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Waterbird Diversity as an Indicator of Ecosystem Sustainability in Kuala Bubon Mangrove Forest Indonesia

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Abstrak: Ekosistem mangrove Kuala Bubon di Aceh Barat berfungsi sebagai habitat penting bagi berbagai spesies burung air yang sangat peka terhadap perubahan lingkungan, sehingga dapat dijadikan sebagai indikator yang andal untuk menilai keberlanjutan ekosistem. Penelitian ini bertujuan untuk mengkaji keanekaragaman burung air dan mengidentifikasi spesies dominan sebagai dasar evaluasi kondisi ekologis mangrove. Pengamatan dilakukan pada enam titik menggunakan metode point count dan transek garis selama bulan Juli–Agustus 2024. Tercatat sebanyak 13 spesies yang tergolong ke dalam tujuh famili, dengan nilai indeks keanekaragaman Shannon–Wiener sebesar H′ = 2.22 yang menunjukkan tingkat keanekaragaman sedang. *Egretta garzetta* merupakan spesies paling dominan, diikuti oleh *Hirundo rustica* dan *Actitis hypoleucos*, yang mencerminkan peran ekosistem mangrove sebagai kawasan penyedia pakan yang produktif. Keberadaan spesies predator dan burung migran juga mengindikasikan berfungsinya jaring-jaring makanan serta proses ekologi yang sehat. Namun demikian, tekanan antropogenik seperti alih fungsi lahan, pencemaran, dan aktivitas penangkapan ikan berpotensi mengancam kualitas habitat. Temuan ini menegaskan pentingnya pengelolaan dan upaya konservasi mangrove secara berkelanjutan guna menjaga stabilitas ekosistem dan mempertahankan keanekaragaman burung air di masa mendatang.
Kata kunci: Analisis; ekosistem; indikator; keanekaragaman burung air; keberlanjutan.

Abstract: The Kuala Bubon mangrove ecosystem in West Aceh serves as an important habitat for various waterbird species that are highly sensitive to environmental changes, making them reliable indicators of ecosystem sustainability. This study aims to assess waterbird diversity and identify dominant species as a basis for evaluating the ecological condition of the mangroves. Observations were conducted at six points using point count and transect line methods during July–August 2023. Thirteen species from seven families were recorded, with a Shannon-Wiener diversity index of H′=2.22, indicating moderate diversity. Egretta garzetta was the most dominant species, followed by Hirundo rustica and Actitis hypoleucos, reflecting the role of the mangrove as a productive feeding ground. The presence of predators and migratory species further signals a functioning food web and healthy ecological processes. However, anthropogenic pressures such as land conversion,

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pollution, and fishing activities may threaten habitat quality. These findings highlight the need for sustainable mangrove management and conservation efforts to maintain ecosystem stability and preserve waterbird diversity in the future.
Keyword: Analysis; ecosystem; indicator; sustainability; waterbird diversity.

1. Introduction

The Kuala Bubon mangrove forest in Aceh Barat is one of the important ecosystems located along the western coast of Aceh Province, Indonesia, with substantial ecological and economic potential [1]. This ecosystem plays a crucial role as a natural barrier against abrasion and high waves, as well as a habitat and nutrient provider for various organisms that inhabit it [2], [3]. In addition, mangroves function as spawning grounds, feeding areas, and shelter for a variety of aquatic biota and terrestrial fauna [4], [5].

One of the faunal groups that heavily depend on the Kuala Bubon mangrove ecosystem is waterbirds [6], [7]. Waterbirds utilize this ecosystem as feeding grounds, nesting areas, roosting sites, and breeding habitats. The presence and activities of waterbirds in a particular area can serve as indicators of ecosystem sustainability, as they are highly sensitive to changes in environmental quality [8], [9], [10]. When ecosystem conditions decline such as due to pollution, reduced mangrove cover, or decreased food availability, it can lead to a reduction in both the abundance and diversity of waterbird species.

The presence of waterbirds in this ecosystem indicates adequate habitat support, both as a source of food and as a suitable place for breeding. However, concerns regarding the sustainability of this ecosystem have emerged due to increasing human activities occurring within the mangrove area, such as mangrove logging, coastal land-use change, fishing activities, and domestic waste discharged from nearby settlements [11].

