macaque and modelled using MaxEnt. The results indicate that long-tailed macaques are primarily distributed in areas with forest cover but are close to anthropogenic activities. The modelling reveals that the habitat suitability for this species in Padang tends to be low to moderate. The environmental variables that exert the most significant influence on their distribution are distance to roads and forest cover (53.3% and 20.1% respectively). Consequently, areas with a higher potential of habitat suitability required particular attention to manage conflicts and populations to avoid potential negative impacts that could arise.

INTRODUCTION

Anthropogenic activity is a significant determinant of species and biodiversity decline (Scheun, Greeff, and Nowack, 2019, Frances, et al., 2022). Several studies exhibited the decline of non-human primate populations due to forest conversion and fragmentation, road construction, and agriculture (Sarania, et al., 2017). Therefore, in order to survive, many animal species, including primates, have to adapt to habitat structure and quality alteration, which will influence their distribution in a human-modified landscape (de Almeida-Rocha, et al., 2020).

Macaca fascicularis is one of opportunistic and cosmopolite primates which known to have the ability to live near humans. Some types of human-macaque interface zones are: agricultural land, cemeteries, eco-lodges, metropolitan cities, rural villages, roads, small islands, towns, temples/religious grounds, and recreation parks (Gumert, Fuentes, and Jones-Engel, 2011). At some study sites in Padang (Gunung Meru, Gunung Padang, and Gunung Panggilun) this species showed their capacity to alter the proportion of human food as their behavioral flexibility to survive in urban habitats (Ilham, et al., 2017).

As human population and activities have been increasingly widespread in primate habitats, there are many disadvantages that may happen. They can be urban pests and threaten humans in their proximity, parasitize human resources and damage dwellings, causing spread of debris within a community (Gumert, Fuentes, and Jones-Engel, 2011), threaten or cause harm to humans by acting aggressively in tourism area ((Mardiah, 2016), and compete with humans for food and space and becoming crop raiders (Utami, Rizaldi, and Novarino, 2016). Furthermore, with close biological similarity of macaques and humans, the potential exchanging of the pathogen will be higher (Permana et. al.,

2023), consequently affecting biodiversity conservation and global health (Kowalewski, et al., 2011). Additionally, there is an urgent need to study this species due to the change of the conservation status. In March 2022, IUCN Red List of Threatened Species announced that based on the global assessment, the status of this species increased into Endangered as a consequence of decreasing habitat and exploitation.

Therefore, it is necessary to understand the contexts and patterns of human-macaque interactions as well as predict the macaques' distribution in Padang and environmental variables affect it. This study using MaxEnt to determine the potential distribution as well as environmental variables significantly influence the long-tailed macaque's occurrence.

RESEARCH METHODOLOGY

The study was conducted in Padang (0°44' and 01°08'S, 100°05' and 100°34'E), West Sumatra in June-November 2022 (Fig. 1). Species distribution data of the macaque species was collected in the areas predicted in Padang through sampling their occurrence points. The sampling of occurrence point (presence data) is aimed to obtain coordinate point of the species, either individually or in colony using GPS and Avenza Maps (Table1) The sampling conducted through direct observation to locations known where the macaques exist based on previous studies as well as information from local citizens. The data then combined with the environmental variables (Table 2)
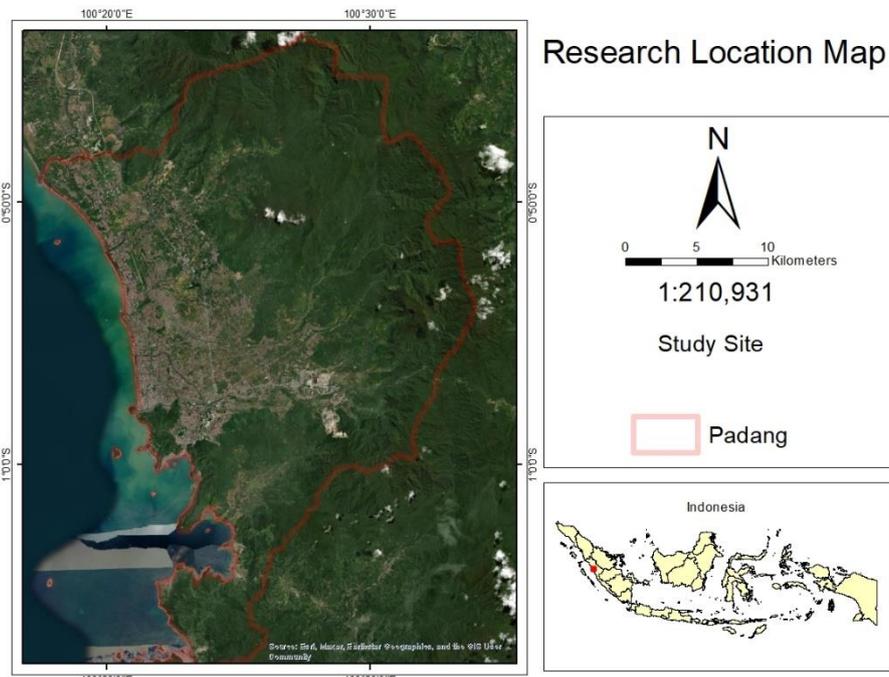

