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# Predicting of Komodo dragon's potential prey habitat suitability using MaxEnt in Riung Nature Reserve, Flores, East Nusa Tenggara, Indonesia

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**Abstract.** *Pramatana F, Aini Y, Rammang N, Mau YS, Arsa IGBA, Mahmud A. 2023. Predicting of Komodo dragon's potential prey habitat suitability using MaxEnt in Riung Nature Reserve, Flores East Nusa Tenggara. Biodiversitas 24: 3128-3139. T*he Komodo dragon (*Varanus komodoensis* Ouwens, 1912) is a big lizard species from the Varanidae family that belongs to the Endangered category (EN) listed on the IUCN red list and Appendix I CITES. This study aimed to reveal the distribution of potential preys Komodo dragons in Rinca Island, Komodo National Park, Manggarai District, East Nusa Tenggara, Indonesia, using Maximum Entropy (MaxEnt), which was collected using rapid assessment methods. The presences of the Komodo dragon's potential prey come from direct and indirect observation or previous studies. We collected 510 points of Komodo dragon prey presence in Riung, Ngada District, East Nusa Tenggara, Indonesia from six species, including cattle, but only used 127 points for analysis based on the correlation. Long-tailed macaque, wild boar, civet, Timor deer, feral horses, and cows were the potential prey for komodo in Riung. Most of the points come from cattle, such as cows. On the other hand, we used environmental habitat to represent prey habitats such as elevation, slope, land surface temperature, moisture index, vegetation index, and distance from specific objects such as distance from agriculture, rivers, road, savanna, and settlement. Komodo dragon's potential prey in Riung was distributed in savanna, mangrove, and lowland forest. The result showed three suitable habitats for the Komodo dragon's potential prey dominated by low and moderate-suitability areas.

**Keywords:** Habitat suitability, komodo dragon, maxent, prey, Riung

## INTRODUCTION

Species distribution models estimate the relationship between environmental characteristics at species occurrences and environmental characteristics within the species' general area of occurrence (Franklin 2010). Hence, predictive models of potential geographic distributions are widely used for various applications in ecology, conservation, and biogeography (Graham et al. 2004; Guisan and Thuiller 2005). MaxEnt is one of the algorithms that can be used to predict a species' potential distribution (Phillips 2005). It is a machine-learning approach based on presence-only data, evaluating the likelihood of presence in a given cell based on environmental features in the same cell (Elith et al. 2006; Wisz et al. 2008; Elith et al. 2010; Elith et al. 2011).

Climate change is projected to match these drivers in intensity and possibly outpace them in the next 50 years (Newbold 2018). Future climate change can lead to shifts in the distribution and abundance of species (Thomas et al. 2004; Ehrlén and Morris 2015; Wang et al. 2018), extinction of species populations (Thomas et al. 2004; Keith et al. 2008; Bestion et al. 2015), range shifts (Chen et al. 2011; Nenzén and Araújo 2011; Bellard et al. 2012; Iverson and McKenzie 2013; Habibzadeh et al. 2021) phonological changes (Anenkhonov 2009; Cuena-Lombraña et al. 2018; Merilä and Hendry 2014; Wolkovich et al. 2012), and physiological trait changes (Dillon et al. 2010; Fois et al. 2018).

Studying the effects of future climate change on the distribution of species is one of the fundamentals of managing informative activities for the conservation of biodiversity (Hosseinzadeh et al. 2017; Kaky and Gilbert 2017, 2019; Chefaoui et al. 2018; Hosseinzadeh et al. 2018, 2020; Baker et al. 2021; Fathinia et al. 2020), and studying the genus *Varanus* (Malakhov and Chirikova 2018; Shadloo et al. 2021; Baral et al. 2023).

The Komodo dragon (*Varanus komodoensis* Ouwens, 1912) is the largest living lizard from the Varanidae family that belongs to the Endangered category (EN), which is listed on the IUCN red list (Jessop et al. 2021). In addition, the Komodo dragon's local name is *ora*, a flagship species in the Komodo National Park area listed in Appendix I of CITES, indicating that selling this species is prohibited in a state of life and body parts. Komodo dragons are only spread across four populations within the Komodo National Park area, with the largest populations on Komodo Island, Rinca Island, Gili Motang, and Nusa Kode, East Nusa

Tenggara, Indonesia. (Ciofi and De Boer 2004; Jessop et al. 2007; Purwandana et al. 2014; Ariefiandy et al. 2017). Santosa et al. (2012) reported the distribution of dragons on Rinca Island often clustered in certain places, such as guard posts or forest areas during the dry season.

In 1980 the Komodo National Park was established to protect most of the Komodo dragon distribution, including the islands of Komodo, Rinca, Padar, Gili Motang, and Nusa Kode. Furthermore, in 1985 several Nature Reserve Areas (*Kawasan Suaka Alam*/KSA) were established to protect the distribution area of the Komodo dragon on Flores Island: Wae Wuul Nature Reserve (*Cagar Alam*/CA) on the west coast, Wolo Tado CA, Riung CA and Seventeen Islands TWA on the north coast. These four locations are under the Natural Resources Conservation Agency (*Balai Besar Konservasi Sumber Daya Alam*/BBKSDA) management of East Nusa Tenggara Province (Nusa Tenggara Timur/NTT). Many habitat pockets are scattered on the island of Flores, East Nusa Tenggara, Indonesia, only classified as having a low population density (Ciofi and De Boer 2004).

