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Full Length Research Article

Ecological Value of Bird Diversity in the Buffer City Area of Indonesia's New Capital, East Kalimantan

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ABSTRACT

The development of Indonesia's new capital will impact the lives of living things, including birds. This study aims to determine the bird species diversity in the buffer cities surrounding Indonesia's new capital area, specifically in Tenggarong, Samarinda, Balikpapan, and Penajam. Bird data were collected using the point count method. The results showed that the bird diversity index (H') in these cities falls within the medium category, with the highest value recorded in Tenggarong (H' = 2.23) and the lowest in Balikpapan (H' = 1.85). The most abundant species were *Hirundo tahitica* in Tenggarong (23.65%) and Balikpapan (23.65%), and *Passer montanus* in Samarinda (28.75%). In Penajam, both *P. montanus* and *Pycnonotus aurigaster* showed the highest relative abundance (21.9%). The evenness index ranged from 0.72 to 0.77 across the four cities, while species richness was categorized as medium in Tenggarong, Samarinda, and Penajam, but low in Balikpapan. Among the 34 bird species identified, 32 were classified as Least Concern (LC), one as Vulnerable (VU), and one as Endangered (EN) according to according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. To safeguard the survival of birds in buffer cities, especially those categorized as VU and EN, both the government and local communities must implement targeted conservation policies, preserve natural habitats, and promote sustainable ecological practices.

1. Introduction

Kalimantan Island, also known as Borneo, is the third largest island in the world (MacKinnon et al. 1996; Widians et al. 2018). This island comprises several countries, including Malaysia, Brunei Darussalam, and Indonesia (Shields 2022), with a large forest area (Siombo 2021) and high biodiversity. Indonesia, with the largest area on the island of Borneo, comprises five provinces: West Kalimantan, Central Kalimantan, South Kalimantan, North Kalimantan, and East Kalimantan (Wegscheider et al., 2018). In 2019, East Kalimantan was chosen as the New Capital of Indonesia to replace Jakarta, and the law was passed in 2022 (Octaleny 2022). East Kalimantan was officially chosen to construct the new Indonesian capital, which will later replace Jakarta (Van de Vuurst and Escobar 2020). Population density and efforts to promote better economic growth in Indonesia are the reasons for relocating the new capital city, known as *Ibu*

Kota Nusantara (IKN) (Ishenda and Guoqing 2019). The selection of East Kalimantan, specifically IKN, as the location for the construction of the new capital was based on several considerations, including large land, strategic location, low potential for social conflict, close to developing cities, minimal disasters (Hackbarth and de Vries 2021), meeting the security defense perimeter, and available carrying capacity of land and the availability of land and water support (Koldobskaya 2022).

The area of IKN is approximately 108,364.48 ha, comprising production forests, conservation forests, and protection forests, which means that development activities directly or inevitably impact the existing ecosystem (Mutaqin et al. 2021). Thus, the development of IKN can lead to changes in the ecosystem or environment that must be anticipated early (Turner et al. 2020). The construction of IKN with a very large area of coverage will reduce the habitat of living things. Cutting trees is an unavoidable activity in the construction of various government buildings and public facilities. Various types of existing ecosystems can undergo changes that will have a chain impact on the population of living things in the area around the construction of IKN, such as birds. The presence of buildings is an unsuitable place for most birds, making it difficult for them to find food and breed (Seress and Liker 2015). Previous research has shown that the loss or decrease in forest cover has a negative effect (decline) on the populations of forest specialist birds, frugivores, and insectivores (Morante-Filho et al. 2015). This animal is highly sensitive to environmental changes (Kumari et al. 2021; Morelli et al. 2021). Birds exhibit an avoidance response to human activity and have varying proximity tolerance distances to humans (Avenzora et al. 2024). Birds can be indicators of changes in a region's environmental conditions and biodiversity (Fraixedas et al. 2020; Härtel et al. 2023).

The development of IKN will impact the bird populations both within and around the designated area, including its buffer cities. The selection of East Kalimantan as the location for IKN has led to increased population growth (Shimamura and Mizunoya 2020). Consequently, intensified human activities are expected to alter environmental conditions and negatively affect bird populations (Schulze et al. 2019). Human activity has a significant impact on the behaviors of animals, particularly birds (Wilson et al., 2020). Human population growth, urbanization, traffic noise, and several other human activities have an impact on changes in bird populations (James Reynolds et al. 2019; Pena et al. 2017; Rashidi et al. 2019).

Despite the ecological importance of the region, studies on avifauna in East Kalimantan remain limited, although the area holds high biodiversity potential. Furthermore, with the development of the IKN, it is crucial to conduct further exploration. In previous research, Putera et al. (2018) examined bird diversity, composition, and abundance in the Kariangau industrial area of Balikpapan, reporting high species richness along rivers such as Wain, Somber, and Paka Dua. Putera et al. (2021) also identified various waterbird species in Balikpapan Bay, including the red egrets (*Ardea purpurea*), great egrets (*A. alba*), little egrets (*Egretta garzetta*), and tongtong storks (*Leptoptilos javanicus*). Isa et al. (2018) documented 63 wetland bird species from 28 families along the Suwi River, East Kutai. Furthermore, Mukhlisi et al. (2022) reported 67 bird species in karst hill forests and 33 in coastal karst areas of Berau, East Kalimantan.