Fig. 1 Research Map Location in Padang

Table 1. Data types used in the study

No	Data	Types
1.	Individual/colony coordinate of Macaques' occurrence point	Primary and secondary data
2.	Environmental variables (covariates)	Secondary data

Table 2. Environmental variables used as predictors in species distribution modeling

No	Environmental Variables	Source
1.	Forest Cover	KLHK
2.	Population Density	Padang Central Bureau of Statistics, 2021
3.	Distance to Roads	Rupa Bumi Indonesia
4.	Distance to Forest	Global forest change

5.	Distance to Conservation Area	BKSDA
6.	Land Use Type	BKSDA
	- Primary forest	
	- Secondary forest	
	- Water bodies	
	- Grassland	
	- Agriculture	
	- Settlement	

The presence data is compiled using Excel which are stored in CSV format. Meanwhile, environmental variable data is stored in ASCII format using the Raster to ASCII extension. Bootstrap procedure is selected with 25% randomized test, 10 repetitions, regularization multiplier with a value of 1, and 5,000 iterations, and saves other settings in standard options. Then the Jackknife test is carried out to see the consistency of the variables that are considered important. The final result of Maxent is encapsulated in an HTML file. This information is generated by Maxent based on the AUC value which represents the performance of the model as well as the environmental variables that contribute to the creation of the model. To analyse the potential distribution of the macaques, connection between macaques' distribution,and environmental variables significantly influence the macaque's occurrence, modeling results in ASCII format are converted into rasters (grids) using the ASCII to Raster extension of QGIS software. In the conversion process, the desired output data is selected in Float type so that the raster value ranges between 0 and 1. Further information on the MaxEnt performance results can be seen from the AUC value as a description of the model performance and environmental variables contributing to model making.

RESULTS AND DISCUSSION

The Long-tailed Macaque Distribution

There were 32 occurrence points of long-tailed macaque encountered during the observation (Table 3). Among 11 subdistricts in Padang, the long-tailed macaques occurrence were distributed in seven subdistricts. Four subdistricts where this species not found were in Padang Barat, Padang Timur, Nanggalo, and Lubuk Begalung as those areas are might be less suitable for the species to live compared to the other subdistricts since they are human densely populated areas with less or without forest as natural habitat for the primate. This is also probably affected by the distance from other forest where the other macaque's population dwell. Antomi (2016) mentioned trends on land use changes in subdistricts in Padang using Citra Landsat from 1989 to 2016 showed no secondary neither primary forest in Nanggalo, Padang Barat, and Padang Timur, while Lubuk Begalung showed significant decrease on primary forest, and big increase in developed area in contrast. Though this species known to be able to survive in fringe habitat, forest edge, or anthropogenic areas, the natural habitats as stated by Supriatna and Wahyono (2000) such as primary, secondary, coastal, mangrove, swamp, and riverine forests, are is still important as the indicator for the macaque's existence.

On the other hand, the macaque can be found in other subdistricts which characterized by having forested areas which inseparable from anthropogenic activities. The highest number of long-tailed macaque was found in Bungus Teluk Kabung, Padang Selatan, and Padang Utara (ranked by highest number respectively), where those areas still have more forest as natural habitat for this species. However, despite the ability of this species to seeking and occupying a new habitat in case of disturbed natural habitat, will be potentially impact on human disease risks (Stark et al 2019). As the long-tailed macaque also dwell in city centers, temples, and forested parks, there will be a relatively higher frequency of interactions with tourists through provisioning (Schurer, et al., 2019), that can be

Table 3. The location, number of occurrence points and individuals of the long-tailed macaque

