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Home Range and Habitat Use of the Endangered Flores Hawk-eagle (*Nisaetus floris*) in Ende, Flores, East Nusa Tenggara

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Abstract

Tthe Flores hawk-eagle (Nisaetus floris) is an endangered raptor endemic to the Lesser Sunda region and remains understudied, hindering effective conservation planning. This study investigates the species' home range, habitat use, and threats at two active nesting sites in Ende District, Flores Island. Home range estimates varied between 8.439 km² (using minimum convex polygon/MCP) and 23.38 km² (using hypothetical-circular home range/HCHR) in Wolojita and from 6.385 km² (MCP) to 23.38 km² (HCHR) in Mbuli. Intensive use areas were relatively small, measuring 0.449 km² in Wolojita and 0.494 km² in Mbuli. Habitat use analysis revealed that in Wolojita, the eagles favored secondary forests, settlements, and shrublands, while in Mbuli, they primarily utilized grasslands and secondary forests, actively avoiding agricultural lands, rice fields, and areas near sulfuric rivers. Secondary forests appear to provide essential resources such as nesting trees and prey availability. However, competition with other raptor species, coupled with anthropogenic threats such as habitat degradation, land-use change, and persecution driven by livestock predation, poses significant risks to the species' survival. Conservation should focus on preserving secondary forests, promoting sustainable land-use practices, and mitigating human-wildlife conflict to ensure the long-term viability of the population.

Keywords: *Nisaetus floris, home range, habitat use, threat, conservation*

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Introduction

Flores hawk-eagle (*Nisaetus floris* Hartert, 1898) is a diurnal bird of prey endemic to the Lesser Sunda Islands (Gjershaug et al., 2004a). It naturally inhabits elevations ranging from lowlands to submontane areas, with occurrences above 1,600 m above sea level (masl) being less common (Gjershaug et al., 2004a; BirdLife International, 2024). While the Flores hawk-eagle is rarely found in primary forests, it occasionally hunts in degraded habitats (Eaton et al., 2016). The current estimated population size of the Flores hawk-eagle is 3201,500 mature individuals. Due to its extremely low numbers, this species was listed as critically endangered (20092023) and then downlisted to endangered by the IUCN (BirdLife International, 2024).

Research on Flores hawk-eagle is still limited to spatial distribution, taxonomy, habitat characteristics, and ecology (Gjershaug et al., 2004a; Raharjaningtrah & Rahman, 2004; Raptor Conservation Society, 2011; 2012; Collaerts et al., 2013; Syartinilia & Setiawan, 2021). While these studies have provided valuable insights into the general aspects, there remains a significant gap in our understanding, specifically in terms of movement patterns and habitat use. The absence of research on movement patterns and habitat use is a notable limitation. Understanding these aspects is crucial for the development of effective conservation strategies for this species.

Furthermore, the findings from this research will serve as a crucial foundation for determining the minimum required area to conserve Flores hawk-eagle. Data on movement patterns and habitat use will allow us to gain a deeper understanding of habitat preference. Knowing the movement patterns of this species is pivotal in determining the appropriate size of conservation areas and in planning for future conservation efforts (Gaibani & Csermely, 2007). With the information gleaned from this research, we can identify the area's most frequently used by Flores hawk-eagle for breeding, foraging, and other essential activities. This will enable us to establish critical zones that need to be safeguarded and preserved, ensuring the long-term survival of its populations. This data-driven approach to conservation planning will contribute significantly to the effective protection of Flores hawk-eagles and their habitats.

Habitat use is not only essential for calculating a species' habitat requirements but also plays a crucial role in species population management. As highlighted by Tapia et al. (2007), habitat use constitutes a fundamental element in conservation and management planning. Additionally, it's worth noting that Flores hawk-eagle nests at Wolojita are situated outside the designated conservation area. Therefore, collecting data on movement patterns and habitat use becomes imperative not only to address potential conflicts with the local community but also to facilitate sustainable habitat management that aligns with the specific needs of the Flores hawk-eagle population.

According to Gjershaug et al. (2004a), the territory size of the Flores hawk-eagle was 40 km^2. In contrast to the situation around Kelimutu National Park, the distance between the Flores hawk-eagle nests in Wolojita Village and Mbulilo'o Village is merely 5.4 km. This suggests that the estimated home range is smaller than the previously mentioned 40 km^2, and it is situated near human settlements. On the other hand, the Javan hawk-eagle, a bird of prey species within the same genus, exhibits a variable home range, ranging from 300 to 3600 ha according to Kaneda et al. (2007), 3,000 ha as per van Balen (2000), and 400 ha based on Gjershaug et al. (2004a). Peery (2000) has pointed out that the size of a raptor's home range is influenced by factors such as prey species, prey abundance, and the body size of the raptor.

In this study, our objectives include: 1) analyze the home range; 2) asses the utilization of habitat; 3) identify threats to the Flores hawk-eagle. The data-driven conservation strategies developed from this study will not only help safeguard the population but also contribute to harmonizing conservation efforts with the needs of local communities.

Methods

Study area The study was conducted in the Otoseso Forest, Sesoboko, Wologawi, and Kopo Settlements, located in Wolojita and Mbulilo'o/Mbuli Village, Ende Regency, Flores Island, East Nusa Tenggara, Indonesia (S8°47'57.996"–S8°50'9.301"; E121°49'48.198"–E121°52'28.695") (Figure 1). Wolojita and Mbuli serve as buffer villages of Kelimutu National Park, situated in the middle of Flores Island, with an altitude ranging from 0 to 1,280 masl, encompassing both lowland and sub-montane ecosystems. Wolojita has been identified as a nesting habitat for the Flores hawk-eagle since 2014. It consists of hilly secondary forests, woody plantations, shrubs, and agroforestry areas, all of which are owned by the indigenous Lio Community. Significantly, this habitat is closely intertwined with human settlements, village roads, and cultivated areas, collectively spanning an expansive area of 5 ha. This unique combination of ecological diversity and human interaction makes Wolojita an ideal location for a comprehensive study on the Flores hawk-eagle, where the intricate relationship between the species and its environment can be explored in depth.

Home range Direct observation was conducted from February to March 2022 on one pair in Wolojita and one pair in Mbuli. Focal animal sampling (FAS) with the Ad Libitum recording technique was employed to determine the activities and habitat types utilized by the Flores hawk-eagle. In addition, a drone or unmanned aerial vehicle (UAV) was utilized to obtain coordinates of Flores hawk-eagle in restricted access areas. The UAV was also employed for mapping the characteristics of the nesting habitat. The tools used in this research included a DSLR camera, a telephoto lens (300600 mm), a rangefinder, a smartphone, and a DJI Mavic Air 2 UAV. The software employed comprised ArcGIS 10.8, DJI Fly, GPS Essentials, Fastone Photo Resizer, Agisoft Metashape Professional (Agisoft LLC, St. Petersburg, Russia), Microsoft Excel, and Google Earth Pro.

Indirect observation was conducted by compiling the monitoring reports carried out by Kelimutu National Park from 2014 to 2022, aiming to obtain encounter coordinates.

