

Habitat suitability modeling for anoa (*Bubalus spp.*) in Mount Sojol Nature Reserve, Central Sulawesi, Indonesia

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Abstract. Ongky, Mustari AH, Prasetyo LB. 2025. *Habitat suitability modeling for anoa (Bubalus spp.) in Mount Sojol Nature Reserve, Central Sulawesi, Indonesia. Biodiversitas 26: 1395-1404.* Anoa are large mammal endemic to Sulawesi Island, Indonesia, inhabiting lowland to mountainous areas. The quality, quantity, and distance of the habitat from human activities mainly influence habitat selection. Mount Sojol Nature Reserve in Central Sulawesi is a vital refuge for this endemic species. However, Mount Sojol Nature Reserve faces pressure from human activities, such as agriculture and hunting, which can lead to human-wildlife conflict. Spatial approaches are essential and can be used to monitor conservation areas effectively. Therefore, it is necessary to understand species' spatial distribution and habitat. The study was conducted from September to December 2023. Anoa Habitat Suitability Model (HSM) using the MaxEnt algorithm, based on anoa presence data from 2019 to 2024 and six environmental variables: elevation, land cover, forest canopy density, distance from rivers, distance from roads, and distance from agricultural fields. The habitat suitability analysis showed that approximately 40,135.83 ha (58.5%) of the total area is suitable for anoa. Among the environmental variables, elevation was the most significant contributor (36.5%), followed by distance from rivers (25.5%), distance from roads (19.3%), and distance from agricultural fields (17.7%) in modeling anoa habitat suitability in Mount Sojol Nature Reserve. Finally, Conservation efforts are essential, especially in habitat management and stricter monitoring in areas with suitable habitat for anoa, to prevent forest conversion and poaching. Conservation education is also needed to raise public awareness of the importance of this species in the area.

Keywords: Anoa, Central Sulawesi, MaxEnt, Mount Sojol

INTRODUCTION

Sulawesi Island is a vital mammal conservation center, mainly due to its high diversity of endemic species and their unique, limited geographical distribution (Broto and Mortelliti 2019). Among these unique endemic mammals is the anoa, which consists of two species: lowland anoa (*Bubalus depressicornis* (C.H.Smith, 1827)) and mountain anoa (*B. quarlesi* (Ouwens, 1910)) (Groves 1969; Burton et al. 2005; Priyono et al. 2024). Since 1986, the International Union for Conservation of Nature (IUCN) has classified the anoa as critically endangered, with current estimates that fewer than 2,500 individuals remain in Sulawesi and a declining sub-population of no more than 250 individuals (Burton et al. 2016a,b). The anoa's unique habitat is under threat from poaching and habitat loss due to land conversion for agriculture and plantations (Mustari 1996; Burton et al. 2007; Arini et al. 2020). The government is trying to protect and preserve this species through Ministerial Regulation Number P.54/Menhut-II/2013 concerning the 2013-2022 anoa conservation action strategy and Regulation of the Minister of Forestry and Environment Number P.106/MENLHK/SETJEN/KUM.1/12/2018 concerning protected species of wild plants and animals.

Habitat selection is a hierarchical process in which animals fulfill their habitat requirements at different

ecological scales. The study of preferred habitats is essential for understanding the distribution and abundance of animals (Bhandari et al. 2021). Several factors influence habitat selection, such as predation (McMahon et al. 2021), resources (Dupke et al. 2017), physiological tolerance, and social interactions (Gersick dan Rubenstein 2017). Anoa inhabits various environments, including mangrove forests, coastal forests, lowland forests, and mountainous areas (Mustari 2019). These animals are generally solitary and exhibit activity both during the day and at night, favoring primary forests where they rest beneath dense canopies. Their habitat selection is strongly influenced by habitat quality and proximity to human activities (Arini and Nugroho 2016). Generally, anoa prefer to live quietly in their habitat and keep their distance from humans, so even minor disturbances can make them seek safer areas (Mustari 2019).

The Mount Sojol Nature Reserve, characterized by diverse ecosystems from lowland to montane forests, serves as a natural habitat for anoa. However, local community activities, including rattan gathering, farming, and hunting, threaten these habitats and their wildlife (Personal observation). Biodiversity conservation is essential for protecting ecosystems, with sustainable practices playing a key role in preserving species' habitats (Riggs et al. 2021; Struebig et al. 2022). Unfortunately, climate change impacts and deforestation within

conservation areas threaten many of these habitats (Tabor et al. 2018; Rijal et al. 2019). Therefore, there is a pressing need for integrated and sustainable data collection and inventory efforts, particularly in the Mount Sojol Nature Reserve, to enhance understanding of species' spatial and habitat distributions. Effective spatial utilization is crucial for various ecological and conservation applications (Fletcher and Fortin 2018).

