



## Full Length Research Article

# Population and Habitat Suitability Index Model of Bali Starling (*Leucopsar rothschildi*) in West Bali National Park

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## ABSTRACT

Bali starling (*Leucopsar rothschildi*) is categorized as an endangered species based on the International Union for Conservation of Nature and Natural Resources (IUCN) red list. Thus, preventing this species from extinction becomes very crucial. One of the most important activities for this purpose is a soft release method to avoid birds' mortality, which has been done in West Bali National Park (WBNP). However, this method creates the dependency of birds to the artificial treatment and may affect the distribution of Bali starling. Therefore, this study aimed to analyze the population and habitat and create a habitat suitability index model for Bali starling in WBNP. Data were obtained by surveying the Bali starling population, including the number of individuals, distribution, age structure, sex ratio, natality, and mortality. Vegetation analysis was also conducted to determine habitat conditions. Finally, map interpretation data was used to develop a suitable habitat model for Bali starling in WBNP. The results showed that 63 Bali starling were found near the resort office, bird release sites, and binding bird cages. It indicated that the habitat of Bali starling has shifted from the soft release site. The habitat suitability index model of Bali starling in WBNP was  $Y = 17.145 + 6.640PC_1 - 4.055PC_2$ , showing the selected variables only give a moderate determination coefficient ( $R^2 = 40.9\%$ ). The artificial treatment created by the WBNP authority seems to be another great factor influencing the existence and distribution of Bali starling in WBNP. It was also indicated that Bali starling could breed in the WBNP, but it tends to have a shifting habitat in the wild.

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## 1. Introduction

Bali starling (*Leucopsar rothschildi*) is an endemic bird species of Bali island listed as a critically endangered species by the International Union for Conservation of Nature and Natural Resources (IUCN) and Appendix I of Convention on International Trade in Endangered Species (CITES) (BirdLife International 2018). The critically endangered status of the species could be due to a small population, restriction to a small area, overexploitation, illegal trading, habitat conversion, and forest fire (Collar et al. 2012; Pramatana et al. 2017). Therefore, the conservation of Bali starling will need to involve a multidisciplinary approach, including political, socioeconomic, and scientific fields. Many studies have been carried out for the conservation of

Bali starling, including breeding and biological behavior (Djohan et al. 2015; Putra et al. 2014), population analysis (Hernowo 2017; Riany and Aunurohim 2013), and habitat analyses (Arinasa 2014; Noerdjito et al. 2017; Roemantyo 2017). However, due to the complexity of many factors influencing the habitat suitability, the population of Bali starling was not significantly increased in wild habitats (Hernowo 2017; Hernowo and Haquesta 2021).

The Bali starling habitat is endemic to the dry monsoon forest of Bali Island, and West Bali National Park (WBNP) is a particular habitat for Bali starling (Sutomo 2021). Furthermore, (Jepson 2016) identified that the major problem for the conservation of this species was the diminishing suitable habitat due to habitat conversion and uncontrolled capture for illegal trading. It brought the species to the endangered status, and it is categorized as a priority species to be concerned globally from the extinction (Duckworth et al. 2012). WBNP's authority promoted activities to prevent the species extinction, such as creating a particular captive breeding center for Bali starling (Bali starling Supervising Management Unit) in Tegal Bunder Resort National Park Management Section Region II and introducing a soft release method for restoring the species population in wild habitat (BTNBB 2013).

