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Short Communication: Flora and aves diversity in the Kasunanan Palace, Surakarta, Indonesia

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Abstract. *Nazar IA, Sunarto, Setyawan AD, Indrawan M, Mahajoeno E, Himawan W, Wijayanti S, Merdekawati NC, Pamungkas DW, Ally H, Waskito DN, Karina R, Kinanti A, Herdananta BY, Sangaji. 2025. Short Communication: Flora and aves diversity in the Kasunanan Palace, Surakarta, Indonesia. Biodiversitas 26: 706-714.* The development of Surakarta City, Central Java, Indonesia, as a MICE (Meeting, Incentive, Convention, and Exhibition) center poses challenges to the availability of land, which threatens green open spaces and their ecological functions. The Palace (*Keraton*), a cultural symbol of Surakarta, has the potential to provide green open space as the manifestation of its local wisdom. This research aimed to identify the diversity of flora and avian fauna that occurred in the Kasunanan Palace, Surakarta, Central Java, Indonesia. The study indicates that the Palace complex was still covered with medium to high vegetation cover, especially in the public open spaces of the Palace. Overall, the diversity index (H') of the flora reached 3.249, indicating a high level with an evenness index (E) of 0.624, indicating moderately even distribution. The most commonly found tree species were *Hibiscus tiliaceus, Terminalia catappa, Mimusops elengi* and *Ficus benjamina.* Fig tree (*Ficus* spp.) is a species with high symbolic and cultural value for the Palace. The avian diversity index (H') reached 2.084, indicating moderate diversity with an evenness index (E) of 0.328, indicating uneven distribution. The most commonly found avian species were *Collocalia linchi, Passer montanus* and *Lonchura punctulata*. These species are generalists, indicating high environmental pressure due to anthropogenic activities. The study results imply that green spaces in *Keraton* provide patches and stepping stones, which is an ideal habitat for developing urban biodiversity. This encourages greenspace restoration efforts based on the function of providing biodiversity through the conservation of special resources (large trees) and improving the quality of patches.

Keywords: Avian, diversity, flora, Keraton Kasunanan Surakarta, local wisdom

INTRODUCTION

Urban green open space (GOS) encompasses vegetation cover and water bodies within the urban landscape (Taylor and Hoschuli 2017). Vegetation component in urban areas provides essential ecosystem services, including controlling microclimate (Graça et al. 2018; Rahman et al. 2020), intercepting and retaining rainwater (Blanusa and Hadley 2019), adding landscape beauty (Wang et al. 2019), serving the habitat of biodiversity (Zhao et al. 2022), mitigating air pollution (Kim et al. 2022) and storing carbon (Ariluoma et al. 2021). Thus, GOS contributes significantly to enhancing the adaptive capacity of urban areas to environmental changes (Graça et al. 2022).

The GOS has a crucial role in coping with the impacts of climate change (Runhaar et al. 2018; Lai et al. 2019). At a local scale, the key to microclimate control by vegetation, which is determined by canopy features and leaf characteristics (Sanusi et al. 2017). The presence of vegetation facilitates photosynthetic metabolism related to the cooling effect (Gunawardena et al. 2017). Therefore, the proportion of vegetation cover serves as a key indicator for assessing the overall ecological quality of urban areas (Richards and Belcher 2020).

The decline of GOS is occurring in the majority of cities worldwide to support population growth and economic development (Huang et al. 2017). Wu et al. (2018) found that the negative impacts of converting GOS primarily occur in tropical and temperate regions. The proportion of GOS tends to follow a common pattern in urban areas in the southern hemisphere (Richards and Belcher 2020). The urban GOS in Indonesia is experiencing a decline due to population growth and density driven by the economic appeal of urban regions (Chan and Vu 2017). For example, in Semarang City the ratio of GOS decreased to 8.2% after the year 2000 (Sejati et al. 2018). Medan City has also undergone a change in GOS from the dominance of high-density vegetation in 2009 to low-density vegetation in 2019 (Zaitunah et al. 2021). Similarly, Yogyakarta has experienced a 39% decrease in non-built-up area during the

period 1990-2017, triggering vegetation loss (Widiyastuti et al. 2020).