Given the ecological significance and growing anthropogenic pressures, it is necessary to study the bird diversity in the IKN buffer zones, specifically in Tenggarong, Samarinda, Balikpapan, and Penajam. This study aims to contribute to baseline data on bird diversity in the IKN buffer zones, which is essential for monitoring population trends and informing conservation strategies in the context of rapid development.

2. Materials and Methods

2.1. Study Area

The research was conducted from May to September 2023, with research locations in the buffer cities of the new capital of Indonesia (IKN), including Tenggarong, Samarinda, Balikpapan, and Penajam (**Fig. 1**).

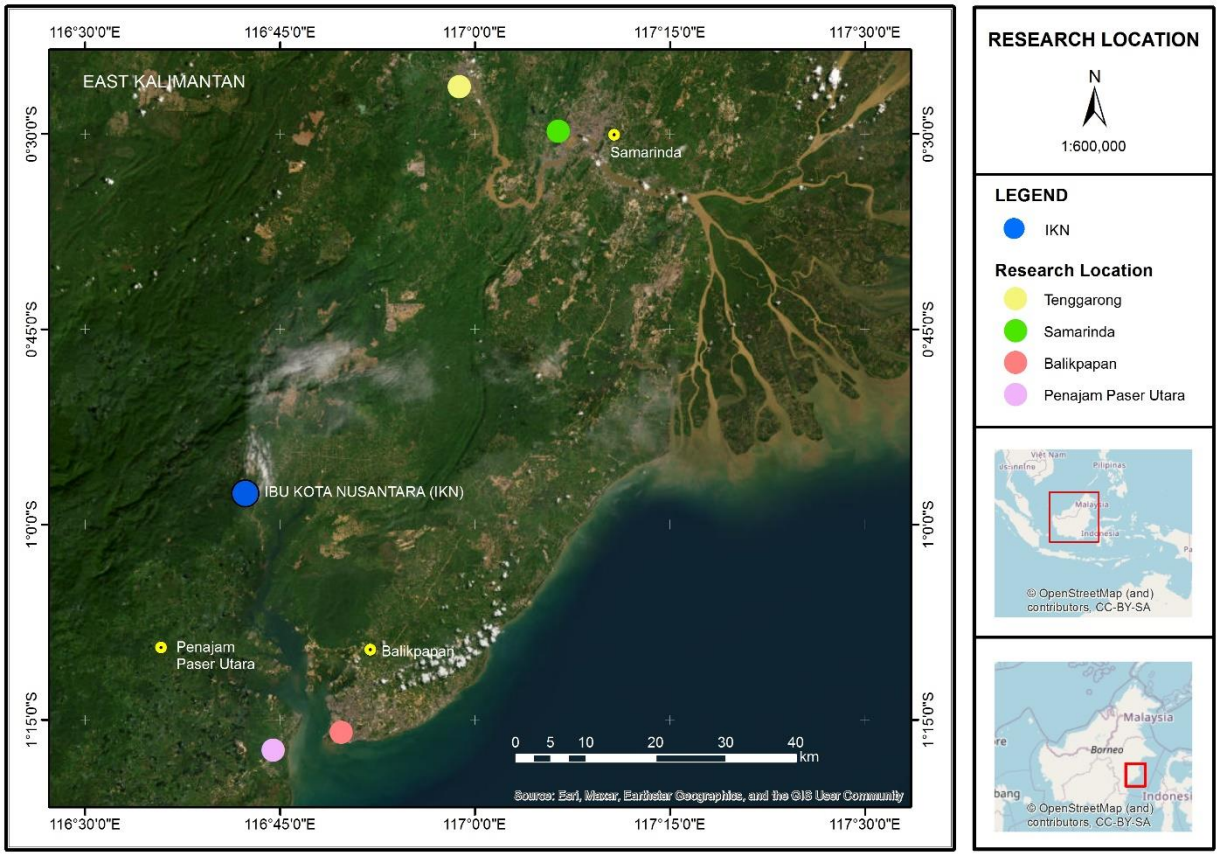

Fig. 1. Research location of bird diversity.

2.2. Procedures

At the specified observation point, bird species data are collected using the Point Count Method (Dröge et al. 2021; Fontúrbel et al. 2020). Each research location consists of 6 representative observation points (that have been previously observed), located in urban areas and still containing vegetation, with an observation period of 10 minutes (Ortega-Álvarez and MacGregor-Fors 2009; van Heezik and Seddon 2017). The distance between one observation point and the other is about 200 m, and the observation radius is 50 m (Maas et al. 2015). The bird observation time at 06.00–09.00 WITA and 15.00–18.00 WITA was adjusted to the time of the bird's highest activity. Furthermore, the birds are observed morphologically, noted, documented and identified using a bird identification book (MacKinnon et al. 2010).