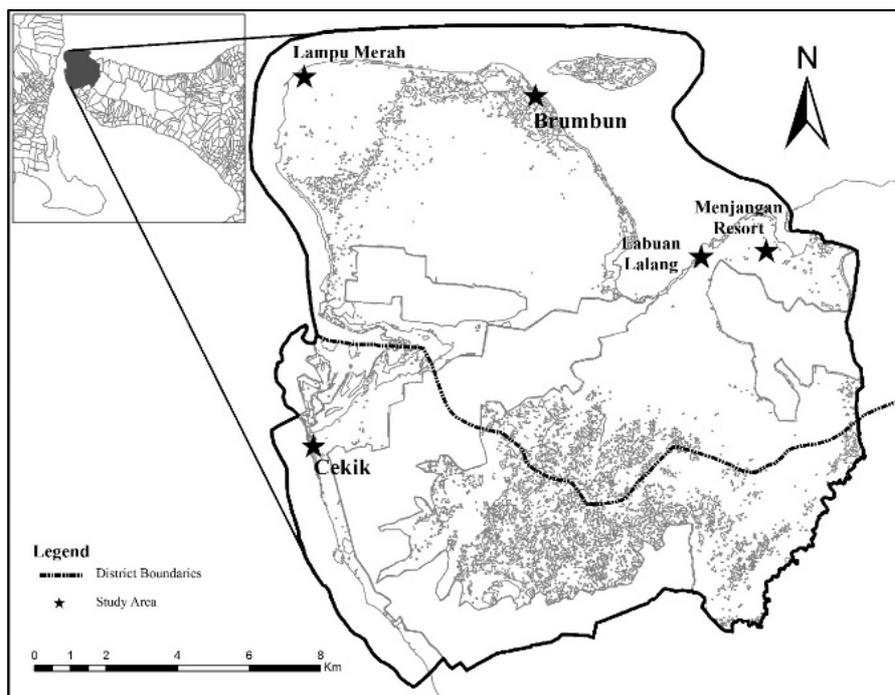
The Bali starling population has positive growth by captive breeding activity, and it can be released into the wild habitat every year since 1998 (BTNBB 2013). However, the survival of released birds was still low, which was indicated by the high mortality of the species. It was suggested that the decreasing number of released species is due to the low competitiveness in the wild habitat (Hernowo and Haquesta 2021). Therefore, WBNP introduced a soft release method to increase the survival of released species in wild habitats. This method consists of pre- and post-release treatments, i.e., giving feed intensively to the released birds and the lure of birds around the introduced area (Hernowo and Haquesta 2021). The combination of captive breeding and soft released methods increased the Bali starling population in wild habitats (Hernowo 2017). However, it causes the habitual dependency of Bali starling and may affect the species distribution in WBNP. In addition, Noerdjito et al. (2017) proposed the reconstruction of habitat for the suitable condition of Bali starling life, and it has to understand all variables for supporting Bali starling conservation. Therefore, analyzing factors that may influence the distribution and the presence of Bali starling in the WBNP area is needed to determine the factors affecting Bali starling's distribution comprehensively. Habitat suitability index (HSI) is used to determine the suitability area for the animal currently studied and can be done by overlaying many factors that influence the species. The result of the habitat suitability index can be used as a basis for conservation species and habitat management (Prasetyo et al. 2017). The suitable area could change towards better or worse based on the success of habitat management. This study aimed to analyze the population and establish a habitat suitability index model of Bali starling in WBNP using the Principal Component Analysis (PCA) method.

## 2. Materials and Methods

### 2.1. Materials

The study was carried out in West Bali Nation Park (**Fig. 1**) on March-April 2017, especially at Cekik Resort National Park Management Section (Region I), Lampu Merah Post, and Teluk Brumbun Resort (Region II), and Labuan Lalang and Menjangan Resort (Region III). The instruments for study consist of camera, bird guide book (MacKinnon et al. 2010), binocular,

compass, Landsat image, Bali administrative map, Global Positioning System (GPS), DNRGPS software, Erdas Imagine 2014, ArcGIS 10.5, IBM SPSS 23.