Threats to the existence of Komodo dragons include habitat degradation (Ariefiandy et al. 2021) and potentially invasive animals, such as Black-Spined Toad (*Duttaphrynus melanostictus* Schneider, 1799), which are feared to enter the Komodo dragon's habitat (Kennedi et al. 2020; Ujvari et al. 2015). In addition, hunting for Komodo dragons, baiting (Santosa et al. 2012), and massive development also threaten their existence. Ardiantiono et al. (2018) reported that there are long-term consequences when the natural presence of Komodo dragons comes into contact with tourism activities. Komodo dragons probably will lose their instinct to hunt and start consistently expecting leftover food or food visitors provide in tourist areas. Walpole (2001) reported that additional feeding was carried out to attract tourists to see Komodo dragons at viewing sites. Komodo dragons show habituation by reducing their negative responses to humans (Ardiantiono et al. 2018; Fauzia 2020). In addition, Ardiantiono (2018) also explained that providing additional food would have a long-term effect on the Komodo dragons.

Mustari et al. (2011) state that five large mammals are prey animals for the Komodo dragon: Timor deer, water buffalo, wild horses, wild boars, and long-tailed monkeys found on Rinca Island. Meanwhile, since 2008, the NTT BBKSDA, with the Komodo Survival Program (KSP), has studied the population of Komodo dragons and their prey animals in the Wae Wuul CA area. They assumed that when an animal is found as prey for the Komodo dragon, this indicates the presence of the Komodo dragon. However, the distribution of prey animals on Rinca Island is random, with a quite large number (Mustari et al. 2011). Furthermore, Timor deer, water buffalo, and horses are herbivores, so the presence of forage as feed plays a role in the existence and sustainability of these animal populations. Therefore, this research was proposed to model the presence of prey animals in the NTT BBKSDA area, which is considered a meeting point for the Komodo dragons. This research also supports the conservation of priority animals currently threatened by land use change so that the results of spatial modeling of habitat suitability as a consideration for managers to manage areas with high habitat suitability for Komodo dragon's potential prey. In addition, the results of this study also provide an overview of the suspected existence of Komodo dragons whose habitat continues under pressure.

## MATERIALS AND METHODS

### Study area

This study was conducted from July to December 2022 in Riung Nature Reserve in Ngada Regency, East Nusa Tenggara, Indonesia from 08.00-17.00 WITA. Those areas are within the management of the East Nusa Tenggara Provincial Natural Resources Conservation Agency (*Balai Besar Konservasi Sumber Daya Alam*/BBKSDA) (Figure 1).

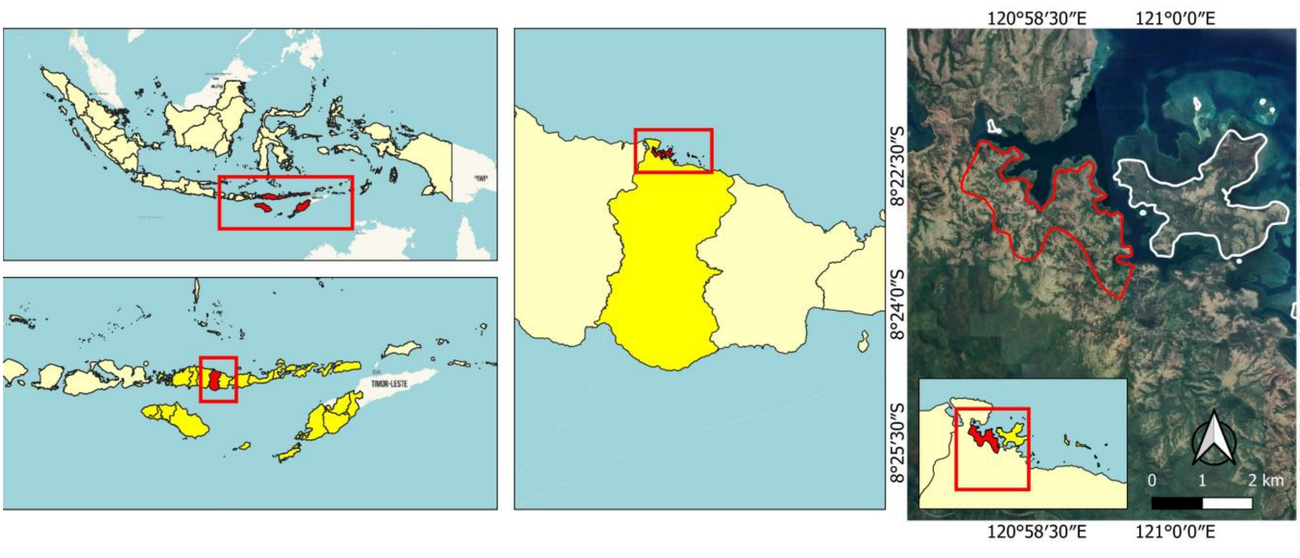


**Figure 1.** Location of Komodo dragon's potential prey in Riung Nature Reserve Ngada District, East Nusa Tenggara, Indonesia

### Procedures

*Data collection*

The research was started by conducting a literature study on the distribution of Komodo dragons, their prey animals, and their habitats to facilitate making tally sheets. Then we collected the presence of the Komodo dragon's potential prey from direct and indirect observation or previous studies. Finally, observations were made using rapid assessment methods in Riung Nature Reserve. Rapid assessment is an observation by recording species found directly or indirectly, such as mammal footprints and feces, without any special paths or locations (Bismark 2011). In addition, observers record the mammal types found during site surveys or walking outside observation hours (Bismark 2011).