2.3. Data Analysis

The bird data obtained were analyzed by species diversity index (H') (Zi-ling et al. 2021), as follows:

$$H' = -\Sigma Pi \ ln \ Pi \quad (1)$$

$$Pi= \quad ni/N \tag{2}$$

where H' is the diversity index, Pi is the proportion of types (obtained from the number of individuals of a particular type divided by the number of all individuals obtained in a location), ni is the number of individuals of a species, N is the number of individuals of all types (H'<1 = high diversity; 1<H'<3 = medium diversity; H'>3 = low diversity).

The relative abundance index was calculated by determining the proportion of individuals of a particular species relative to the total number of individuals observed (Issa 2019; Ullah et al. 2021), as follows:

$$Relative\ abundance\ index = \frac{ni}{N}\ x\ 100 \tag{3}$$

where ni is the Number of individuals of a species, and N is the Number of individuals of all types (>20% = high; 15-20% = medium; <15% = low).

Sorensen similarity index was calculated by comparing the number of shared species between two sites to the total number of species in both sites (Kucuk et al. 2017), as follows:

$$Sorensen\ Similarity\ Index = \frac{2C}{A+B} \tag{4}$$

where A is the species found only in habitat A, B is the species found only in habitat B, and C is the species found in habitats A and B.

The evenness index (E) was calculated by relating the Shannon-Wiener diversity index (H′) to the maximum possible diversity using the number of species (S) (Yelastri et al. 2023), as follows:

$$E = \frac{H'}{ln\ (S)} \tag{5}$$

where E is the evenness index, H' is the Shannon-Wiener Diversity Index, and S is the number of types found (E < 0.20 = low category/non-equal; 0.21 < E <1= high category/equal).

The richness index was calculated by applying the Margalef formula, which relates the number of species to the total number of individuals in a sample (Tu et al. 2020), as follows:

$$R = \frac{S\text{-}1}{ln\ N} \tag{6}$$

where R is the Richness Index, S is the Number of types found, and N is the number of individuals of all types (R < 2.5 = low category; 2.5 < R < 4 = medium category; R > 4 = high category).

Conservation status analysis based on the International Union for Conservation of Nature and Natural Resources (IUCN) (Duenas et al. 2021). Additionally, an analysis of the international trade status, based on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and regulations by the Indonesian government, was also conducted (Ministry of Environment).

3. Results and Discussion

3.1. Bird Species in IKN Buffer City

Various bird species have been successfully recorded and identified in the buffer cities of IKN. A total of 22, 20, 11, and 17 bird species were observed in Tenggarong, Samarinda, Balikpapan, and Penajam, respectively (**Table 1**). Tenggarong recorded the highest species richness, likely due to its geographic and ecological features. Situated along the Mahakam River,

the city is characterized by abundant riverside vegetation and proximity to forested areas. Additionally, Tenggarong is adjacent to Kumala Island, which formerly featured a bird cage tourist attraction, allowing for the observation of various bird species, including *Lonchura oryzivora*, a species endemic to Java whose wild population is in decline (Sophonrat et al., 2019). Notably, large bird species such as *Nisaetus cirrhatus* and *Ardea purpurea* were also recorded in Tenggarong. The presence of *A. purpurea*, a typical wetland bird, is consistent with the city's extensive wetland areas (Ionescu et al. 2020). Moreover, *N. cirrhatus* is known to prefer nesting in large, tall trees near water sources (Pande et al. 2018; Rodrigues et al. 2020), conditions that are still met in parts of Tenggarong and Kumala Island.