**Fig. 1.** Study area in West Bali National Park.

## 2.2. Data Collection

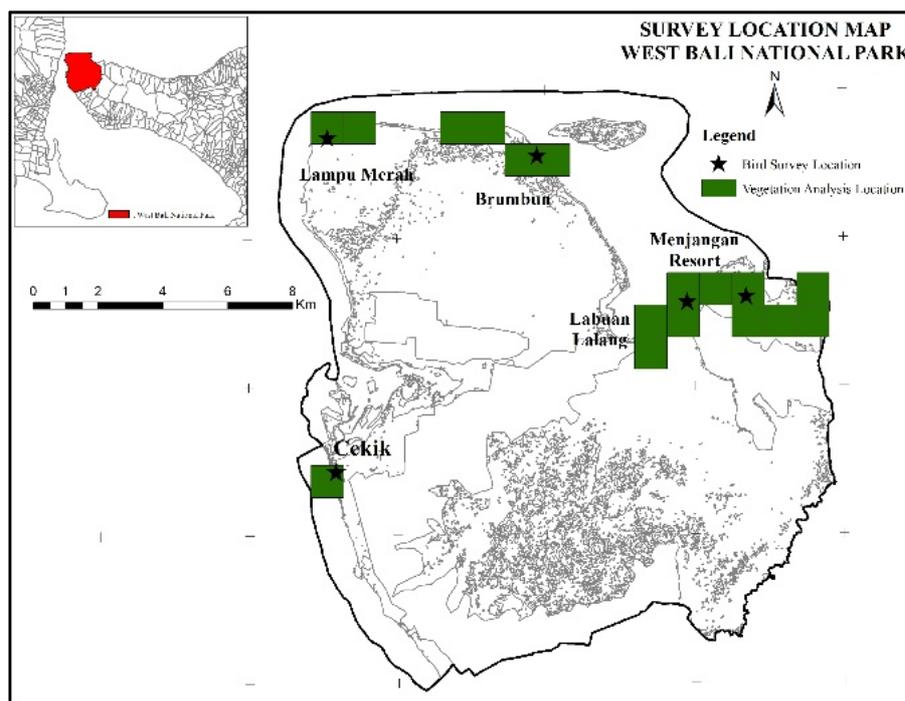
### 2.2.1. Population

The population of Bali starling was collected by field observation, including data of total individual birds, sex ratio, and age structure. In addition, the population natality and mortality were collected from statistics data provided by WBNP. Population data was determined using the concentration count method (Bismark 2011). The method was concentrated at a presumed point place with a high chance of meeting animals in the entire study area (Fig. 2).

### 2.2.2. Habitat

The habitat condition was characterized by analyzing the distance from the road and villages, elevation, slope, vegetation index, temperature, feed and water sources, cover, shelter, nesting box location, and landscape change. The data was obtained by vegetation analysis (Indriyanto 2012), ground check observation, and map interpretation. Vegetation analysis was carried out at the site (Fig. 2) with five plots in each box covering 1 km<sup>2</sup>.

The covering area of the box was determined based on Hernowo and Haquesta (2021), stating that Bali starling result from captivity can move as far as 500–1000 m. The suitability habitat map was created based on the dependent variables (habitat characterization) and independent variables (the meeting point data of the species).



**Fig. 2.** Survey location for collecting data in West Bali National Park.

### 2.3. Data Analysis

#### 2.3.1. Analysis of existence and habitat suitability of Bali starling

The existence of the species in its habitat was analyzed by the Principal Component Analysis method to obtain the optimum factor representing the dependent variable. Vegetation analysis was determined as density, frequency, dominance, and important value index (IVI) for ground cover, seedlings, poles, and trees plants. Habitat suitability data was mapped based on the Geographic Information System (GIS) data. GIS systems can be used to analyze the relationship between species and ecosystem conditions (Sherrouse et al. 2011). The natality of the species was calculated based on the statistical data observed from 2010 to 2016. The mortality of the species was determined based on the statistical data of the bird population observed by WBNP.

#### 2.3.2. Landscape evaluation

Landscape evaluation was carried out based on the patch analysis landcover in the study area. Patch analysis can be used to analyze quantitative data of landscape elements, including class area, total landscape area, number of patches, mean patch size, median patch size, patch size of standard deviation, patch size coefficient of variance, total edge, edge density, mean patch edge, mean perimeter area ratio, mean shape index, area weighted shape index, mean patch fractal dimension, and area weighted mean patch fractal dimension (Paudel and Yuan 2012). In addition, the habitat preference analysis was carried out based on the coordinate point data of direct meeting in the wild habitat, which was processed by principal component analysis. The required data for analyzing the Bali starling existence in WBNP are presented in **Table 1**.

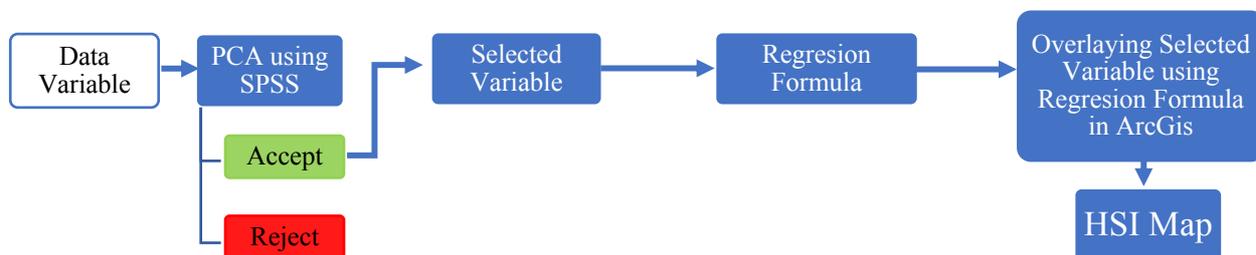
**Table 1.** Data for analysis habitat suitability of Bali starling in West Bali National Park

Y	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>	X <sub>8</sub>	X <sub>9</sub>	X <sub>10</sub>	.	.	X <sub>n</sub>
Point A	a	a	a	a	a	a	a	a	a	a	.	.	a <sub>n</sub>
Point B	b	b	b	b	b	b	b	b	b	b	.	.	b <sub>n</sub>
Point C	c	c	c	c	c	c	c	c	c	c	.	.	c <sub>n</sub>
Point D	d	d	d	d	d	d	d	d	d	d	.	.	d <sub>n</sub>
Point E	e	e	e	e	e	e	e	e	e	e	.	.	e <sub>n</sub>