Maximum Entropy (MaxEnt) is a model grounded in ecological niche theory that utilizes species presence data to assess potential distributions of target species within a specified area (Phillips et al. 2006; Bai et al. 2018; Aulia et al. 2022). It is a widely adopted method for species distribution modeling and habitat suitability modeling (HSM), incorporating various environmental, bioclimatic, and topographic variables (Atmoko et al. 2020; Condro et al. 2021; Siddiq et al. 2023). The MaxEnt model generates Receiver Operating Characteristic (ROC) curves to evaluate its output (Bai et al. 2018). So far, the use of MaxEnt spatial modeling for anoa distribution has been conducted for the entire Sulawesi region (Ardiani et al. 2023a,b; Jaelani et al. 2023). However, our research tried to add environmental variables taken from various sources and anthropogenic disturbance factors to create complexity in building a habitat suitability model for anoa in the Mount Sojol Nature Reserve. To analyze anoa habitat suitability, we chose the MaxEnt model because it has easy access to anoa occurrence data, which has advantages over other modeling methods. The results of this model allow us to present a comprehensive picture of anoa habitat suitability in the Mount Sojol Nature Reserve.

MATERIALS AND METHODS

Study area

This research was conducted from September to December 2023 in Mount Sojol Nature Reserve, located in Central Sulawesi Province, Indonesia. This nature was established in 1987, the reserve aims to protect the diversity of flora, fauna, and their ecosystems. Covering 68,639.31 hectares, the reserve's highest peaks are Mount Sojol at 2,889 meters above sea level (m asl.) and Mount Ogoamas at 2,611 m asl. Mount Sojol Nature Reserve has ecosystems ranging from lowland to mountain forests. Geographically, the reserve is located between 0°15' to 0°45' North latitude and 120°03' to 120°25' East longitude (Figure 1). Administratively, the area is bordered by Toli-Toli District to the north, Parigi Moutong to the east, and Donggala District to the west and south (Central Sulawesi Natural Resources Conservation Centre, unpublished).

Data collection

Data collection for this study was conducted from September to December 2023, using primary and secondary data sources. Primary data consisted of anoa monitoring obtained through direct observation in the Mount Sojol Nature Reserve using the track and sign surveys method (Fragoso et al. 2019; Francis 2019). Sign surveys are also a practical technique and can efficiently assess the spatial distribution of ungulate species across large landscapes (Karanth et al. 2011; Gopalaswamy et al. 2012; Ngoprasert et al. 2019).

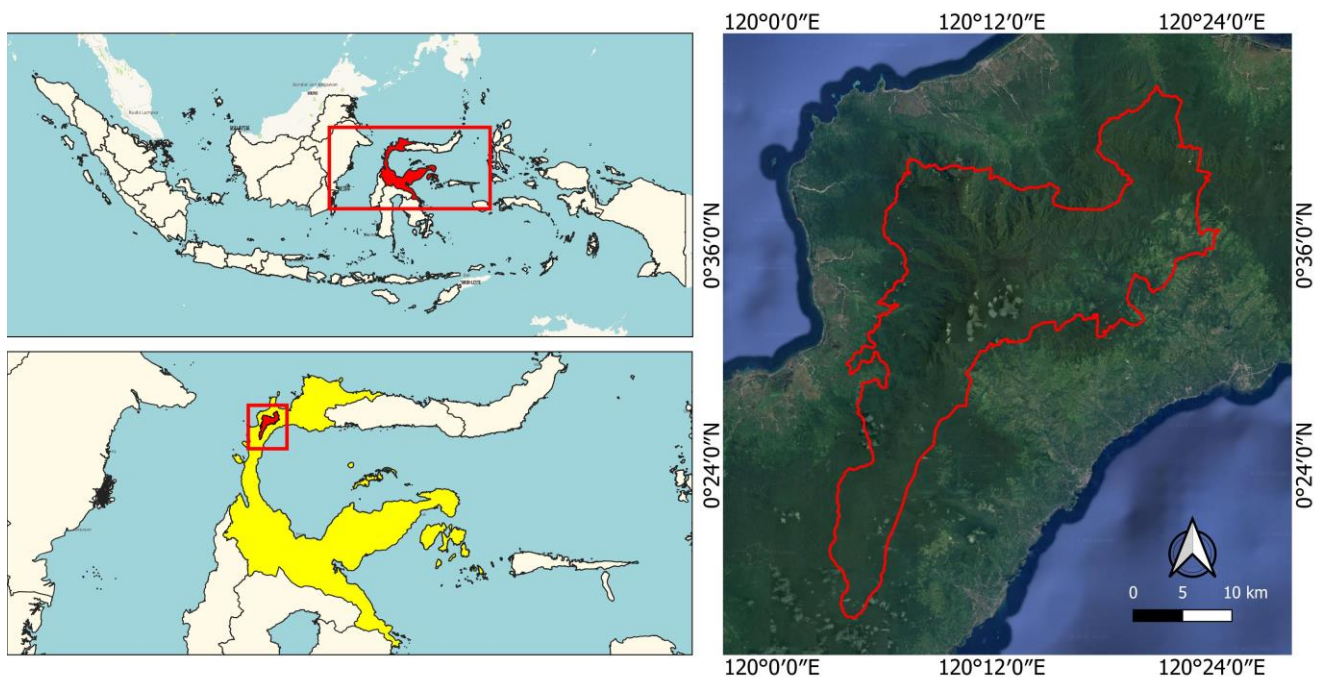


Figure 1. Map of the study area in Mount Sojol Nature Reserve, Central Sulawesi Province, Indonesia. Map sources: Indonesia Earth Shape Map (Geospatial Information Agency), Forest Area Map in 2014 (Ministry of Environment and Forestry), and World Basemap: National Geographic. Map processing was conducted using ArcGIS 10.8 software