Subdistricts	Location	Number of Occurrence Points	Number of Individuals
Koto Tangah	Jembatan Brimob	1	15
	Lubuk Minturun	2	*
	Ngungun Saok	2	*
Kuranji	Sungai Sapih	1	18
Padang Utara	Gunung Pangilun	4	40 (3 groups)
Padang Selatan	Gunung Padang	2	47 (2 groups)
	Bukit Gado-Gado	2	18
	Pelindo Teluk Bayur	1	13
	Simpang Gaung	1	28
Bungus Teluk Kabung	Gunung Meru	3	66 (2 groups)
	Bungus	4	34 (2 groups)
	TPU Bungus	1	5
	Simpang Teluk Sirih	1	9
	Sungai Pisang	1	20
Lubuk Kilangan	Sitinjau Atas	1	11
	Sitinjau Bawah	1	6
Pauh	Halte Pertanian Unand	1	4
	Business Center Unand	1	*
	Batu Busuk	2	*

Note: The asterisk represents the reported findings but unknown number of individuals of the long-tailed macaque in the location

potentially leads into behavioural shifting like on moor macaque in Sulawesi (Riley, et al., 2021).

Areas in Bungus Teluk Kabung and Padang Selatan where the long-tailed macaque found were known to be the tourism area where the macaque provisioned. They do not only eat natural food but also habituated with anthropogenic food which relatively more nutritious. Compared to Padang Selatan and Padang Utara, the long-tailed macaques found in Bungus Teluk Kabung preferred greater amount of human food diets (more than half), as a result of their behavioural adaptation in urban habitat (Ilham, et al., 2018). Though this can enhance their reproductive success, consequently, this can also potentially raise the number of their population over the environment's carrying capacity if the condition is not limited (Ilham, et al., 2018, Marechal, et al., 2016, Schrurer, et al., 2019).

Potential Distribution of Long-tailed Macaque

Figure 4 and 5 show the potential distribution of the long-tailed macaque based on the habitat suitability. According to the distribution map of habitat suitability (Figure 4), it can be seen that proportion of unsuitable habitats of the long-tailed macaque are generally considered low among all of the subdistricts. The textured right-side and down-side areas on the map shows contoured areas in Padang (Bukit Barisan mountains and forest with relatively high altitude) where the macaque is not well-distributed. In contrast, the model shows more distribution on the left-areas which shows grey colour background. Those areas represent the lower altitude, hence more long-tailed macaque distributed there since it was known that long-tailed macaques might be found up to 1.300 meters above sea level (ASL) (Fauzi *et al.*, 2020).
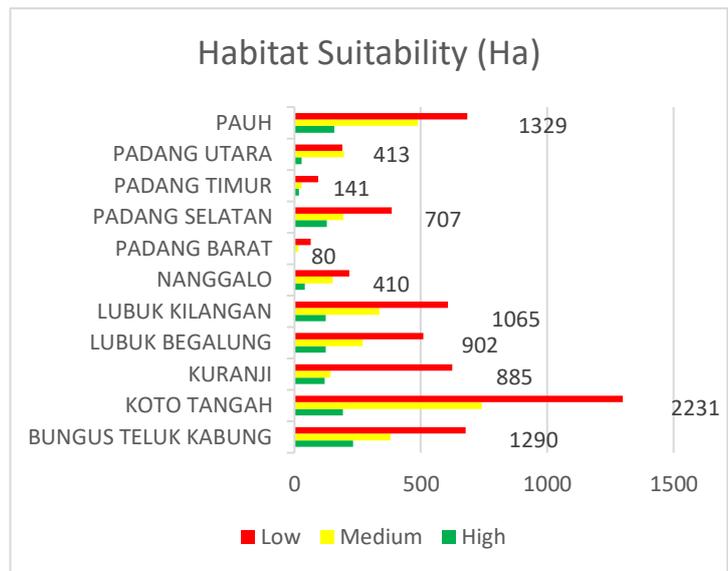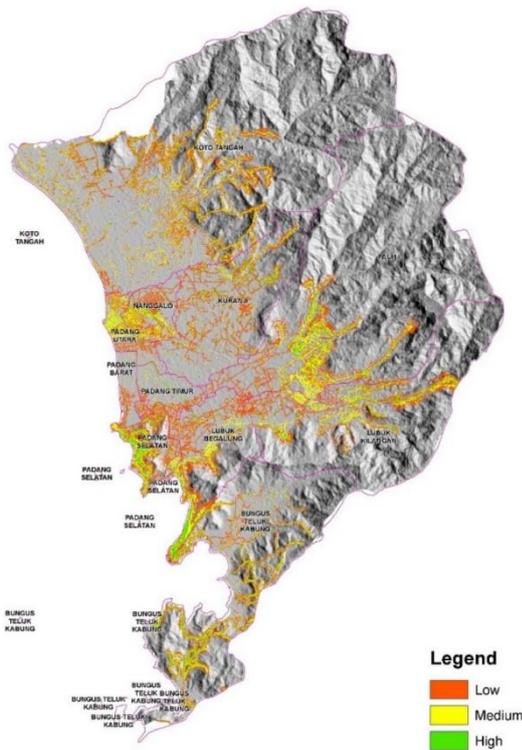
Fig. 4 Prediction Map of The Long-tailed Macaque Distribution in Padang, Fig. 5 Habitat Suitability of The Long-tailed Macaque in Padang