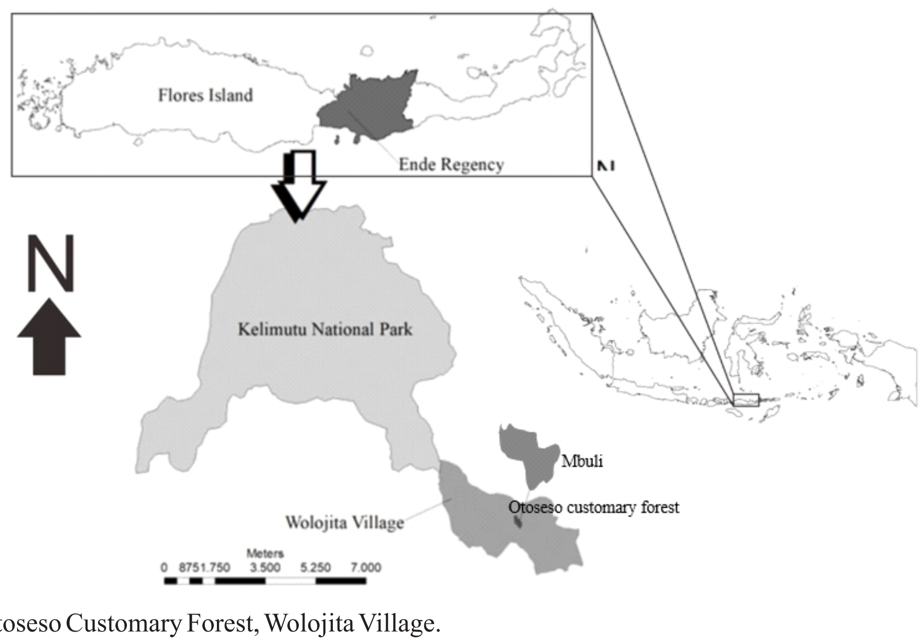

Figure 1 Study area at Otoseso Customary Forest, Wolojita Village.

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Purposive interviews were also conducted with individuals knowledgeable about the Flores hawk-eagle at Wolojita Village and its surroundings, including the traditional community leader (known as "Mosalaki" in the Lio language), members of the Flores hawk-eagle conservation community group named *Jatabara*, and Kelimutu National Park officers. The coordinates obtained using the UAV at the locations indicated by the interviewees were then validated and used as data.

Habitat use and threat Data collection was conducted to gather information on the time budget, habitat types utilized, and environmental variables. The habitat use survey was carried out simultaneously with the home range survey. Following the approach outlined by Tapia et al. (2007), data collection on the habitat use of raptors was categorized into three spatial categories: activity points, activity sites, and activity areas. These categories represent different spatial scales, with activity points referring to nest/nesting trees, activity sites encompassing the area around the nest or post-fledging area (PFA), and activity areas representing the foraging area, which corresponds to the home range.

Vegetation analysis was performed in the nesting area, and subsequently, a UAV was employed to map both the nesting area and the PFA area. The data collection process involved flying the UAV at a height of 120 m, maintaining a constant speed, and utilizing the camera in continuous shooting mode with a 2-second interval. The collected data was processed using the photogrammetry method with Agisoft Metashape, allowing for the generation of a three-dimensional (3D) map.

The factors threatening the existence of the Flores hawk-eagle have been identified through direct observation from 2022 to 2023 and in-depth interviews with key informants, including community leaders, elders, government staff, and members of *Jatabara*. These provide valuable insights into the socio-cultural and economic factors that may impact the Flores hawk-eagle's survival. Community leaders and elderly people often have extensive knowledge of local wildlife and historical changes in the environment. Government staff can provide information on current policies, enforcement challenges, and conservation efforts. Members of *Jatabara*, a local organization, can offer perspectives on community attitudes towards the Flores hawk-eagle and involvement in its protection.

Data analysis *Home range* Home range data analysis was conducted to determine the home range and core area (intensive use area) size. Encounter data obtained from both direct and indirect surveys were analyzed using the Fixed Kernel method (FK) (Worton, 1989). Kernel density was calculated using the density tool in ArcGIS 10.8 Spatial Analyst Tools. The smoothing factor employed was the Optimum Bandwidth (h_{opt}), calculated using the formula as shown in Equation *[1]* provided by Fotheringham et al. (2000).

$$h_{opt} = \left[\frac{2}{3n}\right]^{1/4} \sigma \qquad [1]$$

Here, n represents the sample size (in this study, the number of encounter locations), and σ denotes the standard distance of the encounter locations. The standard distance (Blackburn et al., 2014) was calculated using the standard distance tool in the measuring geographic distributions section of the Spatial Statistics Tools in ArcGIS 10.8. This calculation was performed for both male and female individuals. Throughout the study, the output cell size for all analyses was set to 10 m, and the search radius was adjusted according to the respective optimum bandwidth value.

Isopleth 95% (FK95) was used to estimate the total home range (Gjershaug et al., 2004b; Bosch et al., 2010; Oliveira-Santos et al., 2013; Syartinilia et al., 2015; Syartinilia et al., 2017), and isopleth 50% (FK50) was used to estimate the core area. Besides that, (Pérez-García et al., 2013; Subedi et al., 2020) also used FK95 to make a comparison. However, isopleth 50% (FK50) was used to estimate the core area and isopleth 90% (FK90) to estimate the total home range (Börger et al., 2006; Cardador et al., 2009; Krüger et al., 2014; Margalida et al., 2016; Subedi et al., 2020).

FK95, FK90, and FK50 raster values were obtained by extracting the raster data to get raster values with extracted values to points at Extraction in Spatial Analyst Tools, ArcGIS 10.8. After being extracted, the raster values in the attribute table were set to sort descending from high to low raster values. Afterward, to determine the isopleth values calculation was done by multiplying the sample size with 50%, 90%, and 95% isopleths. When the isopleth raster values were determined, the next step was reclassifying the FK100 raster with Reclassify at reclass in Spatial Analyst Tools ArcGIS 10.8. Each isopleth raster value was reclassified with two classes, and each isopleth raster value was inputted as break values then each isopleth was inputted as new values.

The minimum convex polygon (MCP) and the distance between the nearest nest to obtain a hypothetical-circular home range (HCHR) size (Gjershaug et al., 2004b) were also used in this study to estimate home range size as a comparison. According to Getz et al. (2007), MCP is used for a subset of data localized in space, and the local convex polygon, while according to Subedi et al. (2020) MCP is calculated to represent the foraging area. MCP was calculated with Minimum Bounding Geometry at Features in Data Management Tools ArcGIS 10.8. When running Minimum Bounding Geometry, the Convex_Hull geometry type was chosen to obtain MCP home range estimation. Then, the HCHR size was analyzed manually with ArcGIS 10.8 by measuring the distance of the nest at Wolojita and the Flores hawk-eagle nest at Mbuli Lo'o. After that, the home range size was calculated by assuming that the shape of the home range is a circle with the distance between the nearest nest as a diameter.

Habitat use and threat The habitat data obtained at the activity points were analyzed using the Jacobs index (Jacobs, 1974) (Equation *[2]*) and the Habitat Preference index (HPI) formula (Equation *[3]*) developed by Franklin et al. (1975).

$$Dhb = \frac{r-p}{r+p-2rp} \qquad [2]$$

$$HPI = \frac{px}{pa} \qquad [3]$$

In Equation *[1]* and Equation *[2]*, *Dhb* represents the habitat use index, where r is the proportional use of a specific variable and p is the proportional availability of the variable. HPI, on the other hand, denotes the habitat preference index, with px being the percentage population in the x-habitat and pa representing the percentage of the x-habitat area to the total study area. A homogeneity Chi-square test was conducted to determine if there were significant differences in habitat preferences.

Additionally, vegetation analysis was performed to calculate the important value index (IVI) of seedlings, saplings, lianas, epiphytes, poles, and trees at the activity sites. The Margalef species richness index (Margalef, 1967) and Shannon-Weaver species diversity index (Krebs, 1989) were also computed using Equation *[4]* and Equation *[5]*.

$$Dmg = \frac{S-1}{\ln(N)} \qquad [4]$$

$$H' = \sum pi \ln pi, \text{ where } pi = \frac{ni}{N} \qquad [5]$$

In the above equations, *Dmg* represents the Margalef species richness index, with *N* being the total number of individuals across all species and *S* representing the total number of species. *H'* represents the Shannon-Weaver species diversity index, with *ni* representing the number of individuals for each species and *N* being the total number of individuals across all species.