Table 1. Variables used in this study

Environmental variables	Sources	Data format/resolution	Unit
Land cover	Google Earth Engine	Raster-30 m	Forest and Non-forest
Forest canopy density	Google Earth Engine	Raster-30 m	%
Distance from river	http://tanahair.indonesia.go.id/	Raster-30 m	M
Elevation	www.indonesia-geospasial.com	Raster-30 m	m asl.
Land surface temperature	https://www.usgs.gov	Raster-30 m	°C
Distance from forest edge	Land Cover Interpretation	Raster-30 m	M
Distance from road	http://tanahair.indonesia.go.id/	Raster-30 m	M
Distance from agriculture	http://tanahair.indonesia.go.id/	Raster-30 m	M
Distance from settlement	http://tanahair.indonesia.go.id/	Raster-30 m	M

We integrated the presence of lowland anoa (*B. depressicornis*) and mountain anoa (*B. quarlesi*) in our analyses, as distinguishing between the two species during direct observation is challenging. During tracking, the researcher and assistants conducted point data collection using a Global Positioning System (GPS) by recording signs of anoa presence, such as dung, tracks, beds, puddles, scratches, and food marks along possible anoa paths, such as ridges, hillsides, and river banks (Arini and Nugroho 2016; Mustari 2019). Secondary data were sourced from the Central Sulawesi Natural Resources Conservation Agency, which included monitoring results from camera traps, community and organizational expeditions, and information from residents collected between 2019 and 2024, totaling 101 presence records in the Mount Sojol Nature Reserve.

Environmental variables

We examined the relationship between anoa presence data and various environmental variables that may affect the species' distribution. These environmental variables were identified based on prior scientific literature related to anoa ecology (Mustari 2019; Sulo et al. 2022; Jaelani et al. 2023). The study utilized a dataset comprising nine variables: elevation, Land Surface Temperature (LST), Land Use and Land Cover (LULC), forest canopy density (FCD), and distances from rivers, agricultural areas, settlements, and forest edges, as shown in Table 1.

Land cover data were derived from Sentinel-2 images, classifying areas as either Forest or Non-Forest (including agriculture, water bodies, shrubs, open land, and settlements). Forest canopy density was analyzed to assess forest health based on the percentage of forest floor coverage. This data was obtained from Landsat 8 using Google Earth Engine (GEE) for efficient processing (Bhandari and Nandy 2024; Namasivayam and Ramamoorthy 2024). Elevation data were sourced from the National Digital Elevation Model (DEM), while land surface temperature was acquired from Landsat 8 images. Distances to forest edges were extracted from the land cover classification results, and distances from rivers, agricultural fields, settlements, and roads were calculated using the Indonesia Earth Map, employing euclidean distance methods. All variable data were then converted

into raster layers, resampled to a 30-meter cell size grid, and masked to fit the boundaries of the Mount Sojol Conservation Area using ArcGIS 10.8 (Young et al. 2011).

Variable selection

Multicollinearity analysis aims to see the correlation between environmental variables used in a study. Multicollinearity analysis uses the band collection tool in ArcGIS desktop 10.8. Environmental variables should be removed if the correlation value is ≤ -0.75 or >0.75 (Bradsworth et al. 2017). If multicollinearity occurs, a variable is strongly correlated with other variables in the model, and its predictive power is unreliable and unstable (As'ary et al. 2023).

Habitat suitability analysis

A Habitat Suitability Model (HSM) was created using MaxEnt (v.3.4.4k) (Phillips et al. 2017). Anoa monitoring data was projected based on WGS 1984 UTM 51 n datum in CSV (comma-separated values) format and environmental variables in ASCII format. Then, the following settings were made: the variables used were continuous, using 25% of the distribution points as test data and 75% as training data, a maximum of 5000 iterations, and 15 replicates. The output format was also set to logistic format, and the program was run on auto (Roshani et al. 2024). The jackknife test is used to analyze the variables' contribution level and importance (Promnikorn et al. 2019; Youssef and Pourghasemi 2021). Meanwhile, model accuracy is measured by looking at the average value of the Area Under the Curve (AUC) on the Receive Operating Characteristic (ROC) curve. AUC is an accuracy statistic used to assess model performance. The AUC value varies from 0 (least suitable) to 1 (suitable). A value of more than 0.5 indicates that the final model is very good and informative, thus categorized as follows: 0.5-0.6; poor with 0.6-0.7; normal with 0.7-0.8; good with 0.8-0.9; and very good with 0.9-1.0 (Bai et al. 2018). Furthermore, the Habitat Suitability Index (HSI) has a value range between 0-1, which is then categorized into four suitability classes, namely: not suitable (0-0.2), low suitability (0.2-0.4), medium suitability (0.4-0.6) and high suitability (>0.6). (Zhang et al. 2019; Yan et al. 2020).