Figure 5 demonstrates almost all of the subdistricts tend to have low rather than medium and high habitat suitability for this species to live. Among all of the subdistricts, Koto Tangah has the lowest area for the habitat suitability, followed by Pauh, Bungus Teluk Kabung, Kuranji, and Lubuk Kilangan. Meanwhile, areas with the highest suitability were Bungus Teluk Kabung, followed by Koto Tangah and Pauh.

Environmental Variables Significantly Influence the Long-tailed Macaque's Occurrence

The red line on the AUC curve means value for the 10 MaxEnt runs, while the blue bar represents the standard deviation. The average training area under curve (AUC) for the 10 replicate runs is 0.960 and the standard deviation is 0.012 (Figure 6). AUC with number higher than 0.9 indicates acceptable model with good accuracy. AUC now is widely recognized as the standard approach for evaluating the precision of predictive distribution models. It eliminates the perceived subjectivity in selecting thresholds when transforming continuous probability scores into a binary presence-absence variable by providing an overview of the model's performance across all potential thresholds (Lobo et al., 2008).
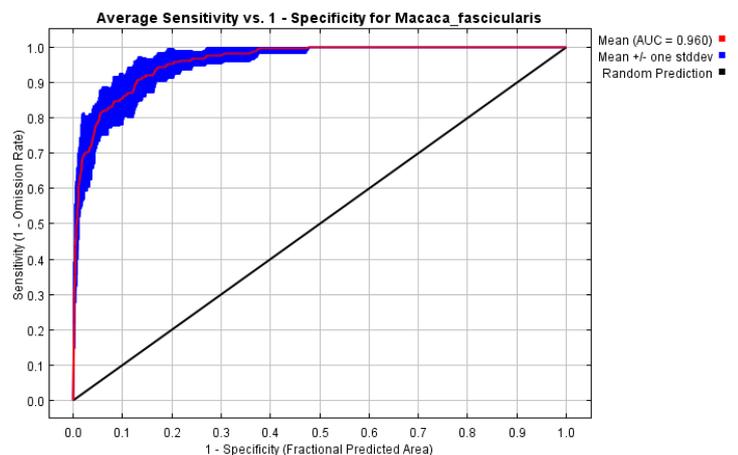

Fig. 6 Performance Curve of Prediction Model

The environmental variables significantly influence the long-tailed macaque's occurrence are them which have value greater than 10%.

Table 4. Percent Contribution of Each Environmental Variables Used

Variable	Percent Contribution
Distance to Road	53.3
Forest Cover	20.1
Distance to Conservation Area	7.5
Land Use Type	7.4
Forest Distance	6.6
Human Population	5

In this prediction, distance to road is one of the environmental variables that affect the long-tailed macaque distribution with percent contribution value is 53.3% (Table 4). Another variable that affected the prediction is forest cover with percent contribution value is 20.1%. The distribution of this species appears to be unaffected by other variables despite the existence of such influences.