Table 1. Bird species found in research locations

No	Bird species	Common name	The buffer city of IKN			
			T	S	B	P
1	*Acridotheres javanicus*	Javan myna	√	√	√	√
2	*Anthreptes simplex*	Plain sunbird		√	-	√
3	*Aplonis panayensis*	Asian glossy starling	-	√	-	√
4	*Ardea purpurea*	Purple heron	√	-	-	-
5	*Ardeola speciosa*	Javan pond heron	-	√	-	√
6	*Collocalia vestita*	Swallow	√	√	-	-
7	*Columba livia*	Rock dove	√	-	√	-
8	*Copsychus saularis*	Oriental magpie-robin	-	√	-	-
9	*Coturnix chinensis*	Asian blue quail	√	-	-	-
10	*Cyornis superbus*	Bornean blue flycatcher	-	-	√	-
11	*Dendrocopos moluccensis*	Sunda pygmy woodpecker	√	√	-	-
12	*Dicaeum cruentatum*	Scarlet-backed flowerpecker	-	-	√	√
13	*Geopelia striata*	Zebra dove	√	√	√	√
14	*Hirundo tahitica*	Tahiti swallow	√	√	√	√
15	*Lanius cristatus*	Brown shrike	√	-	-	-
16	*Lanius schach*	Long-tailed shrike	√	-	-	-
17	*Lonchura atricapilla*	Chestnut munia	√	√	-	√
18	*Lonchura fuscans*	Dusky munia	√	√	√	√
19	*Lonchura pallida*	Pale-headed munia	-	√	-	-
20	*Lonchura punctulata*	Scaly-breasted munia	√	-	-	-
21	*Nisaetus cirrhatus*	Changeable hawk-eagle	√	-	-	-
22	*Oriolus chinensis*	Black-naped oriole	√	-	-	-
23	*Orthotomus ruficeps*	Ashy tailorbird	-	√	√	√
24	*Lonchura oryzivora*	Java sparrow	√	-	-	-
25	*Passer montanus*	Eurasian tree sparrow	√	√	√	√
26	*Pelargopsis capensis*	Stork-billed kingfisher	√	-	-	-
27	*Prinia familiaris*	Bar-winged prinia	√	√	-	-
28	*Prinia flaviventris*	Yellow-bellied prinia	-	-	√	√
29	*Prinia polychroa*	Brown prinia	-	-	-	√
30	*Prinia inornata*	Plain prinia	-	√	-	√
31	*Pycnonotus aurigaster*	Sooty-headed bulbul	√	√	√	√
32	*Rhipidura javanica*	Sunda pied fantail	√	√	-	√
33	*Todiramphus chloris*	Collared kingfisher	√	√	-	√
34	*Todirhamphus sanctus*	Sacred kingfisher	-	√	-	-
Total			**22**	**20**	**11**	**17**

Notes: T= Tenggarong, S= Samarinda, B= Balikpapan, and P= Penajam.

Furthermore, in Samarinda, a migratory bird species, *Todirhamphus sanctus*, was recorded (Andersen et al. 2015). This species migrates from Australia to various regions to avoid winter-

related stress (O'Connell et al. 2019). It primarily feeds on insects, shrimp, and frogs (Erastova and Stanley 2020) and is typically found near water sources where such prey is abundant. Additionally, two bird species observed exclusively in Samarinda were *Copsychus saularis* and *Lonchura pallida*. While *C. saularis* was observed in low numbers, *L. pallida* was frequently encountered in colonies of 6–10 individuals nesting in palm trees. Notably, *Copsychus sechellarum*, a related species, is commonly traded by bird sellers in Samarinda and widely kept by locals, which may contribute to its presence in the area. In particular, *L. pallida* was frequently found nesting in palm trees around the Islamic Center Mosque in Samarinda. These palm trees are commonly distributed in Samarinda but not in other buffer cities, possibly explaining the species' site specificity.

Balikpapan recorded the lowest number of bird species among all study locations. As a coastal city with limited vegetation, significant urban development, and relatively high population density, Balikpapan provides fewer suitable habitats for birds. Consequently, many species tend to avoid the area in favor of environments with better ecological conditions. As the primary gateway to the IKN (Fajri 2023), Balikpapan experiences intense human activity. A unique species recorded only in Balikpapan was *Cyornis superbus*, an endemic species of Borneo, which includes parts of Indonesia, Malaysia, and Brunei Darussalam (Eaton et al. 2016).

In Penajam, another unique species, *Prinia polychroa*, was observed. This species is distributed across Southeast Asia, including Myanmar, Vietnam, and Indonesia (Alström et al., 2020), and is typically found in forests, shrublands, and grasslands (IUCN, 2024). Several types of birds were found at all research locations, namely *Acridotheres javanicus*, *Geopelia striata*, *Hirundo tahitica*, *Lonchura fuscans*, *Passer montanus*, and *Pycnonotus aurigaster*. It is known that the populations of these birds are quite commonly found in East Kalimantan. Some species have the characteristic of being able to interact closely with humans and are omnivores, which enables them to adapt well to the increasingly dense urban environment. Meanwhile, some birds are only found in certain locations, namely *Ardea purpurea*, *Copsychus saularis*, *Coturnix chinesis*, *Lanius cristatus*, *Lanius schach*, *Lonchura pallida*, *Lonchura punctulata*, *Nisaetus cirrhatus*, *Oriolus chinesis*, *Lonchura oryzivora*, *Pelargopsis capensis*, *Prinia polychroa*, and *Todirhamphus sanctus*. This is possible because of the different habitat characteristics at each research location, so not all bird species can adapt, breed, build nests, and find food in those habitats.

3.2. Bird Diversity Index (Shannon-Wiener) in IKN Buffer City

The result of the bird diversity index in Tenggaraong is 2.23, meaning that the category is medium (**Table 2**). The results indicate that the number of species found is quite diverse. The environment is in a relatively stable condition. However, there is potential for ecological pressure, including habitat fragmentation or human disturbance, as the buffer city area develops, which has already been observed. For high relative abundance index species, *Hirundo tahitica* has a value of 20.51%, and *Passer montanus* has a value of 20.05%. It can be said that the relative abundance of two species of such birds falls into the high category. *Hirundo tahitica* can construct nests in various locations, including cliffs and human-built structures (Hasegawa and Arai 2022), while *P. montanus* has good adaptability (Li et al. 2022), including in urbanized areas, so it is reasonable to include the population in the high category.