RESULTS AND DISCUSSION

Anoa presence data records

Anoa are difficult to encounter in person, especially during field observations. This is because anoa are very shy and sensitive to human presence (Mustari 2019). Therefore, marking trajectories and signs left behind can be used to identify anoa distribution and habitat. However, identifying signs requires sufficient knowledge and experience in the field to recognize the presence of anoa to avoid errors and biases. Identifying anoa signs is challenging, especially in tropical forests with dense vegetation and high yearly rainfall. This can complicate the identification process, as tracks left behind are often covered by leaves or lost in the rain. We managed to mark the presence of anoa, such as footprints, feces, puddles, shelters, foraging traces, and horn rubs (Figure 2). Field observations showed that signs of anoa presence were identified through feces at 35 points (34.7%), footprints at 13 points (12.9%), puddles at 5 points (5%), bedding at 2 points (2.0%), food eaten at 8 points (7.9%), horn rubs at 5 points (5%) and secondary data at 33 points (32.7%). Based on previous mammal studies, this study aims further to confirm the presence of anoa in the target area.

Our findings in the field show that anoa encounters were found at an elevation of 305 to 2,776 m asl in the Mount Sojol Nature Reserve. 305-1,000 m asl, we found 31 points; at an elevation of 1,000-1,500 m asl, 18 points; and an elevation of 1,500-2,876 m asl, 52 points can be seen in Figure 3. The ecosystem characteristics of the Mount Sojol Nature Reserve consist of lowland forest and submontane to montane forest. The environment of lowland forests is characterized by a dense canopy and is dominated by rattan that creeps into the tree canopy. In sub-mountain and

mountain forests, the ground floor is covered with litter, tree trunks are covered in moss, and water is available, especially on the slopes of mountains. Where anoa tracks are found, they are left in forest habitats with complex conditions in terms of humidity, temperature, water sources, anthropogenic disturbances, vegetation density, and forest canopy to fulfill the resource needs that allow anoa to inhabit the area.

Influential environmental variable

Nine environmental variables were selected as the first step for processing anoa habitat suitability (Table 2). The environmental variables influence anoa habitat selection based on biotic, abiotic, and anthropogenic disturbance conditions. In addition, our study shows a slight variation in the environmental variables used compared to previous Maxent modeling studies of anoa in Sulawesi (Jaelani et al. 2023). We included forest canopy density and anthropogenic factors, such as distance from agricultural fields and roads, to increase the complexity of the anoa habitat suitability model.

Table 2. Variables, percent contribution, and permutation importance of the anoa habitat suitability model

Variable	Percent contribution	Permutation importance
Elevation	36.5	28.2
Distance from river	25.5	13.4
Distance from road	19.3	33.2
Distance from agriculture	17.7	22.2
FCD	0.4	0.4
Forest	0.4	2.6



Figure 2. Signs of anoa Presence in the Mount Sojol Nature Reserve, Central Sulawesi, Indonesia. A. Footprints; B. Feces; C. Puddles; D. Shelter

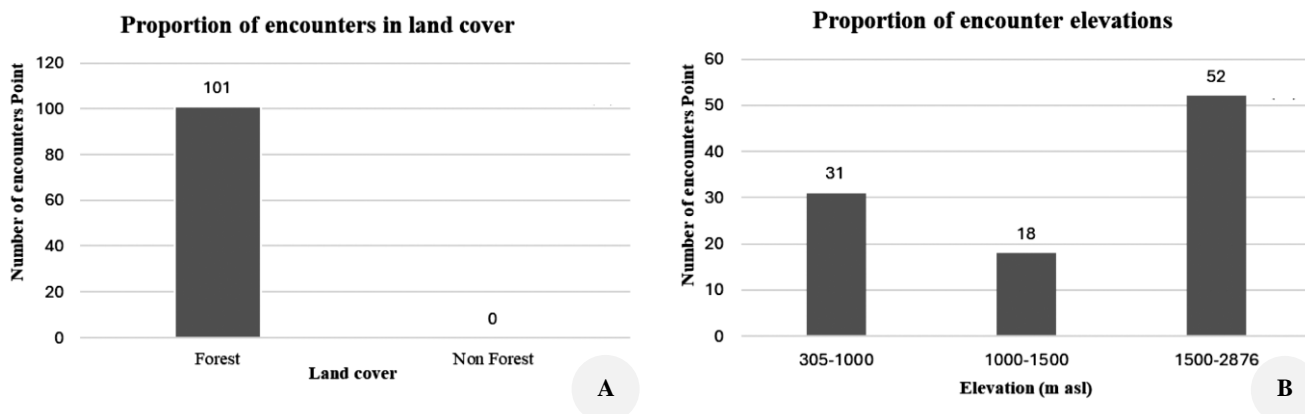


Figure 3. A. Proportion of encounters at elevation; B. Proportion of encounters on land cover