The existence of GOS serves as a mitigation to maintain urban biodiversity (Prihandi and Nurvianto 2022). Therefore, a reduction in the proportion of urban GOS threatens biodiversity (Calderón-Contreras and Quiros-Rosas 2017; Nazombe and Nambazo 2023). The availability of urban GOS is crucial for the existence of biodiversity especially native species (Callaghan et al. 2019). However, urban GOS often faces fragmentation, threatening the biodiversity due to population isolation, movement restrictions, and gene flow limitations (Nisi et al. 2023; Tan et al. 2023), as well as the potential dominance of invasive species (Winkler et al. 2024).

Surakarta plays a strategic role due to its geographical location, socio-economic, and cultural aspects. Surakarta serves as a transportation hub due to its cross-regional position on Java Island and is the center of economic activities within the Greater Solo area. As a consequence, commuting intensity is increasing, creating challenges arising from the city's vital role in the hinterland, supported by significant economic progress and a complete service infrastructure (Setyono et al. 2020a).

Surakarta has been developed as a center of meeting, incentives, convention and exhibition (MICE) destination. Such development has negative impacts on GOS due to the conversion of vegetation cover into built-up areas. Surakarta has a low Green Open Space Index (GOSI) of 30.83, indicating a poor quality of urban land cover of the city. The GOS in Surakarta only covers 255.98 ha while other relevant vegetation covers 480.40 ha. This vegetation area is relatively low compared to the extent of city area which reaches 4672 ha (Himawan et al. 2024). Suboptimal vegetation contributes to environmental issues. Research by Putra et al. (2018) showed that changes in built-up land and the reduction of GOS have a high determination on the increase in temperature, leading to the UHI phenomenon. A similar condition was found in GOS on the Universitas Indonesia's campus, where vegetation affected the microclimate and bird biodiversity (Nadia et al. 2021).

This research aimed to assess flora and avian diversity within the complex of Kasunanan Palace. The research will provide data and information on biodiversity, especially the various tree and bird species, along with their ecological and sociocultural attributes in one GOS in Surakarta.

MATERIALS AND METHODS

Study area and period

This research was conducted from April to September 2023 within the complex of Kasunanan Palace, situated in the Pasar Kliwon Subdistrict, Surakarta City, Central Java, Indonesia, i.e. Alun-alun Lor, Alun-alun Kidul, and Ndalem Djojokusuman (Figure 1). The Kasunanan Palace is located in the central business district with coordinates of 7°34'41.5’ S and 110°49'39.6’ E with altitude of 93 masl. It has tropical monsoon climate with average annual rainfall of 2200 mm. The average air temperature in 2023 reached 27.2°C and the average humidity was 77%. The total area of Kasunanan Palace is 157 ha with the core zone covering 15 ha.