Table 2. Bird diversity index analysis and relative abundance index of Tenggarong

No	Bird species	Common name	Amount	Pi	lnPi	PilnPi	RAI (%)
1	*Acridotheres javanicus*	Javan myna	58	0.13	-2.01	-0.27	13.36
2	*Ardea purpurea*	Purple heron	1	0.00	-6.07	-0.01	0.23
3	*Collocalia vestita*	Swallow	15	0.03	-3.36	-0.12	3.46
4	*Columba livia*	Rock dove	4	0.01	-4.69	-0.04	0.92
5	*Coturnix chinensis*	Asian blue quail	8	0.02	-3.99	-0.07	1.84
6	*Dendrocopos moluccensis*	Sunda pygmy woodpecker	6	0.01	-4.28	-0.06	1.38
7	*Geopelia striata*	Zebra dove	14	0.03	-3.43	-0.11	3.23
8	*Hirundo tahitica*	Tahiti swallow	89	0.21	-1.58	-0.32	20.51
9	*Lanius cristatus*	Brown shrike	1	0.00	-6.07	-0.01	0.23
10	*Lanius schach*	Long-tailed shrike	2	0.00	-5.38	-0.02	0.46
11	*Lonchura atricapilla*	Chestnut munia	86	0.20	-1.62	-0.32	19.82
12	*Lonchura fuscans*	Dusky munia	17	0.04	-3.24	-0.13	3.92
13	*Lonchura oryzivora*	Java sparrow	2	0.00	-5.38	-0.02	0.46
14	*Lonchura punctulata*	Scaly-breasted munia	8	0.02	-3.99	-0.07	1.84
15	*Nisaetus cirrhatus*	Changeable hawk-eagle	3	0.01	-4.97	-0.03	0.69
16	*Oriolus chinensis*	Black-naped oriole	1	0.00	-6.07	-0.01	0.23
17	*Passer montanus*	Eurasian tree sparrow	87	0.20	-1.61	-0.32	20.05
18	*Pelargopsis capensis*	Stork-billed kingfisher	1	0.00	-6.07	-0.01	0.23
19	*Prinia familiaris*	Bar-winged prinia	6	0.01	-4.28	-0.06	1.38
20	*Pycnonotus aurigaster*	Sooty-headed bulbul	22	0.05	-2.98	-0.15	5.07
21	*Rhipidura javanica*	Sunda pied fantail	2	0.00	-5.38	-0.02	0.46
22	*Todiramphus chloris*	Sacred kingfisher	1	0.00	-6.07	-0.01	0.23
Total			**434**		**H'**	**2.23**	

Note: RAI = Relative Abundance Index.

The value of the diversity index and the relative abundance of birds in Samarinda are presented in **Table 3**. The diversity index value of 2.21 indicates that the bird diversity in Samarinda is moderate. The results indicate that the number of species found is quite diverse, and the environment is relatively stable. Some vegetation still appears to be quite abundant in this city. As for the index value of the relative abundance of high species, namely *P. montanus* by 28.7% and *Pycnonotus aurigaster* by 22.68%. This is possible because *P. montanus* and *P. aurigaster* are quite adaptable to their environment (Kurnia et al. 2021; Zheng et al. 2014), and the City of Samarinda provides them with adequate food for their survival. This is supported by the numerous bird species observed during the study.

Table 3. Bird diversity index analysis and relative abundance index of Samarinda

No	Bird species	Common name	Amount	Pi	lnPi	PilnPi	RAI (%)
1	*Acridotheres javanicus*	Javan myna	8	0.03	-3.67	0.09	2.56
2	*Anthreptes simplex*	Plain sunbird	3	0.01	-4.65	0.04	0.96
3	*Aplonis panayensis*	Asian glossy	13	0.04	-3.18	0.13	4.15
4	*Ardeola speciosa*	Javan pond heron	1	0.00	-5.75	0.02	0.32
5	*Collocalia vestita*	Swallow	25	0.08	-2.53	0.20	7.99
6	*Copsychus saularis*	Oriental magpie-robin	1	0.00	-5.75	0.02	0.32