We used Pearson's correlation coefficient for multicollinearity testing. This was done to avoid cross-correlation within the selected environmental variables (Zhang et al. 2019; Li et al. 2023); if the correlation value was ≤ -0.75 or >0.75 , then one of the variables was removed (Bradsworth et al. 2017). The results of the multicollinearity analysis show that three variables are correlated; there are two negatively correlated variables, namely the distance from the edge of the forest and the land cover variable (Forest-non-forest) with a value of -0.96200 , then the elevation variable and land surface temperature with a value of -0.80966 . There is one positively correlated variable, distance from agriculture and distance from settlements, with a value of 0.78702 (Figure 4). Then, we decided to use six variables, including distance from the river, distance from the farm, distance from the road, forest canopy density, land cover (Forest-non-forest), and elevation, to be processed in MaxEnt.

Contribution variable

Determining which variables are essential to the model of anoa habitat suitability in Mount Sojol Nature Reserve can be determined using percent contribution (Phillips et al. 2006; Fikri et al. 2024). The more significant the contribution of a variable to habitat suitability for animals, the more it will affect the presence of mammals, including anoa (Phillips and Dudík 2008; Powell and Iqbal 2022). In this study, four environmental variable factors made the most significant contribution, namely elevation (36.5%), which was the variable that had the most considerable contribution compared to other variables, distance from rivers (25.5%), distance from roads (19.3%), and distance from agricultural land (17.7%), In total, the contribution of these four factors reached 99%. Meanwhile, the level of importance (PI) shows that elevation (28.2%), distance from road (33.2%), distance from farmland (22.2%), and distance from river (13.4%), environmental variables are increasingly important, as indicated by the increasing percentage value of contribution as presented in Table 2. Meanwhile, the jackknife test on the model shows that the highest gain occurs when elevation is used alone, followed

by distance from the river, distance from farmland, and distance from the road, as presented in Figure 5.

The response curves

We selected environmental factors that contributed more than 10% to single-factor analyses. We found that anoa habitat suitability in Mount Sojol Nature Reserve is strongly influenced by elevation and distance from rivers, roads, and agricultural fields. The presence of anoa in the study area is widely distributed in the elevation range of 305-2,766 m asl. Based on field observations, anoa are mostly found on gentle to very steep slopes, and the direction of anoa movement follows the contours to access resources such as food and water sources located on the mountain slopes or the primary river source. The presence of a water source is one of the influential variables; the distance from the river will make it easier for anoa in the Mount Sojol Nature Reserve to be found at a distance of $< 2,500$ m.

	FE	Forest	Agric	River	Settl	Road	FCD	Elev	LST
FE	1,00	-0,96	-0,17	0,04	-0,18	-0,03	-0,17	-0,09	0,11
Forest		1,00	0,17	-0,04	0,19	0,03	0,18	0,09	-0,11
Agric			1,00	0,07	0,79	0,08	-0,02	0,36	-0,30
River				1,00	-0,01	-0,17	-0,14	0,08	0,03
Settl					1,00	0,05	-0,04	0,38	-0,33
Road						1,00	-0,02	0,13	-0,11
FCD							1,00	-0,40	0,31
Elev								1,00	-0,81
LST									1,00

Figure 4. Pearson correlation matrix between predictor variables

Froese et al. (2015) mentioned that anoa were mainly found at the forest's edge in their study. However, this differs from our observations, where anoa was found further into the area. We suspect this is due to intensive human activity at the forest edge. Based on our observations, the further away from human disturbance, the higher the intensity of anoa encounters. This is consistent with the distance from the road curve, which shows that anoa encounters tend to move further away up to a distance of 3,500-20,000 m. The same applies to the distance from the road. The same applies to the distance from farms, which shows that the further away from farms, the easier it is to encounter anoa between 2,000 meters and 8,000 meters into the area.

Maxent prediction evaluation

The ROC curve results (Figure 6) show an average Area Under the Curve (AUC) value of 0.785. This value indicates that the prediction obtained from the MaxEnt model is normal (Bai et al. 2018). Therefore, the models are very informative and can be used for further research.