Vegetation analysis also involved the use of UAV aerial photography to map and measure environmental variables, particularly to identify the size of the area and landscape characteristics. The conservation strategy was determined through a descriptive analysis of the correlation between movement patterns, habitat use, local community involvement, existing conservation regulations, and the strategies required at the specific site and regional level. In addition, the threat data regarding the Flores hawk-eagle was analyzed descriptively. Anthropogenic factors were categorized based on their relative frequency of occurrence, such as high, moderate, low, or none.

Results

Home range In Wolojita, there were a total of 66 encounters, with 50 male and 41 female encounter points. In Mbuli, there were a total of 36 encounters, with 26 male and 21 female encounter points. Flores hawk-eagle was observed alone or in pairs; thus, when counted per individual, the results were not simply the sum of the female and male encounter coordinates. Most of these encounters occurred during the breeding season of the Flores hawk-eagle, from the period when pairs began building nests until the fledglings were able to fly.

The home range size estimation using the FK method in both Wolojita and Mbuli indicated that male individuals had a larger home range compared to female individuals (Table 1).

Habitat use The land cover types within the MCP home range in Wolojita consisted of six types of land cover mentioned above. The areas of each land cover type were as follows: fields/swidden agriculture 416.953 ha (48.73%), crop plantations 217.247 ha (25.39%), settlements 30.704 ha (3.59%), secondary forests 47.002 ha (5.49%), shrubs 136.715 ha (15.98%), and rice fields 6.989 ha (0.82%). The map indicates that the habitat of the Flores hawk-eagle in Wolojita was dominated by fields, plantations, and shrubs. In contrast, settlements accounted for less than 4% of the total MCP home range area (Figure 2).

The habitat of the Flores hawk-eagle in Mbuli comprised eight types of land cover previously described. The areas of these land cover types were fields 176.656 ha (27.67%), plantations 56.987 ha (8.92%), shrubs 167.6 ha (26.25%), rice fields 23.357 ha (3.66%), reeds 4.288 ha (0.67%), settlements 43.32 ha (6.78%), secondary forests 156.644 ha (24.53%), and rivers 9.663 ha (1.51%). The map indicated that the habitat of the Flores hawk-eagle in Mbuli was dominated by fields, shrubs, and secondary forests. Settlements in the Mbuli habitat account for 6.78% of the total MCP home range area.

The activity point in this study was the Flores hawk-eagle nest and nesting tree characteristics (Table 2; Figure 3). During the daytime observations, the average temperature recorded was 27.75 °C, with a minimum of 25 °C and a maximum of 29 °C. The daytime average humidity was measured at 72.25%, and the daytime average air pressure stood at 728.31 mmHg. Conversely, during nighttime observations, the average temperature recorded was 21.5 °C, with a minimum of 20°C and a maximum of 23 °C. The nighttime average humidity was 79.5%, while the nighttime average air pressure measured 739.54 mmHg.

Activity sites The activity site was a 0.04 ha circle area surrounding the Flores hawk-eagle nesting tree, with the nesting tree as its center (Titus & Mosher, 1981). The Margalef Species Richness Index (Margalef, 1967) at the seedlings level was 0.770, saplings was 0.001, poles was 0.481, and trees was 1.820. Whereas the species diversity index, or Shannon-Weiner species diversity index (Krebs, 1989), for seedlings was 1.230 (moderate), saplings was 0.001, poles was 0.377 (low), and trees was 1.099

Table 1 Home range and core area size of the Flores hawk-eagle individual based on MCP, FK, and HCHR size analysis

Origin of individuals	Home range				Core area
	FK90 (km^2)	FK95 (km^2)	MCP (km^2)	HCHR (km^2)	FK50 (km^2)
Wolojita					
Male	1.929	1.929	7.992	23.082	0.609
Female	0.936	0.936	8.024	23.082	0.200
Pair	1.588	1.588	8.439	23.082	0.449
Mbuli:					
Male	1.254	1.254	4.344	23.082	0.451
Female	1.138	1.138	4.681	23.082	0.475
Pair	1.706	1.706	6.385	23.082	0.494

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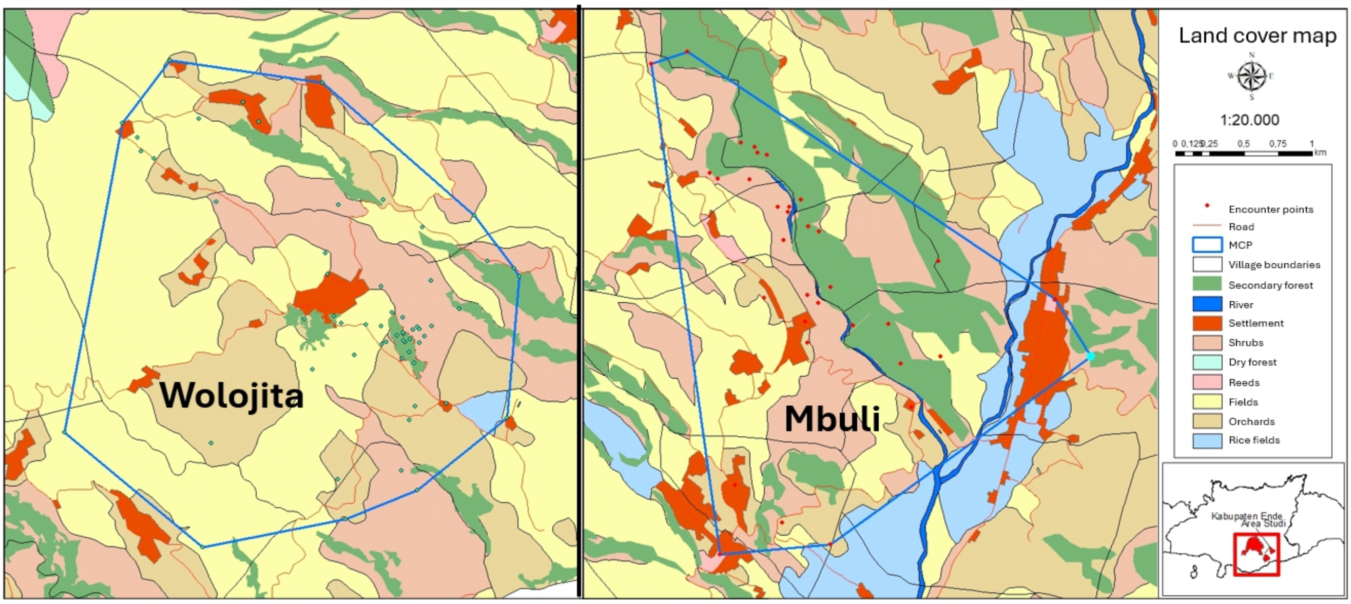

Figure 2 Overlayed MCP home range on land cover of Wolojita and Mbuli.

Table 2 Nest characteristics of Flores hawk-eagle

Parameter	Value
Distance from nest to main trunk	2 m
Number of supporting branches	4
Diameter at breast height (dbh)	1.22 m
Total tree height	25.5 m
Nest height above the ground	19.5 m
Slope class	90.67% (very steep)
Elevation	450 m asl
Distance to nearest water source (river)	420 m
Distance to nearest settlement	460 m