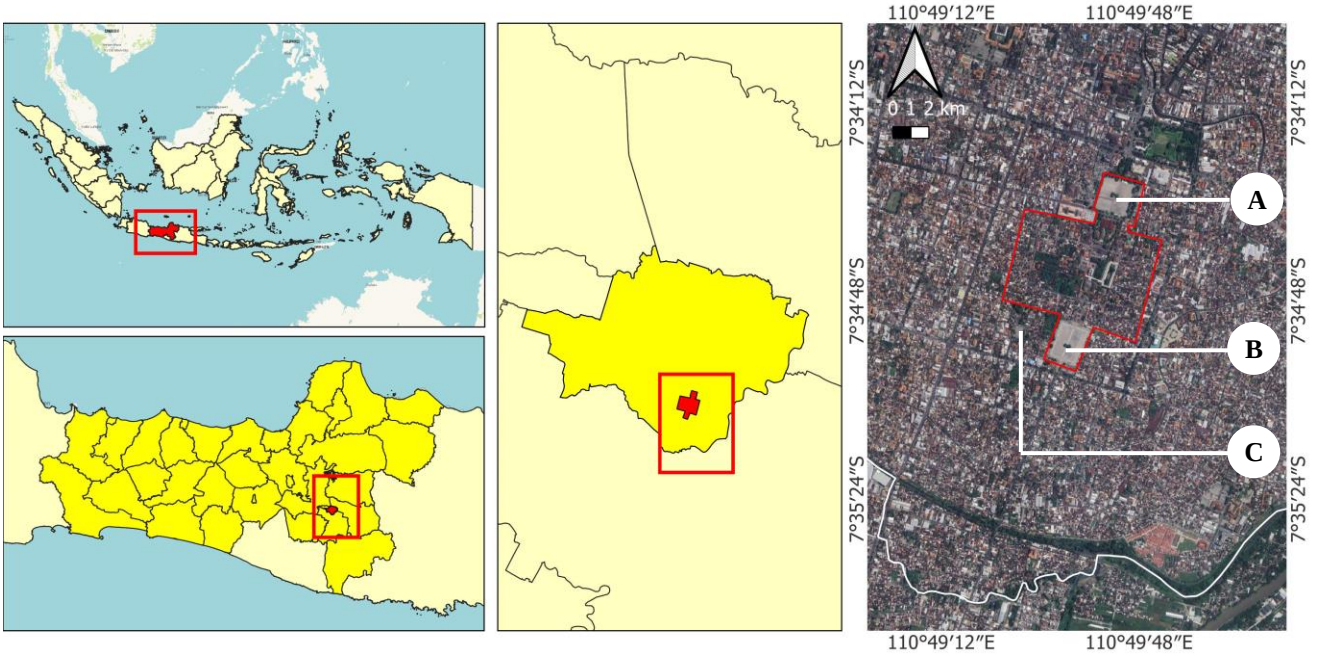

Figure 1. Map of research area in the Kasunanan Palace, Surakarta City, Central Java, Indonesia. A. Alun-alun Lor, B. Alun-alun Kidul, C. Ndalem Djojokusuman

Data collection procedure

The research was conducted through a combination of remote sensing and field survey methods as described below.

Remote sensing

Remote sensing method used Sentinel 2A satellite imagery to obtain the Normalized Difference Vegetation Index (NDVI). The analysis of NDVI produced canopy cover index ranging -1<NDVI<1. Positive and higher values indicate denser trees canopy.

Field survey

Field survey was conducted to obtain data on the diversity of tree and bird in three locations within the complex of Kasunanan Palace, including Alun Alun Lor, Alun Alun Kidul and Ndalem Djojokusuman. The field survey was conducted using a census approach. The survey to inventory species name and numbers of individual plants as well as identification of bird species. Interview was carried out to gather information related to local wisdom and the roles of various tree species.

The instruments used in this research included tally sheets, digital air monitoring equipment, digital temperature meters, an Android smartphone, wooden stakes, raffia ropes, and a laptop. The materials used in this research included Sentinel 2B satellite images, ArcGIS software, Microsoft Office (Word and Excel), Google Forms, and SPSS 26.

Data analysis

Remote sensing

NDVI was calculated using the equation below (Setyono et al. 2020b):

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red})}$$

Where:
NDVI : Normalized Difference Vegetation Index
NIR : Near infrared band in pixels
R : Red band in pixels

NDVI values are converted to spatial form with color variations to distinguish tree canopy cover conditions. Dark green color indicates denser canopy cover while sparse canopy cover is indicated by red color.

Vegetation analysis

Vegetation data was analyzed to obtain ecological indices, namely Shannon-Wiener diversity index and Evennes index. Shannon-Wiener diversity index was calculated using the formula below (Alwi et al. 2021):

$$H' = -\sum \frac{ni}{N} \ln \frac{ni}{N}$$

Where:
H' : Diversity index of Shannon-Wiener
Ni : Number of a given species (i)
N : Total of individuals observed

According to Rahmawaty et al. (2019) the value of H'<1 indicates low diversity, 1≤ H' ≤3 indicates moderate diversity, and H' > 3 indicates high diversity.

The Evenness Index indicates the distribution of each individual relative to the total area of the study. The formula for calculating evenness (E) is as follows (Frahtia et al. 2022).

$$E = \frac{H'}{H\,max} \quad \text{or} \quad E = \frac{-\Sigma pi\,(\ln pi)}{\ln S}$$

Where:
E : Evenness index
S : Number of species
H' : Shannon-Wiener diversity index
H max : Maximum Shannon-Wiener diversity index

Odum (1996) categorized evenness index into several categories, i.e. E<0.5 indicates an uneven distribution pattern, 0.5<E<0.75 indicates a moderately even distribution pattern, and E>0.75 indicates an even distribution pattern.

RESULTS AND DISCUSSION

The Kasunanan Palace serves as a symbol, identity, and distinctive feature of Surakarta. This cannot be separated from the city's historical development, which began with the construction and operation of the Palace. The Kasunanan Palace was built by Sunan Paku Buwono II in 1745 as a relocation of similar facilities in Kartasura, which had been destroyed due to attacks by the Chinese-Javanese forces under Sunan Kuning and the Madurese forces under Cakraningrat IV. The Kasunanan Palace was then developed as a mandala city and an imago mundi for the development of Surakarta at that time (Lombard 1990).