Anoa habitat suitability model

The analysis of anoa habitat suitability in Mount Sojol Nature Reserve categorized habitats into four classes: high, medium, low, and unsuitable, based on the framework created by Zhang et al. (2019) and Yan et al. (2020); this can be seen in Figure 7. The results show that unsuitable habitat covers 28,473.64 hectares (41.5%), low habitat covers 25,965.13 hectares (37.84%), moderately suitable habitat covers 10,569.55 hectares (15.4%), and highly suitable habitat covers 53,601.15 hectares (5.25%) of the total area. Overall, the potential suitable area for anoa is large at 40,135.83 hectares (58.50%) within Mount Sojol Nature Reserve. Model validation showed that anoa encounters occurred most frequently in areas with high habitat suitability (41 points, 40.5%), followed by medium habitat suitability (29 points, 28.7%), low (22 points, 21.8%), and unsuitable (9 points, 8.9%). According to Prasetyo (2017), a higher frequency of animal encounters indicates more excellent habitat suitability. Suitable anoa habitat is mainly located in the western and southern areas of the reserve, with field observations suggesting that the

significant threat of poaching in the eastern part of Mount Sojol Nature Reserve influences this shift in distribution.

Discussion

The results of this study, along with the findings of Ardiani et al. (2023a,b) and Jaelani et al. (2023) show acceptable predictions for spatial modeling of anoa. However, the Normal AUC value obtained in this study is 0.785, which is slightly lower. In addition, there are differences in research results regarding the environmental variables that influence anoa most. In this study, environmental variables that contributed significantly were identified as elevation, distance from rivers, distance from agricultural land, and distance from settlements. This difference can be explained by the selection of variables and data sources used in the modeling process. However, in general, predictions from the species distribution model (SDM) and the Habitat Suitability Model (HSM) can provide important information regarding the factors that most influence anoa distribution.

The environmental variable elevation is the most significant contribution to the model. Elevation is generally clustered as a habitat for mountain anoa, but current conditions do not allow this where the level of anthropogenic disturbances and threats is very high. Under current conditions, anoa no longer have a distinctive habitat, with lowland anoa and mountain anoa using each other's habitat due to hunting and habitat destruction (Okarda 2010; Bowolaksono et al. 2022). Mustari (2019) also explained that both mountain and lowland anoa species live sympatrically, using the same habitat. Anoa are described as individuals who live solitary lives in nature. Anoa occupy forest habitats for activities and resources (Arini and Nugroho 2016; Mustari 2019). This differs significantly from the rest of the *Bubalus* genus regarding habitat selection and social behavior. Asian water buffalo or *B. arnee* (Kerr, 1792) prefers alluvial grasslands and is highly dependent on water (Pokhrel et al. 2019; Bahadur and Adhikari 2023). Tamaraw buffalo (*B. mindorensis* Heude, 1888) from the Philippine Island of Mindoro, on the other hand, move from the forest or riverine areas to grasslands at sunset and hide in wooded areas or tall grasses (Ishihara et al. 2015).