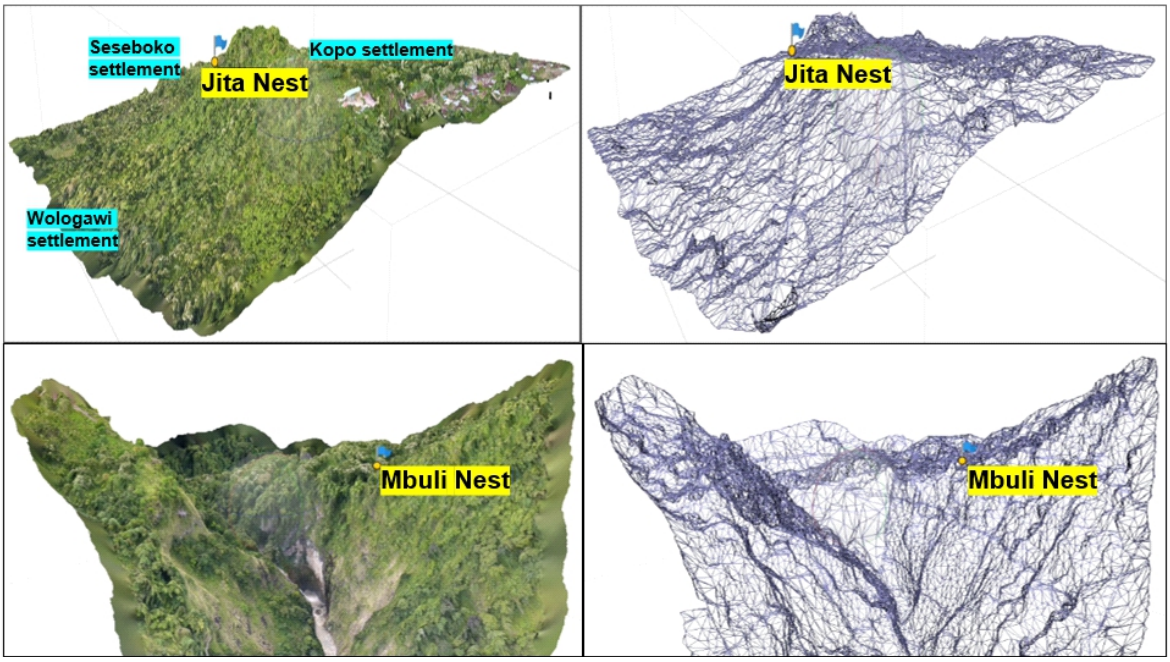

Figure 3 Three-dimensional habitat characteristics with nesting tree marked by a blue flag.

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(moderate). The highest IVI of tree level was *Alstonia scholaris* with 188.01, which means it had an important role in the ecosystem. Then the density of seedlings in this area were 1,175 ind ha^{-1}, saplings were 925 ind ha^{-1}, poles were 200 ind ha^{-1}, and trees were 75 ind ha^{-1}. Additionally, the distance between the trees in this area was 12 m to the *kesi* tree (*Lannea grandis*), and 7 m to another *L. grandis* tree with a smaller size. The average tree's dbh was 89.33 cm or classified as a big tree with the tree height class belonging to the upper canopy. The strata of trees was classified as strata B with a height of 2030 m, the canopy cover was dominant it can receive sunlight from above and partly from the side.

The activity site was mostly utilized by male individual to carry out feeding activity. The male individual was often seen bringing the prey to the nesting tree, particularly when there was a hatchling. Besides bringing prey for the hatchling, the male was also recorded eating its prey on the trees around the nesting tree. According to the information from the local people, the male was also observed eating its prey on the rock of the hillside around the nesting tree. The activity site was also utilized by the Flores hawk-eagle pair to conduct breeding activities, particularly copulation, which was recorded on the *Ceiba pentandra* and *Ficus benjamina* trees.

Activity areas The encounters of male Flores hawk-eagles occurred from elevation 220 masl to 852 masl at Wolojita, Tenda, Nggela, and Pora Village. There are at least three water sources, i.e., streamlet 371.5 m away, sea 1,956.5 m away, and river, which is a mixture of sulphury water and fresh water, 1,180.4 m away. Human disturbances that may threaten the Flores hawk-eagle habitat, i.e., agricultural activities, settlements, village roads, district streets, and schools near the activity site.

The male individual mostly utilizes the activity area to forage the prey. The activity area was also utilized by the female individual together with the female to soar, perch, glide, hover, and courtship display. Based on the homogeneity chi-square test, there is a preference by Flores hawk-eagle when utilizing the land cover (Table 3).

Flores hawk-eagle tends to moderately avoid the agricultural fields that are formed of open areas interspersed with *C. pentandra*, *Mangifera indica*, *A. scholaris*, or *Cocos nucifera*. Flores hawk-eagle has low to moderate avoidance of the crop plantation. Flores hawk-eagle also has a low to moderate preference to utilize the settlements. On the other hand, Flores hawk-eagle has a moderate preference to utilize the secondary forests, and it was the strongest preference in Wolojita habitat. Flores hawk-eagle has a low preference to utilize the shrubs and a strong avoidance to utilize the rice fields.

The calculation of Dhb and HPI has a similar result, it shows that Flores hawk-eagle has a negative value of Dhb and a small value of HPI (Dhb: -0.47; HPI: 0.53) to utilize the fields (Table 3). According to Rahman (2021), the value indicates. Flores hawk-etagles tend to slightly avoid utilizing the agricultural fields. This occurred because the fields are relatively open areas with a few perching trees. There have also occurred intensive farming activities carried out by local farmers that can be a disturbance and even a threat, such as land clearing by burning.

The Flores hawk-eagle has a negative habitat use index value and a low HPI for utilizing orchards (Dhb: -0.37; HPI: 0.54), indicating low to moderate avoidance of these areas. This is due to the intensive activities carried out by local farmers in orchards and the relatively tight canopy cover, which makes it difficult for the hawk-eagle to move. In contrast, the Flores hawk-eagle shows a slight to moderate tendency to utilize settlements (Dhb: 0.38; HPI: 2.11). This occurs because several prey species, such as free-range domestic chickens (*Gallus gallus domesticus*) and piglets

Table 3 Type of land cover size, Jacobs index (Jacobs, 1974), and habitat preference index (Franklin et al., 1975)

Land cover	Size (ha)	Jacobs index (Dhb)	Habitat preference index (HPI)	Description
Field	416.95 (w) 176.66 (m)	-0.470 (w) -0.86 (m)	0.53 (w) 0.10 (m)	Moderate avoidance (w); Strong avoidance (m)
Orchard	217.25 (w) 56.99 (m)	-0.37 (w) 0.12 (m)	0.54 (w) 1.24 (m)	Low to moderate avoidance (w); none-to low preference (m)
Settlement	30.70 (w) 43.32 (m)	0.38 (w) 0,26 (m)	2.11 (w) 1.64 (m)	Low to moderate preference (w, m)
Secondary forest	47.00 (w) 156.64 (m)	0.71 (w) 0.42 (m)	4.69 (w) 1.81 (m)	Moderate preference (w, m)
Shrub	136.73 (w) 167.60 (m)	0.33 (w) 0.04 (m)	1.71 (w) 1.06 (m)	Low preference of shrubs; none-to low preference (m)
Rice field	6.99 (w) 23.36 (m)	-1 (w) -1 (m)	0 (w) 0 (m)	Strong avoidance of rice fields (w, m)
Sulfur river	- (w) 9.66 (m)	- (w) -1.0 (m)	- (w) 0 (m)	Strong avoidance of sulfur river (m)
Reeds	- (w) 4.29 (m)	- (w) 0.62 (m)	- (w) 4.2 (m)	Moderate to strong preference of reeds (m)

Remarks: (w) = Wolojita; (m) = Mbuli. According to Rahman (2021), Dhb values vary from -1 to 0 for negative usage, and from 0 to 1 for positive usage and are categorised as 0 to ± 0.15=0 (no preference); ± 0.16 to 0.40= + or -- (low preference or avoidance); 0.41 to 0.80= ++ or –- (preference or moderate avoidance); and ± 0.81 to 1.0= +++ or --- (preference or strong avoidance). Habitat preference index 1.0 shows no preference so individuals scattered randomly in carrying out their activities.

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(*Sus scrofa domesticus*). However, some local people consider the Flores hawk-eagle to be a harmful animal, resulting in frequent persecution. Despite this, the hawk-eagle still shows a slight preference for utilizing settlement areas.