The Palace existence contributes to the provision of vegetation with high sociocultural value. The plants cultivated within its grounds have high ecological value based on local wisdom. Muslimah and Mukhlison (2017) conducted research on the types of trees in the Kasunanan and Mangkunegaran Palaces, focusing only on the cultural functions of these trees for religious, knowledge, and technological systems. The Kasunanan Palace has a distinctive green character (Lombard 1990), indicating that the Palace carries positive local wisdom related to environmental functions. According to Muslimah and Mukhlison (2017), this is related to three cultural elements: the religion and religious ceremony system, the knowledge system, and the technology and equipment system. Lombard (1990) showed that the Palace chose the types of plants to be grown for specific philosophical reasons. For example, the Alun Alun Kidul area is considered to have a strong connection with various activities of the youth and is dominated by mango trees or *mangga* (*Mangifera indica* L.), as a symbol of courage, with *Waringin Kurung* representing the unity between the ruler (king) and the people.

The Palace area becomes an ideal conservation location in Surakarta. While not endemic, important genetic resources of Central Java, such as *Stelechocarpus burahol* (Blume) Hook.f. & Thomson (*kepel*), cultural plants like

Couroupita guianensis Aubl. (*kepel watu*), *Achras zapota* L. (*sawo kecik*), *Sterculia foetida* L. (*kepuh*), and ecologically valuable trees like *Ficus benjamina* L. (*beringin*), thrive well and are relatively unaffected by anthropogenic interventions (Himawan et al. 2019). The strong application of local wisdom plays a role in the sustainability of conserving these species within the Palace area.

Flora diversity

Flora serves as a symbol of sacredness of Kasunanan Palace (Rosmalia et al. 2021). Symbolically, flora imparts a special meaning to a place, depicting life and influenced by cultural or religious factors (Beratha et al. 2018). Flora acts as a reinforcement of the sacredness of a location, simultaneously symbolizing the spirit and positive hopes or investment in the existence of the universe. The design and types of plants within the Surakarta Palace are determined by the King with symbolic and mystical meanings, aiming to protect against negative influences.

The field survey conducted in this study identified a total of 62 plant species and 183 individuals. The Shannon-Wiener diversity index (H') was 3.249, indicating a high diversity category. The evenness index (E) was 0.624, indicating a moderately even distribution. Overall, the observations on flora diversity showed the dominance of species that are socioculturally significant and are generally considered generalists. Species that are socioculturally significant are flora species used in cultural rituals and are beneficial for daily family life. *Waru* (*Hibiscus tiliaceus* L.) was the dominant species, contributing to 25% of total individuals, followed by *ketapang* (*Terminalia catappa* L.) with 11%, *tanjung* (*Mimusops elengi* L.), *beringin/ waringin* or large banyan tree (*Ficus benjamina* L.) and mango (*Mangifera indica* L.). *H. tiliaceus* is culturally valuable, has traditional medicinal uses, features leaves used as natural umbrellas, and provides shade. *T. catappa* is a tree that grows quickly and is relatively easy to propagate, possibly introduced because it is commonly found in coastal areas. *M. elengi* is a shade tree favored by various bird species because of its fruit. *F. benjamina* is a tree with high cultural value for the Javanese people, and it is even considered sacred. *Waringin kurung* is seen as a symbol of unity between the king and the people. Banyan trees and similar genus (*Ficus* sp.) are easily found within the Kasunanan Palace. Banyan trees hold crucial ecological value because of the various ecosystem services they can provide. Santosa (2017) revealed that *waringin/ringin* is a symbol of the common aristocracy and is typically planted and grown in the yards of Javanese rulers.

The interpretation of NDVI from Sentinel 2B imagery (Figure 2) shows that the Palace complex was still predominantly covered by medium to high canopy vegetation. The main Palacce building, acting as a central hub, connects the two town squares (Alun-alun). All three locations studied had high NDVI values, even though in reality, the town squares were grassy fields. The presence of the main Palace building appears to serve as a biodiversity corridor that connects the trees from the Gladag Gate to Alun-alun Lor and Alun-alun Kidul.

Alun-alun Kidul is an open area and serves a social center for the surrounding community, the people of Surakarta, and a tourist attraction. Direct observations at Alun-alun Kidul revealed differences in vegetation cover between the west and east sides. The west side had the main concentration of large trees with high and wide canopy density. This side was dominated by species like *H. tiliaceus*, *M. elengi*, *T. catappa* and *F. benjamina*. A different condition was found in the east side of the Alun-alun Kidul, where there were fewer trees. The central part of Alun-alun Kidul featured the Ringin Kurung (twin banyan trees), which is an iconic symbol of this location and holds high symbolic significance for the presence of the Keraton.