Notes: Y = Bali starling meeting point; Point A-E = Bali starling's existence coordinat point; X<sub>1</sub> = Distance from the road; X<sub>2</sub> = Distance from the village; X<sub>3</sub> = Elevation; X<sub>4</sub> = Slope; X<sub>5</sub> = Predator of Bali starling; X<sub>6</sub> = Competitor of Bali starling; X<sub>7</sub> = Normalized Difference Vegetation Index; X<sub>8</sub> = Surface temperature; X<sub>9</sub> = Potential of Bali starling feed; X<sub>10</sub> = Water source potential; X<sub>11</sub> = Potential of Bali starling cover; X<sub>12</sub> = Potential of Bali starling shelter; X<sub>13</sub> = Nesting box location; X<sub>14</sub> = Distance of Bali starling movement; X<sub>15</sub> – X<sub>n</sub> = Landscape analysis.

2.3.3. Principal component analysis

Principal component analysis (PCA) is a method to reduce dimensions that preserves the relevant information of the original data. PCA consists of Keiser Meyer Olkin (KMO), Barlett test, anti-image matrix or measurement sampling adequacy value, communalities value, total variance explained, component matrix, and component score coefficient matrix (Shlens 2014). In this study, PCA was used to determine the proportion effect of each habitat variable on the existence of the species. The result was processed by linear regression with the highest number of Bali starling population in each location as an independent factor. The value of selected variables was then converted to a spatial map using a spatial analysis tool in ArcGIS software (Arcmap 10.5). Finally, the habitat suitability index model is made by overlaying a variety of thematic maps from selected variables (Fig. 3).



**Fig. 3.** The habitat suitability index model analysis process.

3. Results and Discussion

3.1. Population and Distribution

The existence of Bali starling was identified in the observation area. In the period of study, the bird is unevenly distributed in WBNP area, including Cekik in Gilimanuk Resort, Lampu Merah post in Resort Prapat Agung, Teluk Brumbun Resort, Labuan Lalang post and Menjangan Resort (IPPA) in Resort Teluk Terima (Table 2). The existence of Bali starling in WBNP near resort office, bird release sites, and bird cages. Bali starling exists at the specific location with high-level treatments for resources needs provided by WBNP. The highest concentration of the species was detected at the Labuan Lalang area. In addition to treatments provided by WBNP, habitat conditions should be the determining factor for the abundance of species in this area. Previously reported that Labuan Lalang area is dominated by monsoon forest vegetation suitable

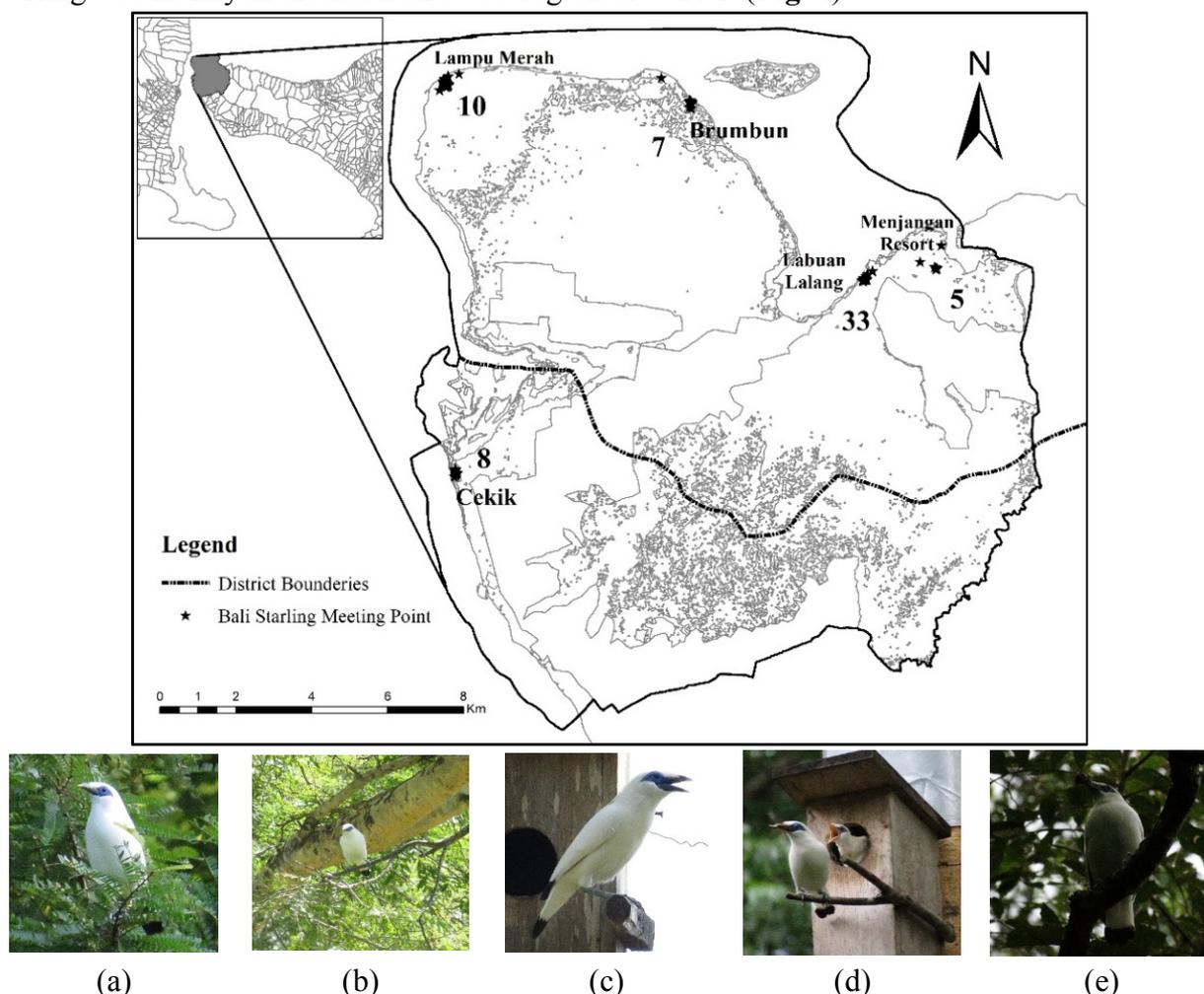
for the natural habitat of Bali starling. Roemantyo (2017) noted that Bali starling is an endemic species to the dry monsoon forest, especially in Bali Island.