The Flores hawk-eagle prefers to utilize secondary forests (Dhb: 0.71; HPI: 4.69), typically located on ridges or hillsides, as these areas are relatively safe from anthropogenic disturbances and threats. Additionally, hillsides provide shelter from inclement weather, particularly gales from the opposite direction. The slope conditions also make it easier for the Flores hawk-eagle to keep an eye out for prey or disturbances and to move efficiently. The secondary forests offer several ecological benefits that make them a preferred habitat. These forests often have a diverse structure with a mix of mature trees, regenerating vegetation, and open spaces, creating ideal conditions for hunting. The presence of tall trees provides suitable perching and nesting sites, while the understory and open canopy gaps support a variety of prey species, including birds, small mammals, and reptiles. Additionally, secondary forests often form ecological corridors that connect different habitat patches, allowing the eagles to move efficiently across their range while maintaining access to essential resources. Moreover, there are many aren trees (*Arenga pinnata*) in secondary forests, particularly on hillsides. Aren fruit is a favorite food of common palm civets (*Paradoxurus hermaphroditus*), which help disperse aren tree seeds through their excrement (Withaningsih et al., 2019), especially on hillsides near water streams. Therefore, the Flores hawk-eagle prefers secondary forests as they are potential habitats for common palm civets, a prey species.

In addition to common palm civets, other prey species such as the spotted house gecko (*Gekko monarchus*) and large flying fox (*Pteropus vampyrus*) can also be found in secondary forests, particularly on large trees. The Flores giant rat (*Papagomys armandvillei*) is another prey species that can be encountered in secondary forests, especially on steep slopes or hill cliffs.

The Flores hawk-eagle has a low Dhb and HPI value for shrubs (Dhb: 0.33; HPI: 1.71), indicating a slight preference for utilizing thorny shrubs due to their relatively open areas. However, shrubs are also located on hillsides and are sometimes interspersed with large trees, allowing the Flores hawk-eagle to occasionally use them for perching. In this study, the Flores hawk-eagle did not appear in rice fields (Dhb: -1; HPI: 0), indicating a strong avoidance of these areas. This is because rice fields are almost entirely open areas without large trees, and in Wolojita Village, rice fields are only found in lowlands close to the coast. This location is also the intensive use area of the short-toed snake-eagle (*Circaetus gallicus*), leading the Flores hawk-eagle to avoid it, at least when the short-toed snake-eagle is present.

Threats Land use conversion poses a significant threat to the habitat of the Flores hawk-eagle. Shrubs and secondary forests on hilltops and hillsides are cleared for agriculture, often involving tree cutting and burning, with smoke causing environmental and health hazards to the eagle. Additionally, residential development reduces perching sites, diminishing habitat suitability. Livestock grazing by cows and goats damages the forest floor and soil layers near nesting sites, while firewood collection and noise from herding activities disturb the ecosystem.

Table 4 highlights the anthropogenic threats faced by the Flores hawk-eagle, categorized by levels of severity and confirmed through direct observation and interviews. High threats include livestock grazing and firewood collecting, moderate threats involve land clearing by burning, while illegal hunting and trapping have minimal direct impacts.

There are also threats from natural disturbances, such as the invasion of other raptor species and storms. Species such as the spotted kestrel (*Falco moluccensis*), Bonelli's eagle (*Aquila fasciata*), and short-toed snake-eagle (*C. gallicus*) compete for limited resources around the nesting area, leading to interspecific competition. When another raptor species is present, the Flores hawk-eagle tends to avoid the area. Additionally, Flores hawk-eagle shows avoidance behavior during the migration of raptors such as the Oriental honey-buzzard (*Pernis ptilorhynchus*), Peregrine falcon (*F. peregrinus*), Chinese sparrowhawk (*Accipiter soloensis*), and Japanese sparrowhawk (*A. gularis*) through their habitat annually. These factors contribute to the challenges faced by the Flores hawk-eagle in maintaining its habitat and resources.

Discussion

Home range The FK method home range estimation in both Wolojita and Mbuli shows that male individuals have a larger home range than females. This is because females are more frequently observed at activity sites and nesting sites, while males are often found in areas farther from nesting habitats. Males are sometimes observed carrying prey, especially

Table 4 Anthropogenic threat to Flores hawk-eagle in Wolojita and its surroundings

Anthropogenic threat	Level of threat	Direct observation	In depth interview	
			(2019– 2020)	(2021–2023)
Land use conversion	+	–	√	√
Land clearing by burning	++	√	√	√
Logging	+	√	√	√
Hunting (using air rifle)	–	–	√	–
Trapping	–	–	√	–
Livestock rearing	+++	√	√	√
Firewood collecting	+++	√	√	√

Remarks: +++ (high), ++ (moderate), + (low), – (none) during the breeding season. This suggests that males need to intensively explore their habitat to find prey for the females and their young. Despite these differences in home range size, there is evidence that the home ranges of male and female individuals can overlap, particularly around nesting sites and key foraging areas. This overlap likely occurs because males frequently return to nesting sites to deliver food, while females may occasionally venture beyond their core nesting areas to forage. Such spatial interactions between males and females have also been reported in other raptor species. Kennedy et al. (1994) found that the home range size of two female *Circus aeruginosus* individuals was smaller than that of males, but their ranges overlapped in areas crucial for nesting and provisioning. This pattern suggests that while males exhibit broader movement patterns, their spatial use remains closely linked to the nesting and foraging needs of their mates and offspring.

The estimation of home range size using FK90 is larger than FK95, as FK90 can provide an unbiased estimate even with relatively small data sets (Börger et al., 2006). Meanwhile, Oliveira-Santos et al. (2013) state that the 95% isopleth in home range estimation represents the smallest area utilized by 95% of the total usage distribution, or where the animal spends 95% of its time. The home range sizes estimated using FK90 and FK95 for males, females, and male-female pairs in Wolojita and Mbuli do not show significant differences. This lack of difference is attributed to the small sample sizes, resulting in the raster values for each isopleth not differing significantly. This indicates that the FK method is not suitable for estimating home range size with small sample sizes. This aligns with Boyle et al. (2009), who found that the MCP method is more accurate for home range estimation when sample sizes are small. In this study, the encounter coordinate data were very limited because they were obtained through direct observation from 2014 without the aid of satellite telemetry equipment.

Using the MCP method, the home range size of male individuals is slightly smaller compared to female individuals (Figure 4). This aligns with Pérez-García et al. (2013), who stated that there is no significant difference in home range size between sexes. The home range size estimated using the FK method is about four times smaller than that estimated using the MCP method and almost ten times smaller than that estimated using the HCHR method. According to Getz et al. (2007), the MCP method is more suitable than the parametric kernel method for estimating home range size and utilization distribution because of its ability to identify rough boundaries (such as rivers and cliffs) and its convergence toward the true distribution with increasing sample size.

For comparison, the home range size of *N. bartelsi* using the MCP method is 310 ha in Mount Salak, West Java (Gjershaug et al., 2004b), and 930 ha in Telaga Warna Nature Reserve, West Java (Kaneda et al., 2007), indicating that the home range size of the Flores hawk-eagle using the MCP method is almost the same as that of *N. bartelsi* according to Kaneda et al. (2007). Furthermore, the home range size of the Flores hawk-eagle using the HCHR method is 23.082 km², with the distance between the nearest nests being 5.42 km. This home range size is almost twice as small as the home range size of the Flores hawk-eagle estimated by Gjershaug et al. (2004a), which is 40 km². A similar home range size was also estimated by Raharjaningtrah & Rahman (2004), which is 38.5 km². This value suggests that the population size of the Flores hawk-eagle could be twice as large as the current population size estimate. This difference may be due to variations in habitat conditions and weather conditions, as stated by Village (1982) and Peery (2000), who noted that the home range size of raptors is influenced by prey availability, seasonal variations, prey type proportions, and the raptor's body size.