Despite the ecological importance of waterbirds, studies investigating waterbird diversity in Indonesian mangrove ecosystems have predominantly focused on species inventories, habitat descriptions, or ecotourism potential in regions outside Aceh. In Aceh, existing studies have mainly documented bird distribution and spatial mapping, while comprehensive ecological assessments

using waterbird diversity as an indicator of mangrove ecosystem sustainability remain scarce [12], [13]. Specifically, no previous study has comprehensively evaluated the diversity, community structure, and species dominance of waterbirds in the Kuala Bubon Mangrove Forest to assess ecosystem sustainability. Therefore, this study addresses this knowledge gap by providing updated information on waterbird diversity and evaluating its potential as a biological indicator of ecosystem sustainability in one of the most important mangrove ecosystems along the west coast of Aceh.

Analyzing waterbird diversity is crucial for evaluating the sustainability status of the Kuala Bubon mangrove ecosystem. Information on species richness, population abundance, and distribution patterns of waterbirds provides a comprehensive picture of the ecological condition of the area. The findings of such assessments can serve as a foundation for developing conservation strategies, management plans, and sustainable utilization of mangroves to maintain their ecological functions and economic benefits for coastal communities.

2. Research Method

This study was conducted in the Kuala Bubon Mangrove Forest area, located in Samatiga District, Aceh Barat Regency, Indonesia, during July–August 2024. A quantitative descriptive approach was employed to calculate the level of waterbird diversity as an indicator of the sustainability condition of the mangrove ecosystem. Field observations were carried out at six observation points selected purposively to represent different mangrove habitat conditions. Surveys were conducted twice daily, in the morning (06:00–09:00 WIB) and afternoon (16:00–18:00 WIB), corresponding to the peak activity periods of waterbirds. At each observation point, observations were conducted using a combination of the point count and line transect methods [14], [15], [16]. The coordinates of each observation point were recorded using a handheld Global Positioning System (GPS). Observations included bird

species, the number of individuals, and habitat characteristics, particularly the type of aquatic substrate supporting waterbird occurrence in the study area.

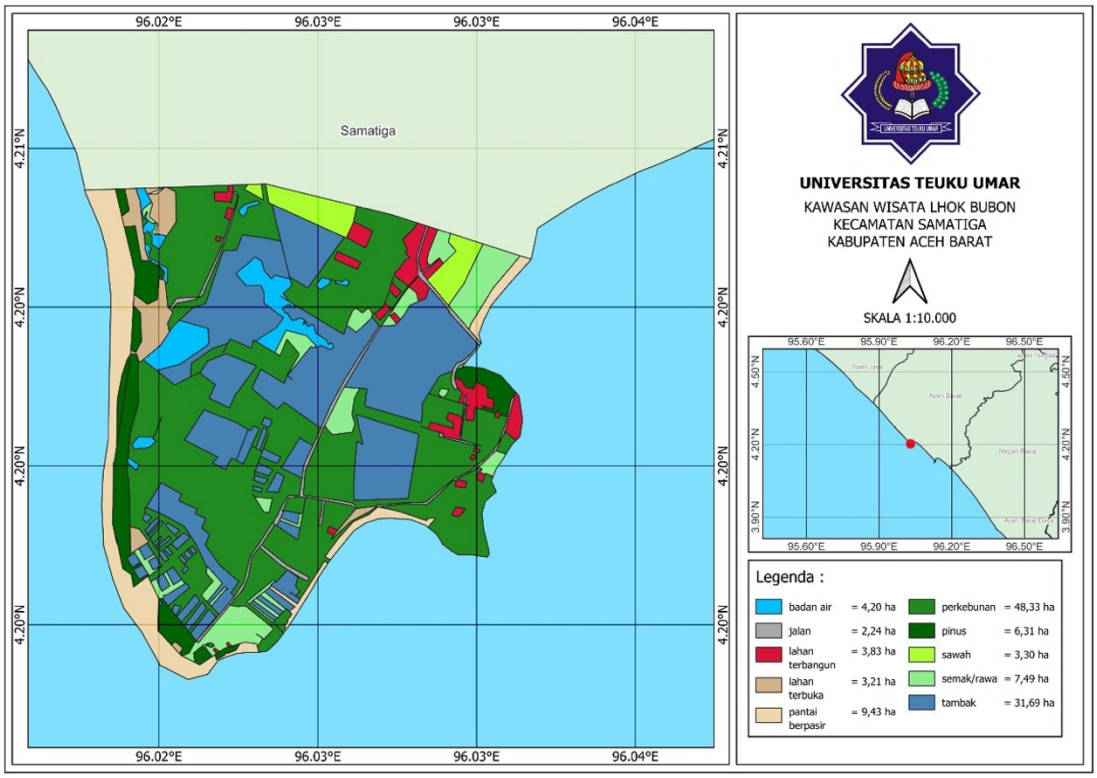


Figure 1. Kuala Bubon Mangrove Forest, Aceh Barat, Indonesia

Waterbird species were identified through direct visual observation using binoculars and photographic documentation. Species identification followed the field guide Birds of the Indonesian Archipelago: Greater Sundas and Wallacea, while scientific names and taxonomic classifications were verified using the latest IOC World Bird List to ensure taxonomic consistency. The recorded species were subsequently compiled in a table containing their local names, scientific names, families, number of individuals, and conservation status. The diversity data were analyzed quantitatively using the Shannon–Wiener Diversity Index (H′) [17], [18], [19]. Species dominance was assessed using the Relative Abundance (RA) index, which expresses the proportion of individuals of each species relative to the total number of individuals recorded during the survey [18].