**Table 2.** Bali starling population in different sites

Location	Number of Population
Cekik	8
Lampu Merah	10
Brumbun Bay	7
Labuan Lalang	33
Menjangan Resort	5
Total	63

Notes: Cekik, Brumbun Bay, and Labuan Lajang are located near the resort office, bird release sites, and birdcages; Lampu Merah and Menjangan Resort are located near the resort office.

The distribution of Bali starling in WBNP is influenced by many factors, such as vegetation structure and composition, distance from the human settlement and road, habitat conversion, and disturbance (Pramatana et al. 2017; Roemantyo 2017). Nevertheless, the distribution of Bali starling was mainly in the north and west region of WBNP (Fig. 4).



**Fig. 4.** Distribution and number of Bali starling population in West Bali National Park: (a) Cekik 8 individuals, (b) Lampu Merah 10 Individuals, (c) Brumbun Bay 7 Individuals, (d) Labuan Lalang 33 Individuals, (e) Menjangan Resort 5 Individuals.

Originally, Bali starling is evenly distributed in the wide area of Bali Island, such as in Bubunan, Gerokgak, Negara, Prapat Agung Peninsula, Gilimanuk, and Teluk Terima (Djohan et al. 2015). The expansive development for human settlement degraded the forest area in Bali Island, leading to the decreasing natural habitat of Bali starling. Since 1947, West Bali Nature Reserve was designated as the conservation area for endemic species of Bali Island. Therefore, the distribution of the Bali starling population shifted towards the western part of the main Bali island and Nusa Penida, such as around the Great Prapat Peninsula, Gilimanuk, and Teluk Terima (Djohan et al. 2015).

### 3.2. Age Structure and Sex Ratio

During the study period, 63 individuals of Bali starling were identified in WBNP, consisting of mature, young, and juvenile birds. The sex type of Bali starling can be suggested from the biological habit of the species. The mated couple of Bali starling are usually in the nest, but young birds commonly gather during their activities. The juvenile birds that can not move outside the box are inside the nest box, and they are still fed directly by mature birds. Nine couples of birds were found during observation. Therefore the sex type of 18 individuals of Bali starling can be identified. The sex type of 45 individual birds was not definitely identified since they are still young or single mature birds. However, it is important to note that the proportion of young and mature age of Bali starlings in WBNP was about 2:5. The age structure of Bali starling is an essential factor for the regeneration of the species, and it contributes to the sustainability of Bali starling in WBNP. Based on the age structure, it seems that the sustainability of Bali starling in WBNP was still relatively high. Due to only 18 individuals of birds could be definitely identified of their sex type, it was indicated that the sex ratio of mature Bali starling in WBNP was closed to 1:1 for each male and female bird. According to Mas'ud (2010), the Bali starling is a monogamous bird species with only one partner for each mating season.