No	Bird species	Common name	Amount	Pi	lnPi	PilnPi	RAI (%)
7	*Dendrocopos moluccensis*	Sunda pygmy woodpecker	6	0.02	-3.95	0.08	1.92
8	*Geopelia striata*	Zebra dove	7	0.02	-3.80	0.08	2.24
9	*Hirundo tahitica*	Tahiti swallow	38	0.12	-2.11	0.26	12.14
10	*Lonchura fuscans*	Dusky munia	19	0.06	-2.80	0.17	6.07
11	*Lonchura pallida*	Pale-headed munia	8	0.03	-3.67	0.09	2.56
12	*Orthotomus ruficeps*	Ashy tailorbird	3	0.01	-4.65	0.04	0.96
13	*Passer montanus*	Eurasian tree sparrow	90	0.29	-1.25	0.36	28.75
14	*Prinia familiaris*	Bar-winged prinia	4	0.01	-4.36	0.06	1.28
15	*Prinia inornata*	Plain prinia	5	0.02	-4.14	0.07	1.60
16	*Pycnonotus aurigaster*	Sooty-headed bulbul	71	0.23	-1.48	0.34	22.68
17	*Rhipidura javanica*	Sunda pied fantail	6	0.02	-3.95	0.08	1.92
18	*Todiramphus chloris*	Sacred kingfisher	1	0.00	-5.75	0.02	0.32
19	*Lanius cristatus*	Brown shrike	3	0.01	-4.65	0.04	0.96
20	*Todirhamphus sanctus*	Sacred kingfisher	1	0.00	-5.75	0.02	0.32
Total			**313**		**H'**	**2.21**	

Note: RAI = relative abundance index.

Balikpapan has the smallest diversity index value among other IKN buffer cities, at 1.85 (**Table 4**). However, the value of the diversity index is still in the medium category. The diverse bird population and vegetation along the coastline and in the urban center have helped maintain relatively stable environmental conditions. However, this city has become a buffer city that serves as the main gateway to the Capital Region, making it the busiest area and having a significant potential for ecological pressure. In this city, the species with a relatively high prosperity index are *H. tahitica* at 23.65% and *P. montanus* at 21.62%. This is similar to the City of Tenggarong, where the diversity index of *H. Tahitica* and *P. Montanus* is the highest.

Table 4. Bird diversity index analysis and relative abundance index of Balikpapan

No	Bird Species	Common Name	Amount	Pi	lnPi	PilnPi	RAI (%)
1	*Acridotheres javanicus*	Javan myna	12	0.04	-3.21	0.13	4.05
2	*Columba livia*	Rock dove	36	0.12	-2.11	0.26	12.16
3	*Cyornis superbus*	Bornean blue flycatcher	1	0.00	-5.69	0.02	0.34
4	*Dicaeum cruentatum*	Scarlet-backed	1	0.00	-5.69	0.02	0.34
5	*Geopelia striata*	Zebra dove	3	0.01	-4.59	0.05	1.01
6	*Hirundo tahitica*	Tahiti swallow	70	0.24	-1.44	0.34	23.65
7	*Lonchura fuscans*	Dusky munia	55	0.19	-1.68	0.31	18.58
8	*Orthotomus ruficeps*	Ashy tailorbird	7	0.02	-3.74	0.09	2.36
9	*Passer montanus*	Eurasian tree sparrow	64	0.22	-1.53	0.33	21.62
10	*Prinia flaviventris*	Yellow-bellied prinia	1	0.00	-5.69	0.02	0.34
11	*Pycnonotus aurigaster*	Sooty-headed bulbul	46	0.16	-1.86	0.29	15.54
Total			**296**		**H'**	**1.85**	

Note: RAI = relative abundance index.

The results of the analysis of the value of the diversity index and the relative abundance index in Penajam (**Table 5)**. The table indicates that the value of the bird diversity index in Penajam is 2.08, indicating it falls within the medium category. The results also show that the number of species found is quite diverse. The environment or habitat still has much vegetation, supporting various birds in finding food and breeding well (Iswandaru and Rohman 2023). The relative abundance index value of species in this city indicates that three bird species are in the highest category, namely *H. tahitica* (20.23%), *P. montanus* (21.39%), and *P. aurigaster* (21.39%). Those three birds are known to be found in other cities, where they are taller than other birds.

Table 5. Results of the diversity index analysis and the relative abundance index of Penajam

No	Bird Species	Common Name	Amount	Pi	lnPi	PilnPi	RAI (%)
1	*Acridotheres javanicus*	Javan myna	21	0.06	-2.80	0.17	6.07
2	*Anthreptes simplex*	Plain sunbird	1	0.00	-5.85	0.02	0.29
3	*Aplonis panayensis*	Asian glossy starling	49	0.14	-1.95	0.28	14.16
4	*Ardeola speciosa*	Javan pond heron	1	0.00	-5.85	0.02	0.29
5	*Dicaeum cruentatum*	Scarlet-backed Flowerpecker	7	0.02	-3.90	0.08	2.02
6	*Geopelia striata*	Zebra dove	3	0.01	-4.75	0.04	0.87
7	*Hirundo tahitica*	Tahiti swallow	70	0.20	-1.60	0.32	20.23
8	*Lanius cristatus*	Brown shrike	8	0.02	-3.77	0.09	2.31
9	*Lonchura fuscans*	Dusky munia	17	0.05	-3.01	0.15	4.91
10	*Orthotomus ruficeps*	Ashy tailorbird	1	0.00	-5.85	0.02	0.29
11	*Passer montanus*	Eurasian tree sparrow	74	0.21	-1.54	0.33	21.39
12	*Prinia flaviventris*	Yellow-bellied Prinia	4	0.01	-4.46	0.05	1.16
13	*Prinia polychroa*	Brown prinia	4	0.01	-4.46	0.05	1.16
14	*Prinia inornata*	Plain prinia	8	0.02	-3.77	0.09	2.31
15	*Pycnonotus aurigaster*	Sooty-headed Bulbul	74	0.21	-1.54	0.33	21.39
16	*Rhipidura javanica*	Sunda pied fantail	3	0.01	-4.75	0.04	0.87
17	*Todiramphus chloris*	Collared kingfisher	1	0.00	-5.85	0.02	0.29
	Total		**346**		**H'**	**2.08**	