Furthermore, the coordinate points are taken at the direct or indirect object's present location as primary data in the subsequent spatial analysis (Merow et al. 2013; Nezer et al. 2017; Phillips 2017; Phillips et al. 2017). Coordinate point data collection using tally sheets compiled on KoboCollect, a web-based and smart mobile app being easier to access, less expensive, and more efficient for data collection in many scientific fields (Lakshminarasimhappa 2022). For example, collect is used in the socio-economic and socio-cultural (Deniau et al. 2017), used for controlling animal problems (Le Bel et al. 2016), used for wildlife management (Palla et al. 2016), etc.

Coordinate points of the observed result were then extrapolated to produce a map of habitat suitability index with ArcGIS 10.8.2 (licensed to Fadlan Pramatana) to create environmental variables and Maxent to create a spatial model (Çoban et al. 2020; Merow et al. 2013; Phillips et al. 2017). In addition, data on the presence of prey animals for the Komodo dragon were also obtained from literature studies carried out by individuals or institutions. The point of presence of the Komodo dragon's potential prey will be collected in a .csv file in Microsoft Excel 2021 version for further analysis on Maxent (Phillips 2017).

*Environmental variables*

Environmental variables are needed to conduct the analysis to develop a species distribution model in Maxent (Phillips 2017; Phillips et al. 2006, 2017; Phillips and Dudík 2008). The environmental variables used in this study include elevation, slope, land surface temperature, moisture index, vegetation index, and distance from specific objects, such as distance from agriculture, river, road, savanna, and settlement. The type of data, source of data, and data collection method are shown in Table 1.

Environmental variables would be used to predict the suitability habitat of the Komodo dragon's potential prey, representing ecological conditions (Williams et al. 2012). The selection of environmental variables is important to improve the accuracy of the potential distribution of species (Li and Ding 2016). Environmental variables can also be based on habitats or variables that affect the presence of these species (Remya et al. 2015; Ma and Sun 2018; Sharma et al. 2018; Zhang et al. 2019b; Li et al. 2023), etc.

### Data analysis

Analyzing data for habitat suitability modeling uses two data types: the presence data for the Komodo dragon's potential prey and environmental variables (Phillips et al. 2006, 2017; Phillips and Dudík 2008; Phillips 2017). Data on the whereabouts of the Komodo dragon's potential prey are stored in comma-separated value (CSV) format, and continuous data for environment variables in ASCII (asc) format to run into maxent (Phillips 2017). Maxent is a tool to model species distribution with habitat suitability outcomes supported by environmental variables data (Che et al. 2014; Na et al. 2018; Sharma et al. 2018; Zhang et al. 2019b; Sun et al. 2021; Ab Lah et al. 2021). Before the maxent analysis is carried out, first to perform spatial autocorrelation testing at the present point and environmental variables to eliminate multicollinearity, which aims to improve the accuracy of the potential distribution model Songchitruksa and Zeng 2010; Merow et al. 2013; Brown 2014; Yu et al. 2016; Li and Ding 2016; Brown et al. 2017; Oxoli et al. 2017; Baek et al. 2019; Perkins-Taylor and Frey 2020). Shrestha (2020) stated that multicollinearity causes significant variables to become insignificant in statistical analysis. Multicollinearity analysis was performed in Microsoft Excel with a value less than -0.5 (negative), and more than 0.5 (positive), such as the analysis conducted by McCarthy (2015), which previously had 14 candidate environmental variables, after completing a multicollinearity analysis, in the final environmental variables used for Maxent analysis were only six.

**Table 1.** Data sources and collection methods for environmental variables of this study

| Data source | Collection method | Environmental variables data |
|---|---|---|
| Digital Elevation Model | Download from DEMNAS | Elevation<br>Slope |
| Landsat 8 | Download from Earthexplorer.usgs.gov | Land surface temperature<br>Moisture index<br>Vegetation index |
| Ministry of Environment and Forestry webgis | Download from webgis | Savanna land cover |
| Indonesian topographical basemap | Download from inageoportal | Agriculture land cover<br>River<br>Road |
| Open street map data | Download from Openstreetmap.org | Settlement |

After passing the multicollinearity test stages, all point data and environment variables are entered into the MaxEnt application. The settings in the Maxent application use the display by default. The MaxEnt application will provide 30% of the data as testing data and 70% as training data Yang et al. 2013; Rahmati et al. 2016; Kornejady et al. 2017; Cabrera and Lee 2020). For maxent analysis, this study used ten times replication, and some studies also use ten times replication to get the best result (Khanum et al. 2013; Su et al. 2021; Zhang et al. 2019a) although the replication is an option that can be used to do multiple runs (Phillips 2017). In addition, the replication can display a statistical summary from spatial distribution modeling (avg, SD, etc.) (Phillips 2017).

## RESULTS AND DISCUSSION

### Spatial autocorrelation and multicollinearity test

During the study, we found 510 data from six species of Komodo dragon's potential prey in Riung, which were dominated by indirect object recordings in the form of feces such as house gecko, civet, Timor deer, horse, cow, and long-tailed macaque (Figure 2).