The inventory of plant species at Alun-alun Kidul identified 17 species with a total count of 114 individuals (Table 1). The dominant species in this location were *H. tiliaceus, T. catappa*, and *M. elengi*. These three species are commonly planted as shade trees in parks and streets. *F. benjamina* was also abundant, highlighting the crucial ecological function of this area.

The fruit-bearing and aesthetically pleasing plant species were not abundantly found in Alun-alun Kidul. Alun-alun is designed as a location for social interaction among the community. The chosen plant types are designed to provide shade and control microclimate temperatures to enhance comfort. Factors controlling temperature, such as canopy ratio, impervious surface coverage, and spatial tree design (Yu et al. 2020), are quite well-implemented in this location. The plant types at Alun-alun Kidul contribute more to ecological functions, such as water infiltration, carbon absorption, and providing habitat for various bird species.

Table 1. List of plant species at Alun-alun Kidul, Kasunanan Palace complex, Surakarta

Scientific name	Number of individuals
Alstonia scholaris (L.) R.Br.	5
Artocarpus heterophyllus Lam.	1
Citrus ×aurantiifolia (Christm.) Swingle	1
Dimocarpus longan Lour.	2
Ficus benjamina L.	7
Gnetum gnemon L.	2
Handroanthus chrysotrichus (Mart. ex DC.) Mattos	1
Hibiscus tiliaceus L.	45
Kigelia africana (Lam.) Benth.	2
Macaranga tanarius (L.) Müll.Arg.	1
Mangifera indica L.	1
Manilkara zapota (L.) P.Royen	2
Mimusops elengi L.	10
Muntingia calabura L.	6
Spathodea campanulata Beauverd	6
Syzygium aqueum (Burm.fil.) Alston	2
Terminalia catappa L.	20
Total number of individuals	114
Shannon-Wiener diversity index (H')	2.07
Evenness index	0.44