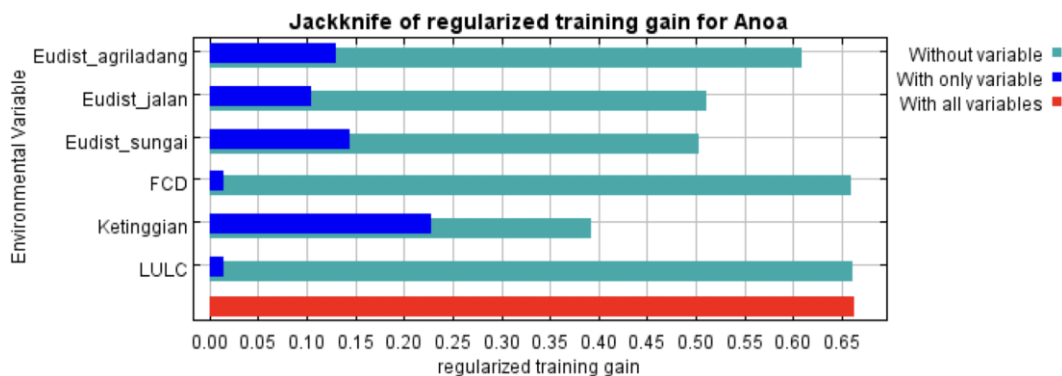


Figure 5. The jackknife training result

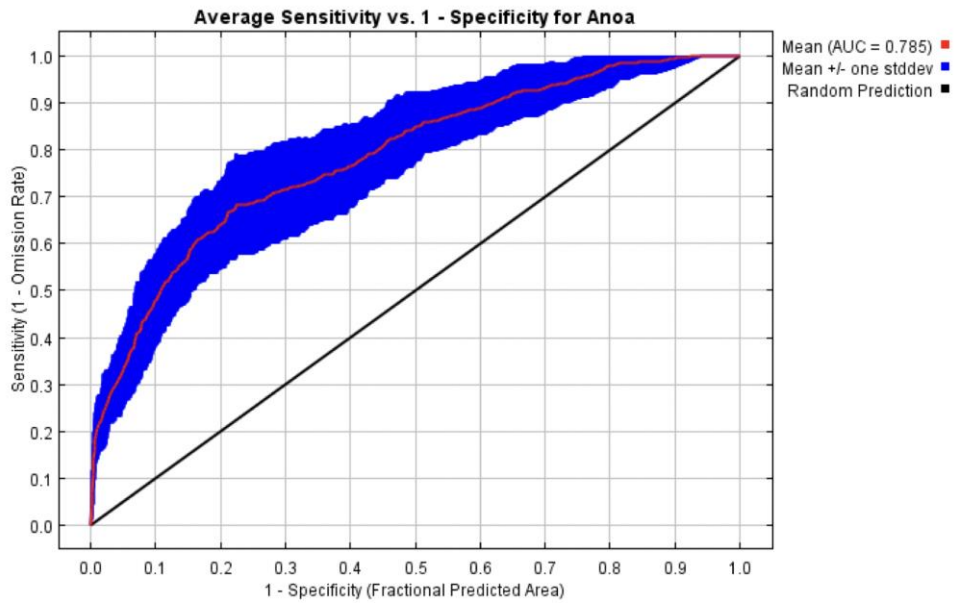


Figure 6. The Receiver Operating Characteristic (ROC)

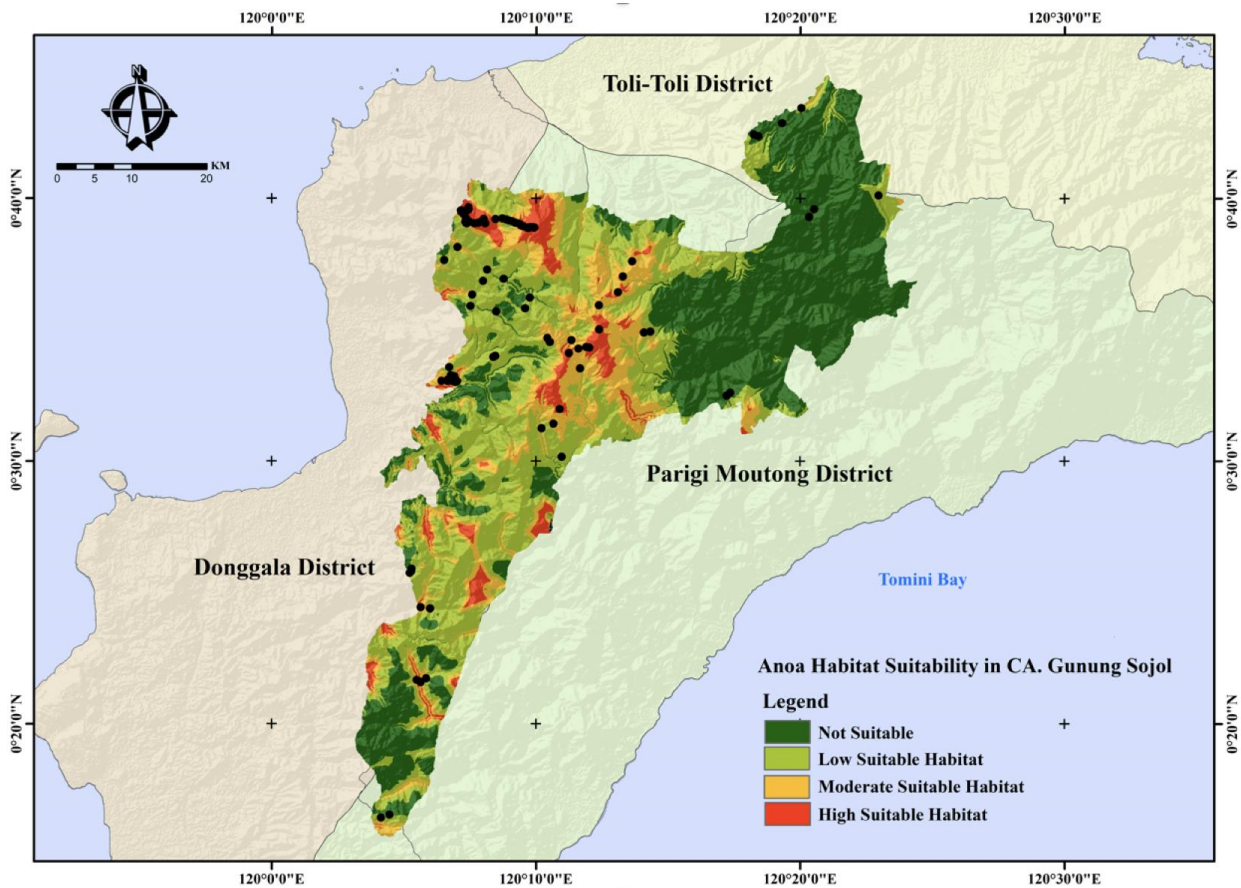


Figure 7. Mapping of anoa habitat suitability in the Mount Sojol Nature Reserve, Central Sulawesi, Indonesia

Tropical forest ecosystems in Sulawesi have high plant diversity (Hasanah and Indrawan 2020). The region has a steep topography, with about 20% of the land having an elevation of more than 1,000 m asl; most of the well-

preserved forests are in mountainous areas (Pitopang et al. 2020; Karin et al. 2023). Brambach et al. (2017) reported a rich diversity of understory tree species in montane forests, with an estimated 130 species. Furthermore, Siregar et al.