Furthermore, a hot spot analysis (Getis-Ord Gi*) was carried out using ArcMap software to reduce spatial autocorrelation from object points data obtained (Oxoli et al. 2017; Songchitruksa and Zeng 2010). The first introduced Getis-Ord Gi* is a distance statistic identifying spatial data patterns classified into hot and cold spots (Getis and Ord 1992). Referring to Anselin (1995), Getis-Ord Gi* is used in local spatial association indicators to identify local spatial clusters, where data points with spatial autocorrelation will be entered at neighboring points. There are two possibilities for spatial data patterns to become spatial autocorrelation issues; data with high values are close together (hot spots), and data with low values are close together (cold spots) (Ord and Getis 1995). The Getis-Ord Gi* method is widely used in species distribution modeling and provides solutions to reduce spatial autocorrelation by assessing data distribution patterns (Cleasby et al. 2020; Cursach et al. 2020; Naimi et al. 2014; Pinault and Hunter 2011; Zhang et al. 2016). The hot spot analysis results produce 127 points free from spatial autocorrelation to reduce bias on the maxent model. Furthermore, environmental variables will be analyzed for multicollinearity first to separate if their environmental variables correlate (Baek et al. 2019; Li and Ding 2016). The following are the results of the multicollinearity test of ten environmental variables with 127 data on komodo's prey presences points, both directly and indirectly (Table 2).

Table 2 shows the results of the multicollinearity test between ten environmental variables, with the result that there are environmental variables that are correlated with a value less than -0.5 (negative) and more than 0.5 (positive) (McCarthy et al. 2015). Thus, the environmental variables free from multicollinearity will be further analyzed for spatial distribution modeling of maxent: moisture index, slope, distance from the settlement, and distance from the savanna.

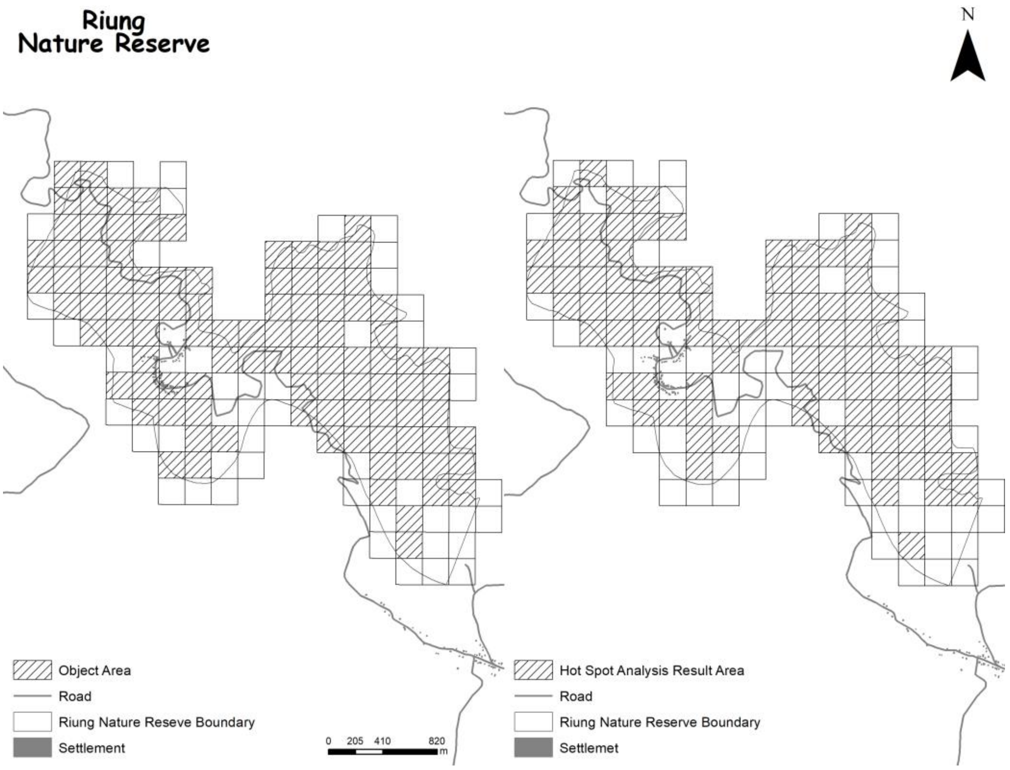


**Figure 2.** Distribution of Komodo dragon's potential prey in Riung based on survey object points and hot spot analysis result points

**Maximum entropy result for Komodo dragon's potential prey**

Moreover, with the presence of all Komodo prey, the modeling accuracy test based on the average sensitivity and specificity graphs (Figure 3) obtained an AUC (Area Under Curve) value of 0.776 with a standard deviation of 0.0414. Therefore, the AUC value indicates a modeling evaluation in the very good category.

The validation of the habitat suitability model produced by MaxEnt uses the AUC test value or the area under the ROC (Receiver Operating Curve) to identify the sensitivity and specificity of the model. In addition, the AUC value shows to observe the prediction accuracy of the distribution model (Lobo et al. 2008). Ultimately, the model will be accepted if the AUC value is >0.5, indicating that the points of presence of species and variables overlap (Fielding and Bell 1997; Phillips 2005; Swets 1988).

Komodo dragon's potential prey in Riung is distributed in savanna, mangrove, and lowland forest. Based on Mustari et al. (2011), the Komodo dragon's prey are Timor deer, water buffalo, long-tailed macaque, wild horse, and wild boar in Rinca island. In Riung, six species are preyed on by Komodo dragons, Long-tailed macaque, house gecko, civet, Timor deer, horse, and cow. Cows and long-tailed macaques possibly became komodo prey and were found almost in Riung areas, while humans had settled horses and cows around the Riung nature reserve. In Riung, local people graze their cattle freely everywhere, so they are found in the nature reserve areas. That also allows komodo to prey on the cattle within their home-range area in the nature reserve of Riung. Still, we have no direct evidence that Komodo dragons prey on their cattle directly because of the difference between the activity of Komodo and monitoring time.