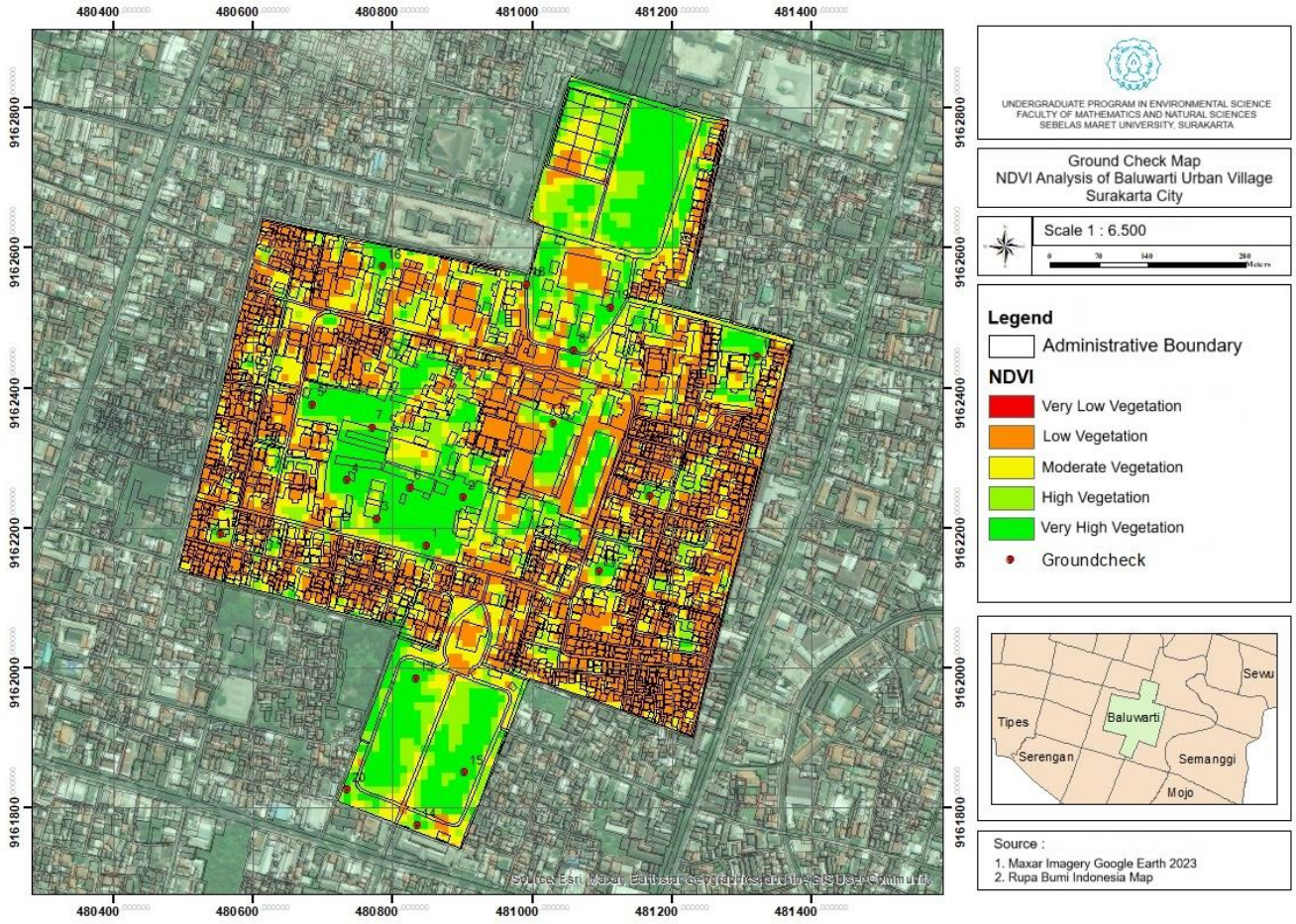

Figure 2. Interpretation of Normalized Difference Vegetation Index (NDVI) of vegetation within Kasunanan Palace complex

Ndalem Djojokoesoeman is one of the building complexes in the southwest corner of the Palace environment. This building is frequently used as a venue for art performances and exhibitions. The total number of plant species found at Ndalem Djojokoesoeman reached 45 with only 65 individuals (Table 2). Species with the most individuals in this location were *M. indica, F. benjamina* and *M. elengi*. Fruits and esthetics plants were more widely cultivated in this area. This result aligns with the historical description by Lombard (1990) on prevalent plants in Palace's residential areas, typically being *M. indica*, which provides fruit and symbolizes encouragement and suggestion before making decision for the young adult (Syahdani and Kardanardi 2022). The presence of *F. benjamina* once again represents the aristocratic identity of the building owners. *M. elengi*, along with *S. cumini*, symbolizes the attention from the king to solve the suffering of their people (Rosmalia et al. 2021). This location also featured some modern plants like *Polyalthia longifolia* (Sonn.) Thwaites.

The identification of plants in Alun-alun Lor revealed seven species, primarily consisting of large-shaded trees (Table 3). The presence of *F. benjamina* once again dominated, indicating the significant importance of this species in relation to the existence of the palace. Species with the most abundant individuals was *K. africana*, which were planted along the main path. *K. africana* is an introduced plant from Africa commonly used in traditional medicine (Nabatanzi et al. 2020). This plant is utilized in traditional herbal remedies for malaria (Imran et al. 2021), fertility enhancement, testosterone boosting (Nabatanzi et al. 2020), and exhibits anti-inflammatory, antioxidant, antimicrobial, antidiabetic, antineoplastic, and anti-urolithic activities (Abbas et al. 2023). It is even used as a supplement in fish farming (Sianangama et al. 2023). The palace utilizes *K. africana* as a natural boundary to demarcate the main square of the Alun-alun Lor from the road. This consideration is based on its fast growth capabilities, suitable for alluvial soil types, and the riverine fringe environment (Halder 2017; Singh et al. 2018).

Evaluation of biodiversity levels indicates that Ndalem Djojokosoeman had the highest biodiversity with H' of 3.65, while the lowest was Alun-alun Lor (0.51), suggesting that Kasunanan Palace complex had a low to high level of biodiversity. The Evenness Index indicates that the species is uneven to evenly distributed. Overall, Ndalem Djojokosoeman had the best vegetation condition. Difference in vegetation conditions is determined by the policies in arrangement and the selection of plant species.