(2022) identified the most diverse families of angiosperms in sub-mountain and montane forests as Araceae, Orchidaceae, and Zingiberaceae. In Mount Sojol Nature Reserve, observations showed the presence of 21 species of food plants consumed by anoa, mainly trees, shrubs, palms, grasses, and mosses, including *Calamus* sp., *Ficus* sp., *Lithocarpus* sp., and *Syzygium* sp. These plants are utilized in various diets, such as leaves, fruits, young stems, bark, and tubers. Ranuntu and Mallombasang (2015) noted that leaves are the primary food source for anoa due to their availability throughout the year, surpassing fruits. Supporting this, Ripple et al. (2015) and Mustari (2019) highlighted that anoa, as herbivores, consume more shrubs than grass. Dense forest environments also serve as shelter for anoa, helping to camouflage them from natural predators and hunters. García-Marmolejo et al. (2015) indicated that high tree density can attract various ungulate species. Although many mammals adapt to altered habitats and thrive in recently logged or secondary forests (Cremonesi et al. 2021; Malhi et al. 2022), anoa require optimal forest conditions and high tree density to survive, suggesting special adaptations to this habitat.

Wild buffaloes favor habitats within 500 meters of water sources (Khulal et al. 2021). Wild buffaloes are similar to anoa, belonging to the same family. Therefore, water sources significantly affect habitat suitability for anoa, as their life processes—such as drinking, grooming, and thermoregulation—are highly dependent on water availability (Ismul 2020). Research shows that encounters between anoa and water sources can occur at distances of less than 2.5 kilometers, which anoa do to obtain a drink. Based on the distribution of anoa's range in the study site, anoa visits riverine areas and moist areas. Anoa often sucks moss at the base of trees and wild grasses. In captivity, anoa can drink between 6-7 Liters/day, with potentially higher water requirements in the wild (Mustari 2019). In addition, large mammals, including anoa, frequently visit salt licks to fulfill their mineral needs (Ajayi and Ogunjobi 2015). They obtain minerals by licking and drinking from these licks, which are essential for their metabolic processes (Gilmore et al. 2020). Natural salt sources are usually found in forested areas, appearing as mineral springs, muddy pools, or mineral-rich rocks (Panichev et al. 2016; Razali et al. 2020; Sim et al. 2020).

Anthropogenic disturbance, especially in proximity to agricultural areas and roads, significantly affects habitat suitability for anoa (Rahman et al. 2020; Yuwono et al. 2020; Gunawan et al. 2024). These animals require specific habitat characteristics for foraging, breeding, and shelter, as anoa cannot live with human disturbance (Putera et al. 2023). Furthermore, Arini and Nugroho (2016) indicated that human activities encourage anoa to retreat deeper into forest areas. Further noted is that anoa are very sensitive to human presence, so they avoid areas with human activities and other disturbances (Sulo et al. 2022; Arini et al. 2025). Such disturbances can majorly impact an animal's habitat, disrupting essential components such as food, shelter, water, and overall home range (Mardiastuti 2018; Putera et al. 2023).

Analysis of the anoa Habitat Suitability Model (HSM) shows that Mount Sojol Nature Reserve has a suitable habitat area of 40,135.83 ha, equivalent to 58.50% of the total area. Mount Sojol Nature Reserve is one of the areas designated as a conservation area for protecting essential and endemic species. The existence of anoa in Mount Sojol Nature Reserve faces considerable threats, including the conversion of forest to dry land agriculture and poaching. Similar problems occur in various conservation areas in the Sulawesi region, such as Bogani Wartabone National Park by Arini and Nugroho (2016) and Gandang Dewata National Park by Ismul (2020). Therefore, effective management is needed to prevent human-anoa conflict in these areas. Anoa is highly sensitive to forest change and destruction (Mustari 2019), affecting habitat selection. Therefore, it is essential to maintain the quantity and quality of habitat currently available. In addition, the study noted that poaching occurs in sub-mountain and montane forest habitats, which are considered ideal for anoa. According to estimates by Rejeki (2018), hunters in Sulawesi harvest around 742 ton of meat yearly, with anoa meat accounting for around 4%, or 29.68 ton, from 284 individuals. If these practices continue, the anoa population in the area risks a significant decline, which could lead to localized extinction. Furthermore, rampant poaching is exacerbated by the local community's lack of understanding of the importance of this endemic species.

This study concluded that anoa is spatially distributed in the Mount Sojol Nature Reserve area, with habitat suitability influenced by environmental variables such as elevation, distance from rivers, distance from agricultural, and distance from roads. Therefore, effective management is required to maintain the anoa habitat. In addition, stricter monitoring is needed in areas with suitable habitat for anoa to prevent poaching. Conservation education is also necessary to raise public awareness of the importance of this species in the area.

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