**Table 2.** The result of the multicollinearity test of ten environmental variables with 127 data points

| Variable | EV1 | EV2 | EV3 | EV4 | EV5 | EV6 | EV7 | EV8 | EV9 | EV10 |
|---|---|---|---|---|---|---|---|---|---|---|
| EV1 | 1 | | | | | | | | | |
| EV2 | 0.11624 | 1 | | | | | | | | |
| EV3 | 0.10242 | 0.05962 | 1 | | | | | | | |
| EV4 | -0.57065 | 0.01145 | -0.30009 | 1 | | | | | | |
| EV5 | -0.60820 | -0.04200 | -0.28469 | 0.92833 | 1 | | | | | |
| EV6 | 0.01141 | -0.35436 | -0.03340 | -0.12223 | -0.02062 | 1 | | | | |
| EV7 | 0.61909 | 0.34173 | 0.09518 | -0.48067 | -0.51776 | -0.17927 | 1 | | | |
| EV8 | 0.71492 | 0.03176 | 0.27327 | -0.74467 | -0.77365 | 0.15562 | 0.55021 | 1 | | |
| EV9 | -0.02709 | -0.35529 | -0.00438 | -0.11878 | -0.01341 | 0.98707 | -0.22165 | 0.13362 | 1 | |
| EV10 | -0.11144 | -0.47108 | -0.07589 | -0.07127 | 0.04819 | 0.63282 | -0.17231 | -0.00030 | 0.65845 | 1 |

Note: EV1 = elevation; EV2 = distance from savanna; EV3 = slope; EV4 = vegetration index; EV5 = moisture index; EV6 = distance from settlement; EV7 = distance from river; EV8 = land surface temperature; EV9 = distance from agriculture; EV10 = distance from road

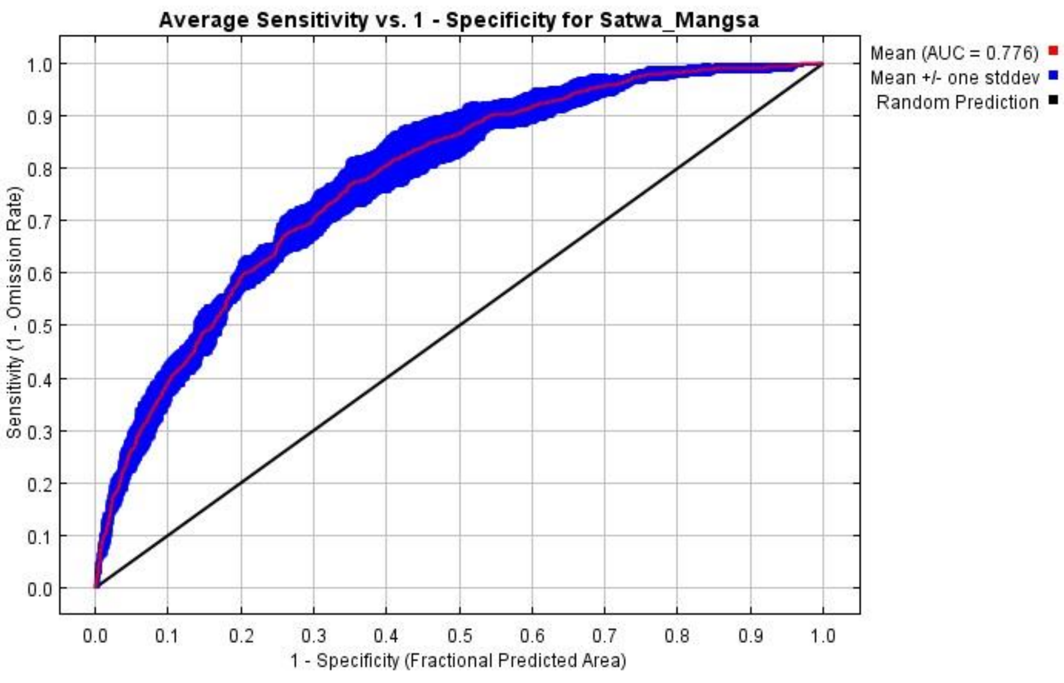


**Figure 3.** The AUC result of Komodo dragon's prey

Besides it, the presence of the Komodo dragon's potential prey was affected by environmental variables. However, based on the results of the jackknife AUC test (Figure 4), it is known that the environmental variable that has the most influence on performance in assessing modeling predictions is the moisture index. The range of values for the moisture index variable is from -1 - +1, where the greater can be categorized as having a high moisture content or a wet area, while the smaller value describes a dry area (Hardisky 1983; Xu 2005; Prasetyo 2017; Orimoloye 2020). Based on the moisture index, the data has a value range of -0.22 – +0.4 with a standard deviation of -0.054, found in savanna, lowland forest and mangrove habitats. At the study site, the moisture index range < 0 indicates a savanna habitat mixed with rocks, while the moisture index value > 0 indicates a savanna habitat dominated by grass and shrubs, lowland forest, and mangrove habitat. This is also explained in Xu (2005), which states that a positive value on the moisture index describes a vegetated area and a negative value describes bare soil and buildings. The magnitude of the influence of environmental variables on modeling is also shown by the table of percent contribution (Table 3), which produces a habitat suitability map of Komodo dragon's potential prey in Figure 5.