Habitat use The habitat use of the Flores hawk-eagle in Wolojita and Mbuli reflects a strong preference for secondary forests, shrubs, and fields, with varying degrees of avoidance for agricultural areas, rice fields, and settlements. The habitat use of the Flores hawk-eagle in Wolojita and Mbuli demonstrates a strong preference for secondary forests, shrubs, and fields, while showing varying degrees of avoidance toward agricultural areas, rice fields, and

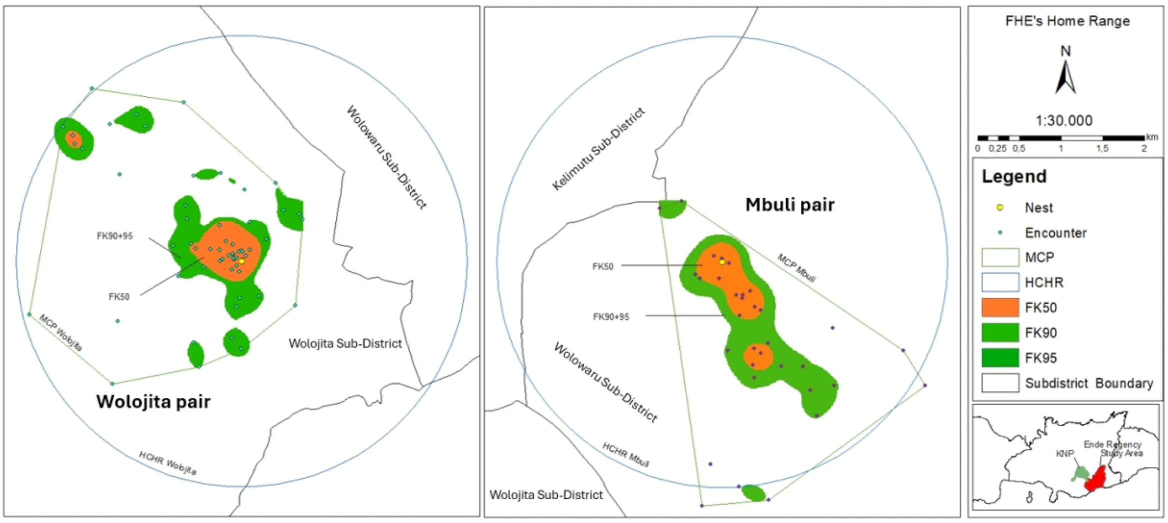

Figure 4 The comparison of FK90, FK95, FK50, MCP, and HCHR size.

settlements. This aligns with findings by Septiana et al. (2020), which reported that *N. bartelsi* utilizes secondary forests for nesting in 60% of cases, compared to 30% in primary forests. These findings highlight the critical role of secondary forests in supporting hawk-eagle populations. The habitat selection indices indicate a low preference for agricultural fields, likely due to their open nature and frequent human disturbances, such as land clearing and burning. Agricultural expansion remains a major driver of raptor habitat loss globally, contributing to population declines among species reliant on forested landscapes (McClure et al., 2018; O'Bryan et al., 2022).

The nesting ecology of the Flores hawk-eagle (*N. floris*) shares several similarities with that of its congener, the Javan hawk-eagle (*N. bartelsi*), although notable differences are evident, particularly in nest tree height selection and preferred forest types (Table 2). Observations of the Flores hawk-eagle suggest that it typically nests on large emergent trees within lowland or hill forest environments.

Compared to the Javan hawk-eagle, the average total height of nest trees used by the Flores hawk-eagle in Halimun Salak National Park is approximately 25.5 m, with nests positioned at a mean height of 19.5 m above ground level (Septiana et al., 2020). In contrast, Nijman et al. (2000) recorded nest tree heights for the Javan hawk-eagle ranging from 30 to 60 m in the Bogor, Sukabumi, and Cianjur regions of West Java, with nests placed between 15 and 50 m above the ground. These data indicate a broader range in both nest tree and nest height for the Javan hawk-eagle, potentially reflecting the greater vertical complexity and structural maturity of forest stands in Java, particularly within montane and protected landscapes.

For both species, nest platforms are typically located near the upper crown, just below the tree apex, often on large horizontal branches close to the main trunk. Constructed primarily from sticks, these nests are frequently reused and refurbished in subsequent breeding seasons, indicating strong site fidelity.

The Javan hawk-eagle, a species primarily associated with humid montane forests, selects significantly taller trees for nesting. Its preferred nest trees include *Altingia excelsa* (*rasamala*), *Litsea* sp. (*huru*), *Agathis dammara* (*damar*), *Nephelium juglandifolium* (*lengsar*), *Macaranga pasticularis* (*manggong*), as well as *Podocarpus* sp., *Quercus* sp., and *Schima wallichii*. These species are typically found in dense, undisturbed primary or mature secondary forests, often on steep terrain (Septiana et al., 2020; Sözer & Nijman, 1995; Nijman et al., 2000).

While both raptors demonstrate a preference for large, structurally stable trees offering sufficient canopy cover for concealment and protection, the Javan hawk-eagle appears more selective, favoring remote and minimally disturbed forest interiors. In contrast, the Flores hawk-eagle, although largely associated with intact forests, has also been observed nesting in semi-disturbed or forest-edge habitats. This variation likely reflects differences in forest structure, degrees of human disturbance, and the availability of tall emergent trees between Java and Flores.

The relatively lower height of nest trees used by the Flores hawk-eagle may reflect the generally lower stature of forest canopies in its range or be a consequence of habitat fragmentation that limits access to mature trees. Nevertheless, the actual nest height above ground is broadly comparable between the two species, suggesting an ecological requirement for vertical placement that is relatively independent of total tree height. This elevated positioning may play a crucial role in reducing predation risk and improving visibility for territorial defence.

These differences highlight the importance of understanding localized habitat features and forest structure when developing conservation strategies for island-endemic raptors. Given that both species exhibit high nest site fidelity and territoriality, the loss of suitable nesting trees due to logging, land conversion, or natural events may have disproportionately negative impacts on population viability.

Threat and implication for conservation Land use conversion, characterized by the clearing of shrubs and secondary forests on hilltops and hillsides, poses a significant threat to the habitat of the Flores hawk-eagle. This threat is exacerbated by intensive agricultural practices, where farmers clear land by cutting down trees and subsequently burning the vegetation (Table 4). The resulting smoke from these burning activities not only disturbs the environment but also poses a serious health hazard to the eagle. Moreover, the reduction in available perching sites due to land clearing further impacts the habitat's suitability. To mitigate habitat loss or modification, it is essential to designate protected areas that preserve habitats for animals with large territories. Understanding the landscape requirements is crucial for effectively conserving and preserving the distribution of raptor species (Harness, 2007).

Cows and goats grazed by local people around nesting sites often damage the forest floor and soil layer, disrupting the ecosystem. This grazing activity also generates noise, as locals need to move their cattle moorings regularly. Additionally, firewood gathering is a common practice among the local community, as some residents still use firewood for cooking. Illegal hunting usually occurs due to farmers using air rifles to protect their fields from long-tailed macaques' attacks. However, these air rifles are sometimes also used to shoot other passing animals, including Flores hawk-eagles.

Conflicts between the Flores hawk-eagle and the local community often arise when the FHE preys on their livestock, such as domestic chickens (*G. gallus domesticus*) and domestic pigs (*S. scrofa domesticus*). This can lead to the Flores hawk eagle being captured or shot by village residents. The primary issue is that the breeding sites are located outside the conservation area, specifically outside the Kelimutu National Park area. This proximity to residential areas increases the likelihood of harassment or hunting of the eagle. Mitigating measures to address these issues include compensating landowners or livestock owners to minimize future damage. Education plays a crucial role in dispelling negative prejudices towards raptors (Harness, 2007).

Managing wildlife populations depends on how habitats are managed or maintained (Anderson & Gutzwiller, 1994). Habitat use is a fundamental consideration in conservation and management planning (Norris, 2004). The underlying assumption is that wild animals will breed and survive in habitats they select (Tapia et al., 2007). The behavior of confined space use is influenced by spatial, temporal, and individual-level processes and has significant impacts on ecological processes (Börger et al., 2008).