### 3.3. Natality and Mortality

The Bali starling regeneration was suggested by the natality and mortality during a specific period. According to the WBNP statistical data of 2010-2016 (Table 3), the average birthrate of Bali starling in the Bali Starling Supervising Management Unit (BSSMU) was 48 individual nestlings, and the death rate of the species was about 42%. Hernowo (2017) reported that the survival of this species in 2007-2010 was about 77%. The survival of the species after breeding is still the biggest problem for the sustainability of Bali starling in wild habitats, as it may be due to the low competitiveness of this species in wild habitats (Hernowo and Haquesta 2021). According to the actual data in 2017, the highest birth of the species was in the Labuan Lalang area. It may be due to the better habitat suitability of Labuan Lalang than the other areas. Aryanti and Wicaksono (2018) reported that Labuan Lalang is categorized as a representative of the natural habitat for Bali starling.

The mature age of Bali starling is about 7-9 months, and the mated couple birds commonly produce 1-3 eggs (Mas'ud 2010). The wet season is an appropriate condition for the mating season of Bali starlings because of the abundant availability of food in wild habitats (Sutomo 2021). However, it was reported that there was a different mating season of Bali starling in WBNP and Nusa Penida. The wet season is the main period of the breeding season in WBNP, while in Nusa Penida, this species breeds during both wet and dry seasons (Djohan et al. 2015). In captive

breeding, the couple of Bali starling can regenerate throughout the year. This species commonly produce eggs in the next cycle after their nestling is 4-5 weeks old (Mas'ud 2010).

**Table 3.** Number of birth and death of Bali starling in Bali Starling Supervising Management Unit

Year	Natality	Mortality
2010	16	10
2011	32	10
2012	31	23
2013	39	28
2014	53	14
2015	67	17
2016	104	39
Average	48.86	20.14

### 3.4. Vegetation Analysis

WBNP is a natural habitat of Bali starling dominated by savanna and monsoon forests. The dry land monsoon forest is the endemic natural habitat for Bali starlings (Sutomo 2021). Based on the vegetation analysis, the savanna ecosystem in WBNP has potential plants sources for feed, cover, and shelter of Bali starling, such as Kemloko (*Phyllanthus emblica*), Pilang (*Acacia leucophloea*), Intaran (*Azadirachta indica*), and Talok (*Grewia eriocarpa*) threes (Table 4).

**Table 4.** Potential plants for supporting Bali starling life in the savanna ecosystem

Species	Growth stage	Number of individuals	DV (ind/ha)	F	D	IVI (%)
Kemloko ( <i>Phyllanthus emblica</i> )	Pole	68	340	0.53	1.12	230.37
Pilang ( <i>Acacia leucophloea</i> )	Pole	7	35	0.13	0.19	33.30
Intaran ( <i>Azadirachta indica</i> )	Pole	4	20	0.13	0.07	26.08
Kemloko ( <i>Phyllanthus emblica</i> )	Tree	67	335	0.63	2.85	196.25
Intaran ( <i>Azadirachta indica</i> )	Tree	17	85	0.20	1.39	67.59
Pilang ( <i>Acacia leucophloea</i> )	Tree	5	25	0.10	0.47	25.24
Talok ( <i>Grewia eriocarpa</i> )	Tree	1	5	0.03	0.04	5.27

Notes: DV = Density value; F = Frequency; D = Dominance; IVI = Important value index

A previous study by (Pramatana et al. 2021) confirmed that Bali starling seems to likely use walikukun (*Schoutenia ovata*), kaliombo (*Terminalia microcarpa*), kemloko (*Phyllanthus emblica*), and talok (*Grewia eriocarpa*) for nesting. In addition, Bali starling also uses mulberry (*Morus alba*), jujube (*Zizyphus jujube*), banana (*Musa* sp), and papaya (*Carica papaya*) as feed sources, and some insects such as worms, grasshopper, dragonfly, ant, and termite as protein sources (Pramatana et al. 2021). In addition, Riany and Aunurohim (2013) note that talok (*Grewia eriocarpa*), tekik (*Albizia lebbeck*), kemloko (*Phyllanthus emblica*), and kesambi (*Schleichera oleosa*) threes were also used for the perching activity and hunting of insects.

Potential plants for supporting the life of Bali starling also can be fulfilled from the monsoon forest ecosystem. Table 5 presented some potential plants in the monsoon forest ecosystem, commonly used for feed, cover, and shelter Bali starling.

The sustainability of Bali starling in WBNP increased by introducing the soft release method. This method consists of treatments for the supporting basic need of Bali starling in the reintroduction area. Assuming that Bali starling's home range is about  $\pm 1$  km (Hernowo and

Haquesta 2021), the vegetation in savanna and monsoon forest was enough available for the supporting life of Bali starling in WBNP.