**Table 3.** Percent contribution of each environmental variable to create a spatial distribution model

| Variable | Percent contribution (%) |
|---|---|
| Moisture index | 49.00 |
| Distance from settlement | 20.60 |
| Distance from savanna | 18.90 |
| Slope | 11.40 |

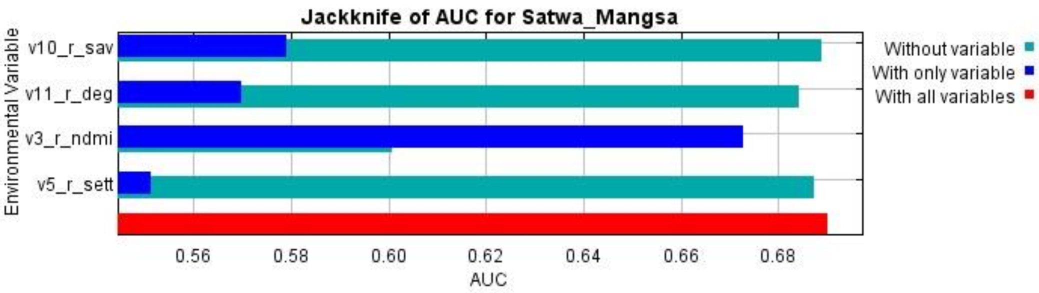


**Figure 4.** The AUC Jackknife for Komodo's prey

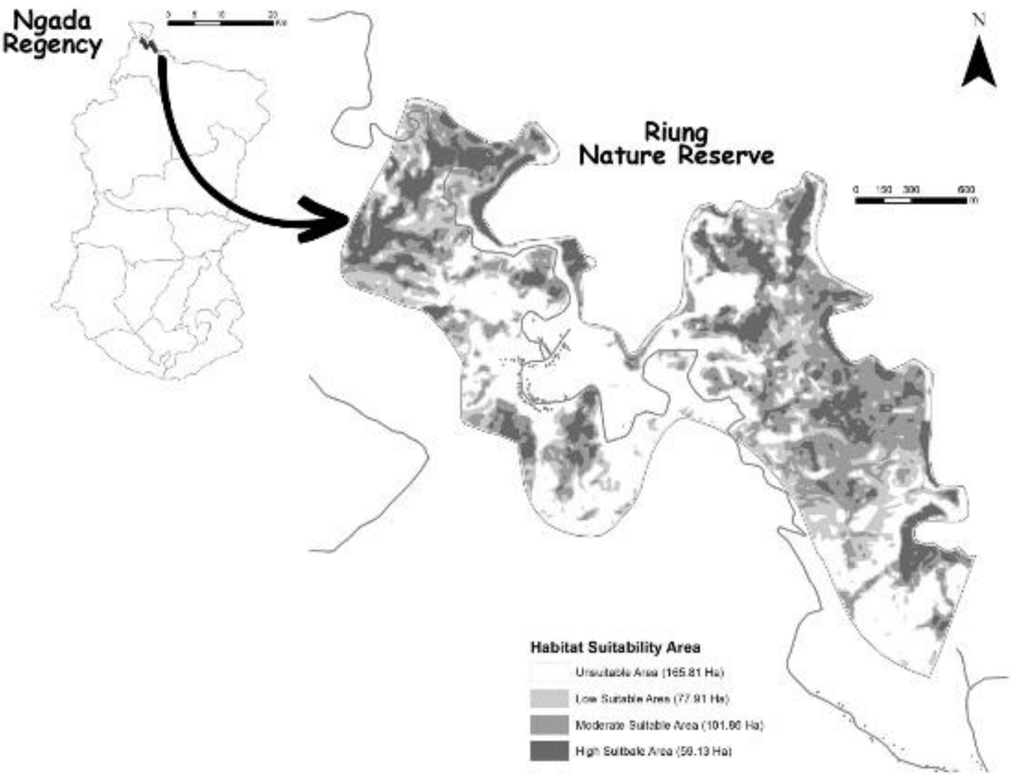


**Figure 5.** Habitat suitability map of Komodo dragon's potential prey

The results of Jackknife will show the contribution of each environmental variable to the model, indicating how important an environmental variable is to the existence of the Komodo dragon's potential prey. The final output from the results of spatial modeling of habitat suitability for Komodo dragon's potential prey is a habitat suitability map. The best chance of attendance is at the Habitat Suitability Index (HSI) value is close to 1, and the Maxent results are close to 0, indicating a low level of closeness/suitability.

The habitat suitability map shows areas with low (77.91 ha), moderate (101.86 ha), and high suitability (59.13 ha) for Komodo dragon's potential prey. In addition, there are areas with low suitability categories than high suitability. Therefore, low suitability indicates low habitat variables for carrying animals' needs.