$$\text{RA } (\%) = \frac{ni}{N} \text{ x } 100$$

ni = number of individuals of species *i*
N = total number of individuals recorded.

3. Results and Discussion

Community Structure and Diversity Values

Waterbird observations in the Kuala Bubon Mangrove area were conducted at six observation points, with two observation periods each day-morning and afternoon. These observations successfully documented various species of waterbirds inhabiting the mangrove ecosystem, including both resident species and migratory species that use the area as feeding grounds or seasonal stopover sites. The following are the images documented during the study.



Pelargopsis capensis *Todiramphus chloris* *Egretta garzetta*

Hirundo tahitica *Ardea sumatrana* *Actitis hypoleucos*

Figure 2. Research Documentation

The recorded data include the identified bird species, the number of observed individuals, and their status within the area. This information serves as the basis for assessing the waterbird community structure and its ecological relationship with the mangrove habitat conditions in Kuala Bubon. The families, local names, scientific names, conservation status based on the IUCN Red List of Threatened Species (2016), along with the diversity index of

waterbirds in the Kuala Bubon mangrove forest, Aceh Barat, are presented in the following table.

Table 1. Waterbird diversity and abundance in the Kuala Bubon Mangrove Ecosystem.

Family	No.	Species	Local Name	Number of Species at Each Station						∑	S
				1	2	3	4	5	6		
Accipitridae	1	*Pandion haliaetus*	Elang tiram	1	-	1	-	-	-	2	LC
	2	*Haliaeetus leucogaster*	Elang laut dada putih	-	1	-	1	-	-	1	LC
	3	*Haliastur indus*	Elang bondol	-	1	2	-	1	-	4	LC
Alcedinidae	4	*Todiramphus chloris*	Cekakak Sungai	2	1	5	4	-	5	17	LC
	5	*Pelargopsis capensis*	Burung pekaka emas	-	4	1	2	3	3	13	LC
Ardeidae	6	*Ardea sumatrana*	Cangak laut	2	1	-	2	2	-	7	LC
	7	*Egretta garzetta*	Kuntul kecil	14	33	4	-	-	19	70	LC
	8	*Egretta alba*	Kuntul besar	7	19	-	-	-	-	26	LC
Coraciidae	9	*Hirundo rustica*	Layang-layang	6	7	12	3	-	18	46	LC
	10	*Hirundo tahitica*	Layang batu	10	9	-	8	6	-	33	LC
Laridae	11	*Chroicocephalus ridibundus*	Camar kepala hitam	3	23	6	-	-	4	36	LC
Meropidae	12	*Merops philippinus*	Kirik-kirik laut	4	2	2	-	-	2	10	LC
Scolopacidae	13	*Actitis hypoleucos*	Kedidi	5	14	6	10	-	-	35	LC
Total				54	115	39	30	12	51	301	
$H' = -\sum pi \ln pi$							2.22				

S = Conservation status based on the IUCN Red List of Threatened Species (2016)
LC = Least Concern
NT = Near Threatened
Vc = Vulnerable under

The results of the study show that the Kuala Bubon mangrove ecosystem is inhabited by 13 species of waterbirds belonging to 7 families. The Shannon-Wiener diversity index obtained was H′ = 2.22, indicating a moderate level of species diversity [20], [21]. This suggests that the mangrove ecosystem is still sufficiently supportive of waterbird life; however, the distribution of individuals among species is not yet even, indicating dominance by certain species [22], [23].

Species Relative Abundance Analysis

Species dominance is an important factor in assessing the stability and ecological characteristics of a habitat. Therefore, an analysis of individual abundance was conducted to identify the species that contribute most to the total population [24], as well as to understand the implications of these dominance patterns for resource availability and the functional roles within the Kuala Bubon area.

Based on the Relative Abundance (RA) analysis that the species dominating the waterbird community in the Kuala Bubon mangrove forest is *Egretta garzetta*, with 70 individuals recorded from the total observed population. This strong dominance is followed by *Hirundo rustica* with 46 individuals, and *Actitis hypoleucos* with 35 individuals.