The long-tailed macaque's occurrence in this model is very close to the road and they can be found until 2000m. The highest occurrence of the species predicted with around 2% conditions of forest cover, and decreases as the percentage getting higher to 100% conditions (Figure 7).
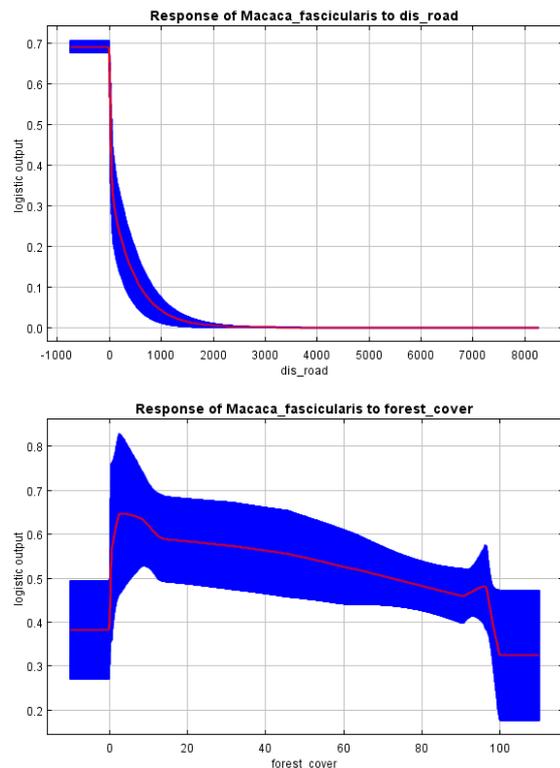

Fig. 7 Response Curve of Long-tailed Macaque Distribution to Distance to Road and Forest Cover

This so-called urban primate indeed can be found in the areas relatively close to human, and roads are suitable area for them to forage (Figure 8). For the roadside macaque, long-tailed macaque group which spent most of their time on the ground and lower canopy preferred to move in quadruped or on the electric cable instead of jumping from tree to tree, and the food choices varies from food waste, food given by humans, and food from the residential areas nearby (Hambali *et al.*, 2014).

This anthropogenic aspect has shown its impact on behavioural shifting as can be seen on moore macaque where they began spending more time along the road foraging in trash pits and waiting for provisions from vehicles (Riley, et al., 2021) and the provisioning along roads probably structuring their distribution/habitat use (Hansen, et al., 2019). Moreover, road infrastructures and collisions with vehicles negatively affect many animal populations globally (Hetman, et al., 2019), and animals that spend more time near road can put them into greater risk of road kills.
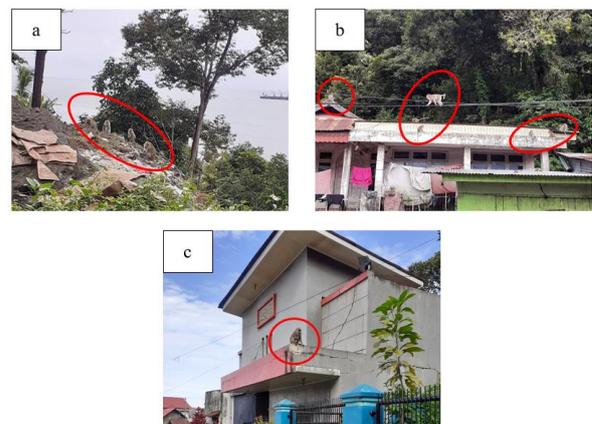

Fig. 8 Long-tailed Macaque Findings in Several Anthropogenic Areas: a. Foraging food waste, b. Quadruped on Electric Cable, c. Near Settlement

Furthermore, the close proximity of this species and humans as a result of dramatic changes of land use, deforestation within the last 3 decades has intensified interaction between non-human primate with human being. It is, therefore, anticipated that the more interaction between human and non-human primate will facilitate the spill-over of many pathogens from human and non-human primate (Anthropozoonotic infection) or vice versa either through mosquito or direct transmission (Lempang, et al., 2022).

Long-tailed macaques are largely influenced by forest cover, even if this prediction may not directly influence this species' distribution. This shows how this species does not necessarily have to live in dense cover forest because they are highly adaptive in various types of habitats (Fitria, 2020). Hansen *et al.* (2019) found In Baluran National Park, the species distribution and habitat analysis of the long-tailed macaque revealed a macaque preference for area close to or on roads and trails, invasive acacia and/or native savannah.

CONCLUSION

According to the study, it can be concluded that:
1) In Padang, the long-tailed macaque distributed in seven subdistricts: Koto Tangah, Kuranji, Padang Utara, Padang Selatan, Bungus Teluk Kabung, Lubuk Kilangan, and Pauh
2) Generally, subdistricts in Padang tend to have low rather than medium and high habitat suitability for the long-tailed macaque to live
3) Environmental variables significantly influence the long-tailed macaque distribution are distance from road and forest cover

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