## Discussion

Habitat suitability links environmental factors and Komodo dragons to support the survival of animals. Guisan and Zimmermann (2000) reported that indirect variables are represented with spatial analysis in habitat areas. Therefore, a model combines abiotic, biotic, and habitat factors to build the link between environmental factors and animals. The variables for Komodo dragons selected were water distance, distance to human activities, and distance to the main road for representing the presence of the prey around human activities. Mostly in Riung, the prey and human overlapped for using resources. So, it is also possible for cattle to become prey to Komodo dragons, i.e., cows. In Riung, cattle were released anywhere that the cattle freely entered the conservation area. Therefore, the overlapped area between wildlife animals such as Timor deer and cattle like cows is possible. In addition, the cattle preferred to choose a sloping area until moderate than a steep area. Khadka and James (2016) reported that slope and canopy areas affect animals' grazing choices. This result is also supported by Kayat et al. (2017) that there are different preferences between cattle and wildlife animals in the field. But Baskaran et al. (2016) reported different results from *Antilope cervicapra* Linnaeus, 1758 and *Equus caballus* Linnaeus, 1758, concentrated in similar grassland areas, and show the two species use together 11 out of 15 types of feed.

Prey's presence could affect Komodo dragons' behavior, actually movement behavior. That is linear with Sims et al. (2007, 2012) reported reptiles' movement to optimize prey foraging strategies. Purwandana et al. (2016) classified Komodo dragons into small dragons (<5 kg), medium dragons (15-25 kg), and large dragons (>50 kg) to understand that body mass affects prey preferences. Small Komodo dragons usually will consume small prey. Here are the differences between Komodo dragons in Riung and the main island of the komodo national park, which is about the body mass. Komodo dragons in Riung are smaller than Komodo dragons in Komodo Island. The potential prey for small Komodo dragons must include house geckos because geckos in the area overlap with Komodo dragons' habitat in Riung. Still, there is insufficient evidence showing Komodo dragons preying on geckos directly. We only found feces from the Komodo dragon's potential prey in all locations in Riung, showing that they can prey on house geckos (Figure 6).


**Figure 6.** Potential prey for Komodo dragon in Riung based on prey feces: A. Timor deer; B. Wild boar; C. Long-tailed macaque; D. Geck

Other Komodo dragons' prey in the location is long-tailed macaques, civets, Timor deer, cows, and feral horses. That follows the results by Ariefiandy et al. (2013), which found three ungulates prey animals for the Komodo dragons: Timor deer, feral pig, and water buffalo. Previously, Mustari et al. (2011) reported that the potential prey for Komodo dragons are Timor deer, water buffalo, long-tailed macaque, wild horses, and wild boar. Among these five types of potential prey, three main prey are Komodo dragons, wild boars, Timor deer, and water buffalo (Ariefiandy 2011; Ariefiandy et al. 2013; Jessop et al. 2006). This is because the Komodo dragons selectively choose their prey according to the behavior of their prey. Long-tailed macaques, for example, are classified as difficult to catch because they move in groups and quickly, so they have good coordination to evade predators (Mustari et al. 2011). This statement is supported by Satria (2013), who states that Long-tailed macaques in the dry tropical forest of Rinca Island have a size of 40 individuals per group. Furthermore, Satria (2013) also reported the feeding habit of long-tailed macaques in all three age classes (adult males, adult females, and young) horizontally utilizing more of the outermost tree canopy while vertically making more use of the forest floor.

The distribution pattern of the prey animals for the Komodo dragons follows the habitat type closely related to the availability of food for these prey animals. Timor deer and water buffalo are herbivores, so the presence of forage as feed is important in the existence and sustainability of these animal populations (Santosa et al. 2008; Masyud et al. 2007; Mustari et al. 2011). In addition to prey animals, residents' livestock, such as cows and goats, can run wild in the conservation area. These cattle in Riung exist because of human settlement (Figure 7), which could decrease the habitat's quality as a source of feed for mammals in wildlife (Sawadogo et al. 2005; Yoshihara et al. 2008; Baskaran et al. 2016). It also grazes in the habitat of the Komodo dragons, which could cause a decrease in the population of mammals as prey animals due to competition for resources with cattle (Mustari et al. 2010; zu Dohna et al. 2014). It is also a concern that this livestock may become dragons' prey even though they have not yet been found direct evidence that the Komodo dragons preyed on the cows and feral horses during the study.