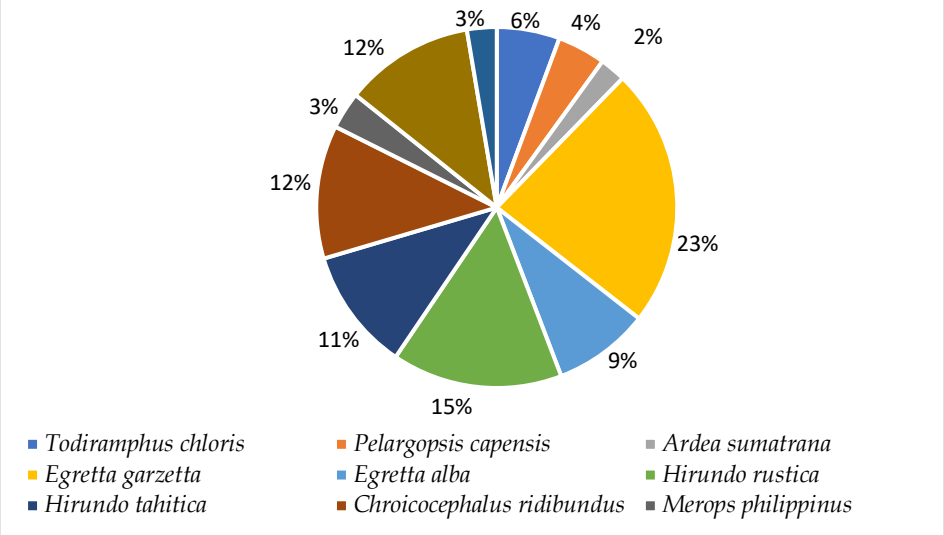


Figure 3. Percentage of Species Dominance

The most dominant species, the Little Egret (*Egretta garzetta*), indicates that the mangrove area provides an abundant food supply, especially small fish and aquatic invertebrates that form its primary diet. In addition, the muddy substrate in the intertidal zone provides an ideal location for foraging activities. This dominance is followed by *Hirundo rustica*, *Actitis hypoleucos*, and *Hirundo tahitica*. The presence of these fish- and aquatic-organism-feeding bird species further reinforces the important role of the mangrove ecosystem as a feeding ground for waterbirds [25], [26].

The presence of predator species such as *Pandion haliaetus* and *Haliaeetus leucogaster*, although in relatively small numbers, indicates that the food chain in this ecosystem is still functioning well. Predator populations are typically lower than those of their prey, and thus their occurrence serves as a positive indicator that ecosystem productivity remains stable [27]. Meanwhile, the presence of migratory species such as the Black-headed Gull (*Chroicocephalus ridibundus*) suggests that this area plays an important role in the migratory routes of shorebirds along the western region of Sumatra.

The moderate diversity value may also reflect early signs of potential threats to the balance of the waterbird community. Species that rely heavily on specific areas become vulnerable when ecological disturbances occur. Anthropogenic activities such as the conversion of mangrove areas into aquaculture ponds or settlements, water pollution from domestic waste, and fishing boat traffic can exert pressure on the habitat quality of waterbirds [28], [29]. If these pressures are not properly managed, they may lead to a decline in waterbird populations and ultimately reduce the ecological potential of the area.

Overall, the Kuala Bubon mangrove ecosystem still exhibits relatively good and functional conditions, as indicated by the adequate abundance of aquatic organisms and the sustained role of the ecosystem as an important habitat. However, the dominance of certain species and the presence of environmental pressures highlight the need for proper management and conservation efforts to ensure ecosystem sustainability and to maintain waterbird diversity in the future.

4. Conclusion

The results indicate that the Kuala Bubon mangrove ecosystem remains in relatively good condition and continues to support waterbird communities, with 13 species from 7 families recorded and a Shannon-Wiener diversity index of H’ = 2.22, categorized as moderate. The dominance of species such as *Egretta garzetta*, *Hirundo rustica*, and *Actitis hypoleucos* suggests that the area functions

as a productive feeding ground with abundant small fish and invertebrates. The presence of predators like *Pandion haliaetus* and migratory species such as *Chroicocephalus ridibundus* further indicates that ecological functions and trophic interactions within the ecosystem are still maintained.

However, the moderate level of diversity also reflects emerging environmental pressures on the waterbird community. Anthropogenic activities such as mangrove land conversion, water pollution from domestic waste, and increased fishing activities may degrade habitat quality if not properly managed. Therefore, this study highlights the need for sustainable management and conservation efforts in the Kuala Bubon mangrove area to maintain ecosystem stability and preserve waterbird diversity in the future.

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