Table 2. List of plant species at Ndalem Djojokusuman, Kasunanan Palace complex, Surakarta

Scientific name	Number of individuals
Agalaonema sp.	1
Allamanda cathartica L.	1
Alocasia macrorrhiza (L.) Schott	1
Anthurium × *ferrierense* T.Moore and Mast.	1
Artocarpus altilis (Parkinson) Fosberg	2
Averrhoa carambola L.	1
Bambusa sp.	1
Beaucarnea recurvata (K.Koch & Fintelm.) Lem.	2
Bougainvillea glabra Choisy	1
Callistemon viminalis (Sol. ex Gaertn.) G.Don	1
Capsicum frutescens L.	1
Carica papaya L.	1
Coleus scutellarioides (L.) Benth.	1
Cordyline sp.	1
Dieffenbachia maculata (Lodd.) G.Don	1
Epipremnum aureum (Linden & André) G.S.Bunting	1
Erythrina crista-galli L.	2
Ficus benjamina L.	4
Ficus pumila L.	1
Ficus racemosa L.	1
Ficus religiosa L.	1
Ficus septica Burm.fil.	1
Heliconia psittacorum L.f.	1
Hibiscus rosa-sinensis L.	1
Ixora sp.	1
Jasminum sambac (L.) Aiton	1
Jasminum officinale L.	1
Leucaena leucocephala (Lam.) de Wit	2
Magnolia champaca (L.) Baill. ex Pierre	1
Mangifera indica L.	5
Manilkara zapota (L.) P.Royen	1
Mimusops elengi L.	4
Murraya paniculata (L.) Jacq.	2
Musa sp.	1
Pistia stratiotes L.	1
Platycerium bifurcatum (Cav.) C.Chr.	1
Plumeria alba L.	1
Polyalthia longifolia (Sonn.) Thwaites	3
Polyscias scutellaria (Burm.fil.) Fosberg	1
Pterocarpus indicus Willd.	1
Samanea saman (Jacq.) Merr.	2
Schefflera arboricola Hayata	1
Solanum torvum Sw.	1
Syzygium cumini (L.) Skeels	3
Tamarindus indica L.	1
Total number of individuals	65
Shannon-Wiener diversity index (H')	3.65
Evenness index	0.87

Table 3. List of plant species at Alun-alun Lor, Kasunanan Palace complex, Surakarta

Scientific name	Number of individuals
Ficus benjamina L.	6
Ficus elastica Roxb.	2
Filicium decipiens (Wight & Arn.) Thwaites	12
Kigelia africana (Lam.) Benth.	86
Pinus merkusii Jungh. & de Vriese	4
Polyalthia longifolia (Sonn.) Thwaites	2
Terminalia catappa L.	1
Total number of individuals	113
Shannon-Wiener Diversity Index (H')	0.51
Evenness Index	0.11

The major public areas are controlled by the king and the palace management based on their meanings and philosophies. This research found that the placement and selection of plant species based on the Palace's culture is related to ecological needs. Banyan trees (*Ficus* spp.) was dominant in the palace complex as this tree serves as a symbol of power as well as the role of the ruler in protecting and nurturing the community (Rosmalia et al. 2021). Similar condition was also found in the Yogyakarta Palace which indicates that several key plants with great importance in socio-cultural of Javanese society were widely conserved in the palace area (Syahdani and Kardanardi 2022).

Banyan trees provide important ecosystem services. These trees have a large canopy coverage area, making it a promising candidate for optimal climate change mitigation (Lin and Lin 2010). Research by Ihsan and Rosleine (2019) shows that trees with moderate canopy thickness and broad canopy cover effectively control microclimate temperatures. Wujeska-Klause and Pfautsch (2020) identifies plants with wide canopy covers are more ideal in regulating the microclimate because they better regulate temperatures during both day and night. These features cannot be found in other locations in Surakarta. The Keraton Kasunanan environment is one of the locations able to provide vegetation with these features.

Avian diversity

Kasunanan Palace is associated with the presence of several fauna. One of the most popular and enduring is the presence of the *kebo bule* or white buffalo which is still kept in Alun-alun Kidul and involved in various cultural rituals and celebrations. Lombard (1990) indicated that in the past, Kasunanan Palace had more fauna, such as elephants and tigers, before they were relocated to the zoo.

This study documented 16 bird species in Kasunanan Palace of which 15 species with 403 individuals were recorded in Alur-alur Lor while 13 species with 174 individuals were in Alun-alun Kidul. It had Shannon-Wiener Diversity index of 2.08, indicating moderate biodiversity and the Evenness index of 0.33, indicating uneven distribution. Almost all documented bird species are considered to have a low risk of extinction, except for one species, the Javan Myna (*Acridotheres javanicus* Cabanis 1851), which is considered to be Vulnerable based in IUCN Red List (Table 4).