**Table 5.** Potential plants for supporting Bali starling life in the monsoon forest ecosystem

Species	Growth stage	Number of individuals	DV (ind/ha)	F	D	IVI (%)
Talok ( <i>Grewia eriocarpa</i> )	Pole	28	140	0.49	0.49	86.27
Walikukun ( <i>Actinophora fragrans</i> )	Pole	21	105	0.27	0.11	41.42
Laban ( <i>Vitex pinnata</i> )	Pole	2	10	0.04	0.03	6.43
Intaran ( <i>Azadirachta indica</i> )	Pole	10	50	0.13	0.17	27.86
Pilang ( <i>Acacia leucophloea</i> )	Pole	4	20	0.09	0.08	14.13
Intaran ( <i>Azadirachta indica</i> )	Tree	27	135	0.27	9.24	91.63
Talok ( <i>Grewia eriocarpa</i> )	Tree	82	410	0.69	0.13	77.99
Walikukun ( <i>Actinophora fragrans</i> )	Tree	14	70	0.20	0.11	17.90
Pilang ( <i>Acacia leucophloea</i> )	Tree	6	30	0.11	0.64	12.97
Tekik ( <i>Albizia lebbbeck</i> )	Tree	3	15	0.04	0.20	5.12
Bekol ( <i>Ziziphus mauritiana</i> )	Tree	1	5	0.02	0.11	2.36
Laban ( <i>Vitex pinnata</i> )	Tree	14	70	0.20	1.17	25.27

Notes: DV = Density value; F = Frequency; D = Dominance; IVI = Important value index.

### 3.5. Principal Component Analysis

The 36 designated variables were used for determining influenced variables to the existence of Bali starling in WBNP. Ten selected variables were obtained from these variables by SPSS 23 analysis (Table 6).

**Table 6.** Range value of selected variables

Value	Selected Habitat Variables									
	DR	DV	E	ND	ST	DNB	DC	DFP	DCP	MPE
Minimum	0	543.30	4	0.11	29.20	0	0	20	20	340
Maximum	1359.30	7296.20	43	0.45	38.60	1955.80	2202.30	190	190	2145.30

Notes: DR = Distance from the road, DV = Distance from the village, E = Elevation, ND = Normalized Difference Vegetation Index, ST = Surface temperature, DNB = Distance from nesting box location, DC = Distance of Bali starling movement, DFP = Density of feed plants, DCP = Density of cover plants, MPE = Mean patch edge.

The significant influence of variables on the existence was analyzed based on the Keiser Meyer Olkin (KMO) and Barlett Test values. The selected variables significantly influenced the existence of Bali starling in WBNP with the KMO value 0.713 (>0.5) and Barlett Test value 0.0001 (<0.05). This result suggested that many factors are involved in the characteristics of the Bali starling habitat. However, to obtain the information of dominant variables, further statistical analysis is required. The Measure Sampling Adequacy (MSA) value of selected variables was >0.5, which means that the selected variables have fulfilled the requirement for the subsequent statistical test.

Based on the eigenvalue (>1), two constructed component factors were obtained (Table 7), and then it was subjected to the varimax rotation for the correlation analysis between variables for each factor.

**Table 7.** New factor formed based on eigenvalue

Component	Initial eigenvalues		
	Total	% Variety	% Variety Cumulative
1	5.48	54.80	54.80
2	3.38	33.85	88.65
3	0.35	3.51	93.35

Notes: Component = new constructed factors from principal component analysis

Ten influences variables and two new constructed factors were subjected to advanced analysis to obtain the value of the feature factor. The value of the feature factor indicated the correlation between each variable with constructed factors (**Table 8**).

**Table 8.** Value of feature factor

Habitat Variables	Components	
	1	2
Distance from the road	0.19	0.91
Distance from the village	-0.90	-0.14
Elevation	0.07	0.91
NDVI	0.85	0.08
Surface temperature	-0.92	-0.14
Distance from the nest box	0.03	0.99
Distance from the cage	0.04	0.99
Density of feed plants	0.91	-0.03
Density of cover plants	0.97	0.08
Mean patch edge	-0.97	-0.07