Note: RAI = relative abundance index.

3.3. Sorensen Similarity Index

Calculating the values of the bird similarity index in the four cities that became the study's locations, it is evident that the cities of Samarinda and Penajam have the highest index of species similarity, at 0.76 out of 0–1 (**Table 6**). The results indicate that both locations have a relatively high level of species similarity or a similar community structure. The lowest value in the species' similarity index is the city of Tenggarong, followed by Balikpapan. Balikpapan has habitat conditions near the coast, little vegetation, and high human activity. It is very different from Tenggarong, where conditions are characterized by the banks of rivers, abundant vegetation, and minimal human activity. Of course, these conditions influence the birds living in these cities. Meanwhile, the similarity index value approaching 0.5 indicates that the level of bird species similarity between the two locations is moderate, where half of the species found are of the same type (Samarinda-Tenggarong; Balikpapan-Penajam).

Table 6. Sorensen similarity index

No	Location	Tenggarong	Samarinda	Balikpapan	Penajam
1	Tenggarong	-			
2	Samarinda	0.57	-		
3	Balikpapan	0.24	0.45	-	
4	Penajam	0.41	0.76	0.57	-

3.4. Evenness Index and Richness Index

The evenness index of the type based on the number of individuals successfully counted in four buffer cities has a value of 0.72–0.77 (**Fig. 2**). This value indicates that each city has an evenness index that falls within the equitable category, ensuring that no species dominates excessively and thereby maintaining relative diversity. The habitat currently in every buffer city can still provide supportive factors for the life of several types of birds. In terms of the richness index, Balikpapan exhibits a low richness index of 1.76, which falls below the threshold of 2.5. The other three cities have a richness index of 2.74–3.46, indicating a medium level of richness. Balikpapan has the fewest bird species compared to any other city.

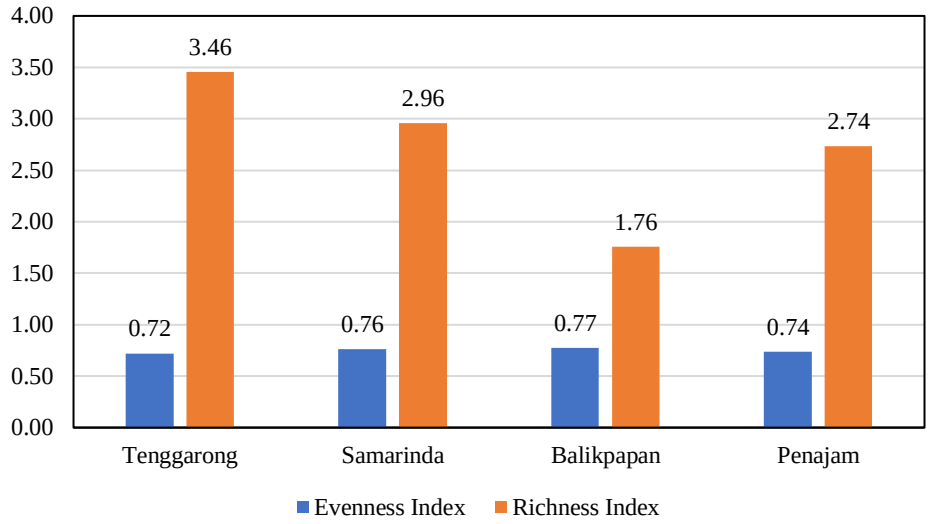

Fig 2. Evenness index and richness index.

3.5. Conservation Status

Various species of birds have been classified according to their conservation status by the International Union for Conservation of Nature and Natural Resources (IUCN) (Luther et al. 2016; McClure and Rolek 2020), a recognized authority on the conservation of global species. The conservation status of a species is crucial for maintaining the sustainability of every species in the world. **Table 7** shows that out of 34 bird species obtained from all locations, 32 species of birds had a Least Concern (LC) status, one species, *Acridotheres javanicus*, had a Vulnerable (VU) status, and one species, *Lonchura oryzivora*, had an Endangered (EN) status. A bird of the LC category means that the number of populations in the environment is still safe and at minimal risk of extinction. Meanwhile, birds that fall into the VU and EN categories require serious attention from related parties, including both the community and the government, to mitigate the threat of extinction.