The dominant bird species during the observations in both Alun-alun Keraton Kasunanan locations were the Linchi swiftlet (*Colocalia linchii*, 29%), House sparrow (*Passer montanus* Linnaeus 1758, 20%), Scaly-breasted munia (*Lonchura punctulata* Linnaeus 1758, 17%), and Olive-winged Bulbul (*Pycnonotus goiavier* Scopoli 1786, 10%). The availability of diverse tree species like *M. elengi* provides an ideal habitat. Most of the species encountered belong to the generalist group, which can adapt relatively easily to environmental dynamics and high anthropogenic pressures.

Table 4. List of avian species at Alun-Alun Lor and Alun-Alun Kidul, Kasunanan Palace complex, Surakarta

Local name	Scientific name	Number of individuals		
		Alun-alun Lor	Alun-Alun Kidul	Total
Bondo Jawa	*Lonchura leucogastroides* Moore 1858	15	13	28
Bondol peking	*Lonchura punctulata* Linnaeus 1758	97	0	97
Burung-gereja	*Passer montanus* Linnaeus 1758	66	49	115
Cabai Jawa	*Dicaeum trochileum* Sparrman 1789	18	14	32
Cinenen Jawa	*Orthotomus sepium* Horsfield 1821	5	0	5
Cinenen pisang	*Orthotomus sutorius* Pennant 1769	1	1	2
Cucak kutilang	*Pycnonotus aurigaster* Vieillot 1818	2	16	18
Kerak kerbau	*Acridotheres javanicus* Cabanis 1851	15	7	22
Layang-layang batu	*Hirundo tahitica* Gmelin 1789	1	3	4
Madu Sriganti	*Cinnyris jugularis* Linnaeus 1766	6	2	8
Merbah cerucuk	*Pycnonotus goiavier* Scopoli 1786	56	0	56
Perkutut Jawa	*Geopelia striata* Linnaeus 1766	5	2	7
Punai gading	*Treron vernans* Linnaeus 1771	0	1	1
Takur Ungkut	*Psilopogon haemacephalus* P.L.S.Müller 1776	4	5	9
Tekukur biasa	*Spilopelia chinensis* Scopoli 1786	4	3	7
Walet linci	*Collocalia linchi* Horsfield and F.Moore 1854	108	58	166
Total number of individuals		403	174	577
Shannon-Wiener Diversity Index (H')		2.084		
Evenness Index		0.33		

Alun-alun in Kasunanan Palace is a patch in urban area with an extent of 157 ha. The large patch size (>53.3 ha) makes this location ideal as regional hubs with a high ability to support biodiversity (Beninde et al. 2015). Thompson et al. (2022) showed that bird diversity and abundance were significantly correlated with patch size and the presence of neighbouring settlements. The large area of the Alun-alun in Kasunanan Palace provides greater resources and niche complexity to accommodate a variety of bird species (Jasmani et al. 2017). The presence of grassy fields surrounded by dense, old trees has a positive effect on bird diversity (Muhlbauer et al. 2021).

The Green Open Spaces (GOS) in both Alun-alun of Kasunanan Palace provide ideal conditions as bird habitats. Prihandi and Nurvianto (2022) showed that spacious urban green space in Yogyakarta City located away from anthropogenic pollution (such as motor vehicle emissions and noise), and having a flat slope contributed to higher bird diversity. The philosophical axis used as the basis for the spatial arrangement of the Javanese palaces supports the existence and sustainability of bird biodiversity. The cosmological conception of the creation of the universe serves as a guide for the Kasunanan Palace. This conception is grounded in the philosophy of what is known as *kiblat papat kalima* Pancer. The core complex of the palace embodies the Javanese philosophy of the phases of human life, known as *sangkan paraning dumadi* with each location representing a phase of life. This spatial arrangement indirectly forms a biodiversity corridor connecting Alun-alun Lor and Alun-alun Kidul. The condition of Alun-alun Lor, with more structures, provides more niches for a variety of higher species.

The Kasunanan Palace landscape provides important value for urban biodiversity in Surakarta. The palace provides additional green open space unlikely to be converted to other land uses and functions. The biodiversity within the complex of Kasunanan Palace is quite high and represents ecological and socio-cultural values. Ecological functions are supported by the socio-cultural values existed in Kasunanan Palace which safeguard the conservation of biodiversity.

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