The habitat of the Flores hawk-eagle at Wolojita iss located outside the conservation area, particularly outside the Kelimutu National Park, necessitating additional attention (Ministry of Environment and Forestry, 2022). The population of residents in Wolojita is 1,502 with a density of 138.43 individuals km^{-2} and a growth rate of -2.53% (Badan Pusat Statistik, 2022). This indicates a relatively sparse population density with the population decreasing due to urbanization. These conditions may have a positive impact on the existence of the Flores hawk-eagle, as urban sprawl was less extensive compared to cities.

Conclusion

The estimated home range size of the Flores hawk-eagle ranges from 8.439 km² in Wolojita and 6.385 km² in Mbuli to 23.38 km², based on MCP and HCHR methods, respectively, with an estimated intensive use area of 0.449 km² and 0.494 km². The Flores hawk-eagle at Wolojita prefers to utilize secondary forests, settlements, and shrubs. However, it shows avoidance of orchards, fields, and rice fields. In addition, at Mbuli, it prefers grassland, secondary forests, and settlements. It has no preference on crop plantation and shrubs, on the other side it strongly avoids fields/swidden agriculture, sulfurous rivers, and rice fields. Secondary forests are preferred due to the presence of several natural prey species, suitable vegetation conditions, and favorable slope classes that meet its habitat requirements. However, it also faces interspecific competition with other raptor species in these habitats. The primary threats to the Flores hawk-eagle's existence stem from anthropogenic factors, including habitat loss, land use changes, and conflict with humans. Predation on livestock in settlements often leads to persecution of the bird. Effective conservation strategies must address these threats by protecting secondary forests, mitigating human-wildlife conflict, and promoting sustainable land use practices among local communities. Enhanced education and awareness programs are crucial to reduce negative perceptions and ensure the coexistence of the Flores hawk-eagle with village residents.

Recommendation

To enhance the understanding of the Flores hawk-eagle's ecology and conservation, future research should incorporate GPS transmitters for tracking movement patterns, habitat utilization, and potential threats. This technology will provide precise, continuous data on home range, dispersal, roosting sites, and foraging behavior, enabling targeted conservation efforts. Additionally, GPS tracking can help identify risks such as habitat fragmentation and human disturbances while supporting long-term monitoring of survival and breeding success. Integrating this approach with community involvement will strengthen conservation strategies and ensure sustainable species management.

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References

Anderson, S. H., & Gutzwiller, K. J. (1994). Habitat evaluation methods. In T. A. Bookhout (Eds.), *Research and management techniques for wildlife and habitats* (pp. 254–271). Bethesda: The Wildlife Society.

BirdLife International. (2024). *Nisaetus floris*. The IUCN red list of threatened species 2024: e.T22732096A229714191. https://doi.org/10.2305/IUCN.UK.2024-2.RLTS.T22732096A229714191.en

Blackburn, J. K., Hadfield, T. L., Curtis, A. J., & Hugh-Jones, M. E. (2014). Spatial and temporal patterns of anthrax in white-tailed deer, *Odocoileus virginianus*, and hematophagous flies in West Texas during the summertime anthrax risk period. *Annals of the Association of American Geographers*, *104*(5), 939–958. https://doi.org/10.1080/00045608.2014.914834

Börger, L., Franconi, N., De Michele, G., Gantz, A., Meschi, F., Manica, A., Lovari, S., & Coulson, T. (2006). Effects of sampling regime on the mean and variance of home range size estimates. *Journal of Animal Ecology*, *75*(6), 1393–1405.

Börger, L., Dalziel, B. D., & Fryxell, J. (2008). Are there general mechanisms of animal home range behaviour? A review and prospects for future research. *Ecology Letters*, *11*, 637–650. https://doi.org/10.1111/j.1461-0248.2008.01182.x

Bosch, R., Real, J., Tintó, A., Zozaya, E. L., & Castell, C. (2010). Home-ranges and patterns of spatial use in territorial Bonelli's Eagle *Aquila fasciata*. *Ibis*, *152*(1), 105–117. https://doi.org/10.1111/j.1474-919X.2009.00985.x

Boyle, S. A., Lourenço, W. C., da Silva, L. R., & Smith, A. T. (2009). Home range estimates vary with sample size and methods. *Folia Primatologica, International Journal of Primatology*, *80*(1), 33–42. https://doi.org/10.1159/000201092

Badan Pusat Statistik (2022). *Kecamatan Wolojita dalam* *angka*. Ende: Badan Pusat Statistik Kabupaten Ende.

Cardador, L., Mañosa, S., Varea, A., & Bertolero, A. (2009). Short communication: Ranging behaviour of Marsh Harrier *Circus aeruginosus* in agricultural landscapes. *Ibis*, *151*(4), 766–770. https://doi.org/10.1111/j.1474-919X.2009.00963.x

Collaerts, P., Collaerts, E., Verbelen, P., & Trainor, C. R. (2013). Discovery of the critically endangered Flores hawk-eagle *Nisaetus floris* on Alor Island, Indonesia. *Birding ASIA*, *19*, 48–51.

Eaton, J. A., van Balen, B., Brickle, N. W., & Rheindt, F. E. (2016). *Birds of the Indonesian Archipelago. Greater Sundas and Wallacea.* Barcelona: Lynx Edicions.

Franklin, W. L., Mossmann, A. S., & Dole, M. (1975). Social organisation and home range of Roosevelt elk. *Journal of Mammalogy*, *56*, 102–118. https://doi.org/10.2307/1379610

Fotheringham, A. S., Brunsdon, C., & Charlton, M. (2000). *Quantitative geography: Perspective on spatial data analysis*. Thousand Oaks: Sage.

Gaibani, G., & Csermely, D. (2007). Behavioral studies. In *Raptor research and management techniques* (pp. 117–128). Blaine: Hancock House Publishers.

Getz, W. M., Fortmann-Roe, S., Cross, P. C., Lyons, A. J., Ryan, S. J., & Wilmers, C. C. (2007). LoCoH: Nonparametrics kernel methods for constructing home ranges and utilization distributions. *PLoS ONE*, *2*(2), Article e207. https://doi.org/10.1371/journal.pone.0000207

Gjershaug, J. O., Kvaloy, K., Rov, N., Prawiradilaga, D. M., Suparman, U., & Rahman, Z. (2004a). The taxonomic status of Flores hawk eagle *Spizaetus floris*. *Forktail*, *20*, 55–62.

Gjershaug, J. O., Røv, N., Nygård, T., Prawiradilaga, D. M., Afianto, M. Y., Hapsoro, & Supriatna, A. (2004b). Home-range size of the Javan hawk-eagle (*Spizaetus bartelsi*) estimated from direct observations and radiotelemetry. *Journal of Raptor Research*, *38*(4), 343–349.

Harness, R. E. (2007). Mitigation. In *Raptor research and management techniques* (pp. 365–382). Blaine: Hancock House Publishers.

IUCN. 2022. *The IUCN red list of threatened species*. Version 2022-2.

Jacobs, J. (1974). Quantitative measurement of food selection. *Oecologia*, *14*, 413–417. https://doi.org/10.1007/BF00384581

Kaneda, H., Prawiradilaga, D. M., & Yamagishi, S. (2007). Home range and habitat use of an individual Javan hawk-eagle (*Spizaetus bartelsi*). Short communications. *Journal of Raptor Research*, *41*(1), 68–71. https://doi.org/10.3356/0892-1016(2007)41[68:HRAHUO]2.0.CO;2

Kennedy, P. L., Ward, J. M., Rinker, G. A., & Gessaman, J. A. (1994). Post-fledging areas in Northern Goshawk home ranges. *Studies in Avian Biology*, *16*, 75–82.

Krebs, C. J. (1989). *Ecological methodology*. New York: Harper and Row Publishers.