Table 7. Status of bird conservation

No	Bird Species	Common Name	Conservation status		
			IUCN	CITES	P 108/2018
1	*Acridotheres javanicus*	Javan myna	VU	-	-
2	*Anthreptes simplex*	Plain sunbird	LC	-	-
3	*Aplonis panayensis*	Asian glossy	LC	-	-
4	*Ardea purpurea*	Purple heron	LC	-	-
5	*Ardeola speciosa*	Javan pond heron	LC	-	-
6	*Collocalia vestita*	Swallow	LC	-	-
7	*Columba livia*	Rock dove	LC	-	-
8	*Copsychus saularis*	Oriental magpie-robin	LC	-	-
9	*Coturnix chinensis*	Asian blue quail	LC	-	-
10	*Cyornis superbus*	Bornean blue flycatcher	LC	-	-
11	*Dendrocopos moluccensis*	Sunda pygmy woodpecker	LC	-	-
12	*Dicaeum cruentatum*	Scarlet-backed flowerpecker	LC	-	-
13	*Geopelia striata*	Zebra dove	LC	-	-
14	*Hirundo tahitica*	Tahiti swallow	LC	-	-
15	*Lanius cristatus*	Brown shrike	LC	-	-
16	*Lanius schach*	Long-tailed shrike	LC	-	-
17	*Lonchura atricapilla*	Chestnut munia	LC	-	-
18	*Lonchura fuscans*	Dusky munia	LC	-	-
19	*Lonchura oryzivora*	Java sparrow	EN	App II	Protected
20	*Lonchura pallida*	Pale-headed munia	LC	-	-
21	*Lonchura punctulata*	Scaly-breasted munia	LC	-	-
22	*Nisaetus cirrhatus*	Changeable hawk-eagle	LC	App II	Protected
23	*Oriolus chinensis*	Black-naped oriole	LC	-	-
24	*Orthotomus ruficeps*	Ashy tailorbird	LC	-	-
25	*Passer montanus*	Eurasian tree sparrow	LC	-	-
26	*Pelargopsis capensis*	Stork-billed kingfisher	LC	-	-
27	*Prinia familiaris*	Bar-winged prinia	LC	-	-
28	*Prinia flaviventris*	Yellow-bellied prinia	LC	-	-
29	*Prinia polychroa*	Brown prinia	LC	-	-
30	*Prinia inornata*	Plain prinia	LC	-	-
31	*Pycnonotus aurigaster*	Sooty-headed bulbul	LC	-	-
32	*Rhipidura javanica*	Sunda pied fantail	LC	-	Protected
33	*Todiramphus chloris*	Collared kingfisher	LC	-	-
34	*Todirhamphus sanctus*	Sacred kingfisher	LC	-	-

In addition, a review of international trade under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) shows that of the 34 known bird species, two species are listed in Appendix II, namely *Nisaetus cirrhatus* and *Lonchura oryzivora* (CITES 2024). The position of the two birds in Appendix II indicates that their existence in trade requires regulation and policy to avoid extinction for birds that fall into the category protected under Indonesian Regulation (Ministerial Regulation No. P.106/MENLHK/SETJEN/KUM.1/12/2018), there are three species, namely *N. cirrhatus*, *Lonchura oryzivora* and *Rhipidura javanica*.

Based on the results obtained, attention from the community and the government is necessary to ensure the survival of birds in the capital's buffer city, preventing their extinction. Conservation education for the community, combined with strict policies, is expected to be effectively implemented, ensuring the preservation of the bird population amidst various threats.

4. Conclusions

The conclusion is that the diversity of birds found in the buffer cities of Indonesia's new capital (IKN), including Tenggarong, Samarinda, Balikpapan, and Penajam, as measured by the Shannon-Wiener index, falls within the medium category. The highest diversity index is Tengarong at 2.23, and the lowest is Balikpapan at 1.85. The conservation status of 34 bird species, as determined by the International Union for Conservation of Nature and Natural Resources (IUCN), is as follows: 32 with Least Concern (LC) status, 1 with Vulnerable (VU) status, and 1 with Endangered (EN) status. Additionally, there are two birds classified under Appendix II and three birds listed as protected status according to the regulations of the Minister of Environment. The continuously developing and changing condition of the buffer city will significantly impact the bird population. Birds that can adapt will survive, while those that cannot will be displaced, move elsewhere, or even become extinct. Therefore, these birds need regular attention and monitoring to ensure their continued existence.

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Author Contributions

All authors contributed equally and complementarily, including conceptualization, methodology, data collection, data analysis, writing and project administration.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation

During the preparation of this work, the authors utilized Quilbot to assist with translating the manuscript, aiming to improve its grammatical structure and enhance readability. Then, the translation results are cross-checked and edited to ensure they align with the actual data intent.

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