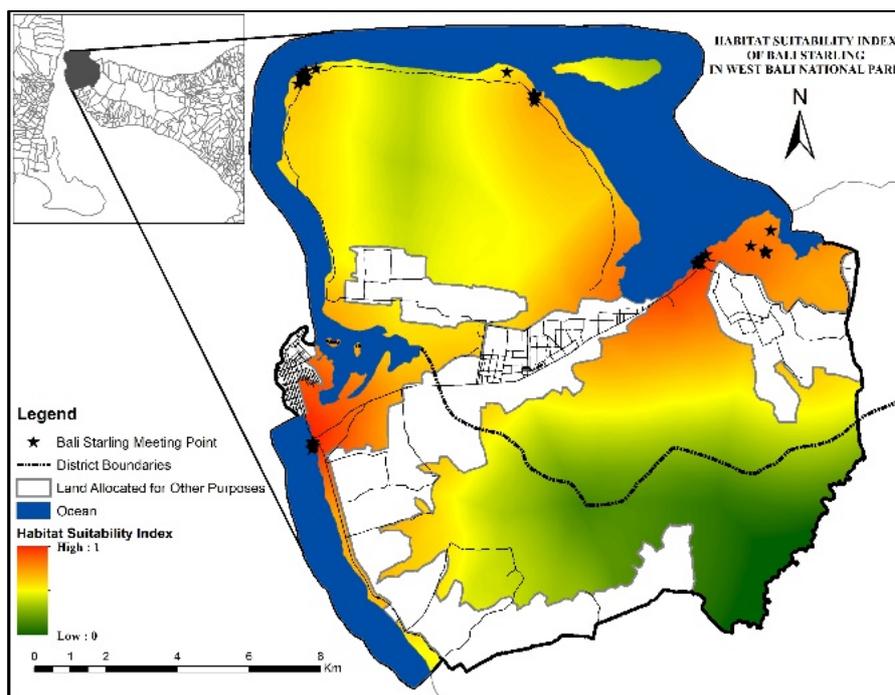
The influences variables for the first factor (PC<sub>1</sub>) were the distance variable, NVDI, surface temperature, density of feeding plant, density of cover plant, and mean patch edge. The influences variables for the second factor (PC<sub>2</sub>) were the distance from road, elevation of area, distance from nest box, and the distance from cage. The varimax rotation of loadings factor value obtained a PC<sub>1</sub> and PC<sub>2</sub> equation as follows:  $PC_1 = -0.902 (DV) + 0.854 (ND) - 0.918 (ST) + 0.915 (DFP) + 0.973 (DCP) - 0.966 (MPE)$ ;  $PC_2 = 0.927 (DR) + 0.907 (E) + 0.995 (DNB) + 0.993 (DC)$ . The linier regression analysis was carried out for the dependent variable with the highest meeting frequency of Bali starling (**Table 9**), which obtained equation model  $Y = 17.145 + 6.640 PC_1 - 4.055 PC_2$  ( $R^2 = 0.409$ ).

**Table 9.** Results of linear regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	17.14	0.67		25.76	0.00
PC_1	6.64	0.68	0.60	9.77	0.00
PC_2	-4.05	0.68	-0.37	-5.96	0.00

The low determination coefficient ( $R^2$ ) value indicated that other variables affect Bali starling in WBNP, which the selected variables could not explain. Based on distribution data, Bali starling exists at the specific location with high availability of basic needs provided by WBNP such as food, water, mating place, lure bird, and control of predator and competitor. Therefore, it leads to the concentration of Bali starling existence in the artificial treatments area. **Fig. 5** shows

the habitat suitability map of the Bali starling in WBNP based on the statistical analysis of selected variables.



**Fig. 5.** Habitat suitability index map of Bali starling in West Bali National Park.

The artificial condition created by WBNP authority seems to be a significant influence variable to the existence and distribution of Bali starling, which was not counted in the variables of the equation model. However, based on the validation test, the equation model was acceptable with the meeting point of the species was 100% located in the class area having a high suitability value. The meeting point of Bali starling in this research was 237, and all of them were located in an area with high suitability value. Therefore, it was indicated that the constructed model was acceptable. The artificial treatment created by the WBNP authority seems to be another significant factor influencing the existence and distribution of Bali starling in WBNP. Bali starling could move wider spread if the treatment stopped.

#### 4. Conclusions

The population of Bali starling in the WBNP tends to increase, mainly due to the reintroduction process. The age structure of young and mature birds was 2:5, and unmated mature birds dominated it. The regeneration of the species in the last six years was positively increased with an average birth and death rate of 48.86 and 20.14 individuals, respectively. The promising sustainable life of Bali starling in the wild habitat of WBNP was supported by the availability of suitable vegetation in the savanna and monsoon forests, and it was indicated by the habitat suitability map model which was dominated by suitable habitat for Bali starling life. The model was acceptable based on the validation test, although it can only explain the diversity as high as 40.9%. The artificial treatment created by the WBNP authority seems to be another significant factor influencing the existence and distribution of Bali starling in WBNP. Therefore, the WBNP authority should consider modifying the artificial treatment to recover the wild character of the Bali starling in WBNP.

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