Krüger, S. C., Allan, D. G., Jenkins, A. R., & Amar, A. (2014). Trends in territory occupancy, distribution, and density of the Bearded Vulture *Gypaetus barbatus meridionalis* in southern Africa. *Bird Conservation International*, *24*(2), 162–177. https://doi.org/10.1017/S0959270913000440

Margalef, R. (1967). Some concepts relative to the organization of plankton. *Oceanography and Marine Biology-An Annual Review*, *5*, 257–289. https://doi.org/10261/166489

Margalida, A., Pérez-García, J. M., Afonso, I., & Moreno-Opo, R. (2016). Spatial and temporal movements in Pyrenean bearded vultures (*Gypaetus barbatus*): Integrating movement ecology into conservation practice. *Scientific Reports*, *6*, Article 35746. https://doi.org/10.1038/srep35746

McClure, C. J. W., Westrip, J. R. S., Johnson, J. A., Schulwitz, S. E., Virani, M. Z., Davies, R., Symes, A., Wheatley, H., Thorstrom, R., Amar, A., Buij, R., Jones, V. R., Williams, N. P., Buechley, E. R., & Butchart, S. H. M. (2018). State of the world's raptors: Distributions, threats, and conservation recommendations. *Biological Conservation*, *227*, 390–402. https://doi.org/10.1016/j.biocon.2018.08.012

Ministry of Environment and Forestry. (2022). Decree of Minister of Environment and Forestry Number: SK.77/Menlhk/Setjen/KSA.2/1/2022 regarding Flores Hawk-eagle (*Nisaetus floris*) Conservation Strategy and Action Plan for 2021–2030. Jakarta: Ministry of Environment and Forestry.

Nijman, V., van Balen, S. B., & Sözer, R. (2000). Breeding biology of Javan hawk-eagle *Spizaetus bartelsi* in West Java, Indonesia. *Emu-Austral Ornithology*, *100*(2), 125–132. https://doi.org/10.1071/MU9826

Norris, K. (2004). Managing threatened species: The ecological toolbox, evolutionary theory and declining-population paradigm. *Journal of Applied Ecology*, *41*, 413–426. https://doi.org/10.1111/j.0021-8901.2004.00910.x

O'Bryan, C. J., Allan, J. R., Suarez-Castro, A. F., Delsen, D., M., Buij, R., McClure, C. J. W., Rehbein, J. A., Virani, M. Z., McCabe, J. D., Peter, T., Negret, P. J., Greig, C., Peadar, B., & Kissling, W. D. (2022). Human impacts on the world's raptors. *Frontiers in Ecology and Evolution*, *10*, Article 624896. https://doi.org/10.3389/fevo.2022.624896

Oliveira-Santos, L. G. R., Zucco, C. A., & Agostinelli, C. (2013). Using conditional circular kernel density functions to test hypotheses on animal circadian activity. *Animal Behaviour*, *85*, 269–280. https://doi.org/10.1016/j.anbehav.2012.09.033

Peery, M. Z. (2000). Factors affecting interspecies variation in home-range size of raptors. *The Auk, 117*(2), 511–517. https://doi.org/10.1093/auk/117.2.511

Pérez-García, J. M., Margalida, A., Afonso, I., Ferreiro, E., Gardiazabal, A., Botella, F., & Sanchez-Zapata, J. A. (2013). Interannual home range variation, territoriality and overlap in breeding Bonelli's Eagle (*Aquila fasciata*) tracked by GPS satellite telemetry. *Journal of Ornithology*, *154*, 63–71. https://doi.org/10.1007/s10336-012-0871-x

Raharjaningtrah, W., & Rahman, Z. (2004). Study on the distribution, habitat and ecology of Flores hawk-eagle *Spizaetus cirrhatus floris* in Lombok, Sumbawa, Flores, Komodo and Rinca Islands, Nusa Tenggara, Indonesia. *Annual Report of Pro Nature Fund*, *13*(1).

Rahman, D. A. (2021). *Dasar-dasar ekologi kuantitatif: Teori dan aplikasi*. Bogor: IPB Press.

Raptor Conservation Society. (2011). Study on distribution, population, habitats and ecological aspect of Flores hawk-eagle (*Nisaetus floris*) on Rinjani National Park and other protected area in Lombok Island West Nusa Tenggara, Indonesia. Final Report for the Mohammed bin Zayed Species Conservation Fund. Cianjur: Raptor Conservation Society.

Raptor Conservation Society. (2012). Continued a survey of distribution, population, habitats and ecological aspects of Flores hawk-eagle (*Nisaetus floris*) in and around Flores Island, East Nusa Tenggara-Indonesia. Final Report for the Mohammed bin Zayed Species Conservation Fund. Cianjur: Raptor Conservation Society.

Septiana, W., Munawir, A., Pairah, P., Sodahlan, M. E., Irawan, Y., Santosa, Y., & Prasetyo, L. B. (2020). Distribution and characteristics of Javan hawk eagle nesting trees in Gunung Halimun Salak National Park, Indonesia. *Jurnal Biodjati*, *5*(2), 182–190. https://doi.org/10.15575/biodjati.v5i2.8481

Sözer, R., & Nijman, V. (1995). Behavioural ecology, distribution and conservation of the Javan hawk-eagle *Spizaetus bartelsi* Stresseman, 1924. *Verslagen en Technische Gegevens*, *62*(1), 11–22.

Subedi, T. R., Pérez-García, J. M., Sah, S. A. M., Gurung, S., Baral, H. S., Poudyal, L. P., Lee, H., Thomsett, S., Virani, M. Z., & Anadón, J. D. (2020). Spatial and temporal movement of the Bearded Vulture using GPS telemetry in the Himalayas of Nepal. *Ibis*, *162*(2), 563–571. https://doi.org/10.1111/ibi.12799

Syartinilia, Makalew, A. D. N., Mulyani, Y. A., & Higuchi, H. (2015). Landscape characteristics derived from satellite-tracking data of wintering habitats used by oriental honey buzzards in Borneo. *Landscape and Ecological Engineering*, *11*, 61–71. https://doi.org/10.1007/s11355-013-0237-4

Syartinilia, Al Farisi, G. A., & Higuchi, H. (2017). Landscape characteristics of oriental honey buzzards wintering in western part of Flores Island based on satellite-tracking data. *IOP Conference Series: Earth and Environmental Science*, *91*, Article 012031. https://doi.org/10.1088/1755-1315/91/1/012031

Syartinilia, & Setiawan, R. M. K. (2021). Spatial distribution and landscape characteristics of Flores hawk-eagle (*Nisaetus floris*) habitat in Flores Island. *Journal of Natural Resources and Environmental Management*, *11*(4), 542–549. https://doi.org/10.29244/jpsl.11.4.542-549

Tapia, L., Kennedy, P. L., & Mannan, R. W. (2007). Habitat sampling. In *Raptor research and management techniques* (pp. 153–169). Blaine: Hancock House Publishers.

Titus, K., & Mosher, J. A. (1981). Nest site habitat selected by woodland hawks in the central Appalachians. *The Auk*, *98*(2), 270–281. https://doi.org/10.1093/auk/98.2.270

van Balen, B., Nijman, V., & Prins, H. H. T. (2000). The Javan hawk-eagle: Misconceptions about rareness and threat. *Biological Conservation*, *96*(3), 297–304. https://doi.org/10.1016/S0006-3207(00)00092-6

Village, A. (1982). The home range and density of kestrels in relation of vole abundance. *Journal of Animal Ecology*, *51*, 413–428. https://doi.org/10.2307/3974

Withaningsih, S., Parikesit, & Alham, R. F. (2020). Diversity of bird species in the coffee agroforestry landscape: Case study in the Pangalengan Sub-district, Bandung District, West Java, Indonesia. *Biodiversitas*, *21*(6), 2467–2480. https://doi.org/10.13057/biodiv/d210619

Worton, B. J. (1989). Kernel methods for estimating the utilization distribution in home-range studies. *Ecology*, *70*(1), 164–168. https://doi.org/10.2307/1938423