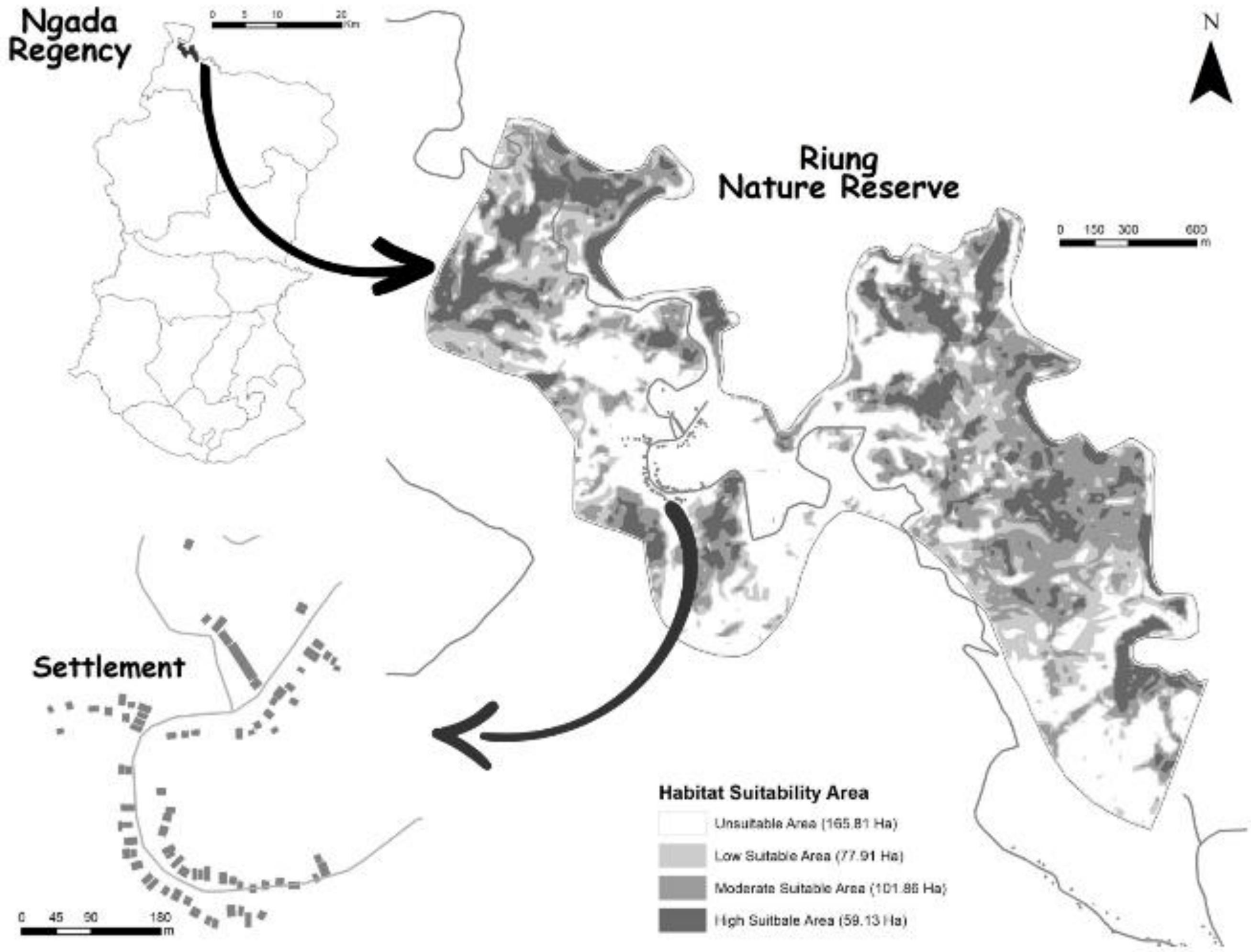


**Figure 7.** Human settlement in Riung Nature Reserve is close to moderate and low suitability areas of prey suitability habitat

The prey distribution location in Riung was also dominated by cattle presence; cows and horses were found in almost all locations in Riung. The cattle and their activities overlapped with the Komodo dragons' habitat and prey distribution prediction (Ariefiandy et al. 2021). Also, another threat to the presence of Komodo dragon is the conflict in this area is getting serious between the local community and the stakeholder. But on the other hand, we still find Komodo dragons in Riung around steep savanna with shrubs within the conflict area, but this discovery was not documented due to limited methods, tools, and time constraints.

We directly found a juvenile Komodo dragon around the hill close to the mangrove area but in the adjacent savanna; this area is hilly and dry but close to mangroves. Around this place, there is no water source for herbivores or ungulates. This Juvenile differs from Komodo on the main island of Komodo National Park. The Komodo has a lighter color, and the body is smaller than in the Komodo National Park. Therefore, the body size differences will also affect their prey size. For example, komodo dragons with body mass >18 kg will consume adult ungulates (Purwandana et al. 2021).

Wildlife animals, including Komodo dragons and their prey, tend not to harm humans and disturb human activities. In Riung, the local community lived in a conservation area close to low and moderate habitats suitable for prey. That may become a serious problem if conflicts between Komodo and the local community occur, possibly when the cattle become more potential prey to Komodo than another animal. This hypothesis can be true because, in Riung, most prey points' presences come from cattle than other ungulates. On the other hand, Komodo will not disturb human settlement unless there is no potential prey, such as cattle. The issue about human settlement and human activities in the Riung Nature Reserve area also affects the distribution of natural prey of Komodo dragons, such as Timor deer, caused by foraging competition in the grazing areas.

These results cannot explain whether a site suitable for prey animals is ideal for Komodo dragons. Referring to Ariefiandy et al. (2021), predicted distributions of Komodo dragons with the single-season occupancy models using the package unmarked intersect with Komodo dragons' prey suitable area in this study. It will be interesting to compare using the maximum entropy modeling with more detailed environmental variables according to Komodo dragons' ecology. Shadloo et al. (2021) reported in predicting habitat suitability for the desert monitor (*Varanus griseus* subsp *caspius* Eichwald, 1831) using the Generalized Boosting Model (GBM), Generalized Additive Model (GAM), and Random Forest (RF) methods using ten environmental variables with a significant variable result is precipitation seasonality. Hosseinzadeh et al. (2020) also reported on the predicting past, current, and future habitat suitability and geographic distribution of the Iranian endemic species *Microgecko latifi* Leviton & Anderson, 1972 (Sauria: Geckonidae) using maxent analysis with 19 environmental variables and five variables selected after the correlation test produced a significant variable is precipitation of the warmest quarter. Both studied the habitat suitability of lizard species with a significant bioclimatic variable. Further studies can be carried out to analyze the habitat suitability of lizards (*V. komodoensis*) by referring to (Hosseinzadeh et al. 2020; Shadloo et al. 2021) using physical and bioclimatic variables, and the results of Komodo dragons' potential prey habitat suitability studies can also be added as environmental variables with categorical data types.

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