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Assessment of biodiversity and conservation status of flora and fauna in Madiun City, East Java, Indonesia

OKID PARAMA ASTIRIN[1,2,♥], FETRIA WIDIYANTI[3], SURATMAN[1], NUGROHO ANDI PURNOMO[2], MUH ARIF RAMADLON[4], HADI WIWIT HENDRO CAHYONO[2], DIAGAL WISNU PAMUNGKAS[5], WIDYA MEGA RAHMAWATI[6]

[1]Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel.: +62-271-669376, Fax.: +62-271-663375, ♥email: parama_astirin@staff.uns.ac.id
[2]Center of Environmental Research, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia
[3]Madiun City Food and Environment Agency. Jl. Salak III No.7A, Taman, Madiun 63131, East Java, Indonesia
[4]Prospect Institute. Jl. Pleret Utama No.33A, Banyuanyar, Banjarsari, Surakarta 57137, Central Java, Indonesia
[5]Indonesia Dragonfly Nature Conservation. Sleman, Yogyakarta, Indonesia
[6]Department of Biosciences, Faculty of Mathematics and Natural Sciences, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

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Abstract. *Astirin OP, Widiyanti F, Suratman, Purnomo NA, Ramadlon MA, Cahyono HWH, Pamungkas DW, Rahmawati WM. 2025. Assessment of biodiversity and conservation status of flora and fauna in Madiun City, East Java, Indonesia. Biodiversitas 26: 3965-3972.* Madiun City is a small municipality that has evolved into an urban center due to its strategic position as the hub of socio-economic activities, including trade, industry, and healthcare. Urbanization in the town poses a threat to biodiversity. This is due to changes in land use and cover, natural exploitation, introduction of exotic species, air and water pollution, and climate change. This study aims to explore biodiversity in Madiun City to inform the development of strategies and policies for natural resource management. The observations revealed that Madiun City is home to 122 tree species, 76 species of ornamental plants, and 143 species of animals, including mammals, birds, reptiles, amphibians, fish, and insects. Eight plant species and five animal species are listed in the IUCN Red List. Additionally, there are eight plants and five animals listed under CITES, as well as six animals listed as protected under the Ministry of Environment and Forests' P106/2018. *Leucopsar rothschildi*, *Padda oryzivora*, and *Pavo muticus* are birds listed under all the three protection instruments, suggesting their conservation importance. Green open spaces with aviaries are crucial for conserving biodiversity, as they offer a range of ecological, aesthetic, social, and economic benefits. Community participation with the local government is vital to conservation programs in urban areas. Active community involvement in conservation programs and socialization can significantly support the success of biodiversity conservation.

Keywords: Biodiversity, fauna, flora, green open space, Madiun City

INTRODUCTION

Indonesia is among the countries with the fastest rates of urbanization in the world. The number of cities increased from 50 to 94 between 1980 and 2010, driven by the growth of Indonesia's population to over 260 million (Mardiansjah et al. 2021). It is estimated that 60% of the Indonesian population is concentrated in Java Island, which is considered as one of the most densely populated islands globally (Wirawan and Tambunan 2018). This figure indicates that the degree of urbanization in Java is higher than in other islands. Small cities are also affected by urbanization, in addition to densely populated metropolitan areas. Twelve small towns in Java, with populations ranging from 100,000 to 300,000 in 2010, were identified, despite not being located near large cities or urban areas (Wirawan and Tambunan 2018). One of them is Madiun City which is situated in the lowlands of East Java Province.

Madiun City is relatively small in extent, with an area of 33.23 square kilometers. Its population grew 4.3% from 2000 to 2010 (Wirawan and Tambunan 2018). Madiun City's population density was 5,136 people/km^2 in 2010 and increased to 5,873/km^2 in 2020 (Fitriyani et al. 2023). The city is a target of urbanization due to its strategic location as the center of regional activities in western East Java and the hub with the nearby Central Java Province. This position makes Madiun City as the center of government services, trade, industry, education, and health. This city is an exceptionally strategic transit region because it has a flat topography, making it an easy route for bus and train transportation and supports hinterland areas with well-known cultural and tourism potential.

Urbanization has a positive impact on human's life, particularly in terms of economic growth (Celik et al. 2024; Liu et al. 2024). Urbanization improves the welfare of its people. However, this development can also harm the environment and biodiversity directly or indirectly. The direct impact is habitat loss, destruction and fragmentation that changes vegetation cover to buildings and roads (Wang et al. 2022; Liu et al. 2025). Population increases also generate significant waste, which has a detrimental impact on the environment (Astirin et al. 2025). Urbanization also indirectly affects biodiversity through various factors,

including changes in soil moisture and compaction, climate change resulting from the urban heat island effect, and disturbances in hydrology (Feng et al. 2021; Zhang et al. 2022). Such phenomena also occurred in Madiun City, where land changes of 3% to 6% increased surface temperature, leading to an uneven temperature range of 16-30°C due to changes in land cover within the city (Fitriyani et al. 2023). It results in pressures that exceed the adaptive capacity of species and reshape the community structure to fit the new habitat (Liu et al. 2025).

Biodiversity is a valuable asset for national and regional development, so integrated management is necessary between sectors and levels of government. Preserving biodiversity is crucial to fulfill basic human needs. This is because biodiversity delivers various ecosystem services which are beneficial to enhance human welfare by improving air quality, enriching soil, and providing natural resources for food and medicine (Zhao et al. 2022). Therefore, the development of urban cities must be carried out sustainably, with consideration for environmental aspects. One strategy can be manifested by allocating green open space to conserve biodiversity in urban area.

A biodiversity inventory is an activity that collects data and identifies living things, such as animals and plants, in a specific area. The information in biodiversity distribution is crucial in informing policy strategies and making informed decisions for natural resource management (Meyer et al. 2015; Stephenson and Stengel 2020). Globally, IUCN and CITES summarize the biodiversity of various countries. IUCN is recognized as the standard for assessing a species' extinction risk, while CITES protects species from illegal trade (Tianpei et al. 2022; Venkateswarlu et al. 2025). Indonesia also has regulations that technically protect biodiversity through the Minister of Environment and Forestry (KLHK) Regulation Number P.106 of 2018, which contains a list of protected species in this country (Astirin et al. 2025).

Biodiversity in Madiun City is still not widely explored. Information and inventory of biodiversity in Madiun City are crucial for making informed decisions or amending environmental conservation efforts. Therefore, the government can mitigate the impact by striking a balance between the sustainability of natural resources and efforts to develop urban infrastructure. The purpose of this study is to establish an inventory and monitor biodiversity in Madiun City, providing a basis for developing natural resource management strategies. With this information, it is expected that development activities can take into account the presence of flora and fauna, particularly species that are critical to maintaining endemic values and those that are at risk of extinction due to development activities.

MATERIALS AND METHODS

Study area

This research was conducted in Madiun City, East Java Province, Indonesia which comprises three sub-districts: Taman, Manguharjo, and Kartoharjo. The city is bordered to Madiun Regency to the north, east, west, and south (Figure 1). Geographically, the region is situated between 7°35.680'S and 7°40.909'S and 111°33.535'E and 111°29.719'E, with an altitude of 75-59 meters above sea level. The air temperature in Madiun City ranges from 20˚C to 35˚C, and the annual rainfall is approximately 2,000mm.

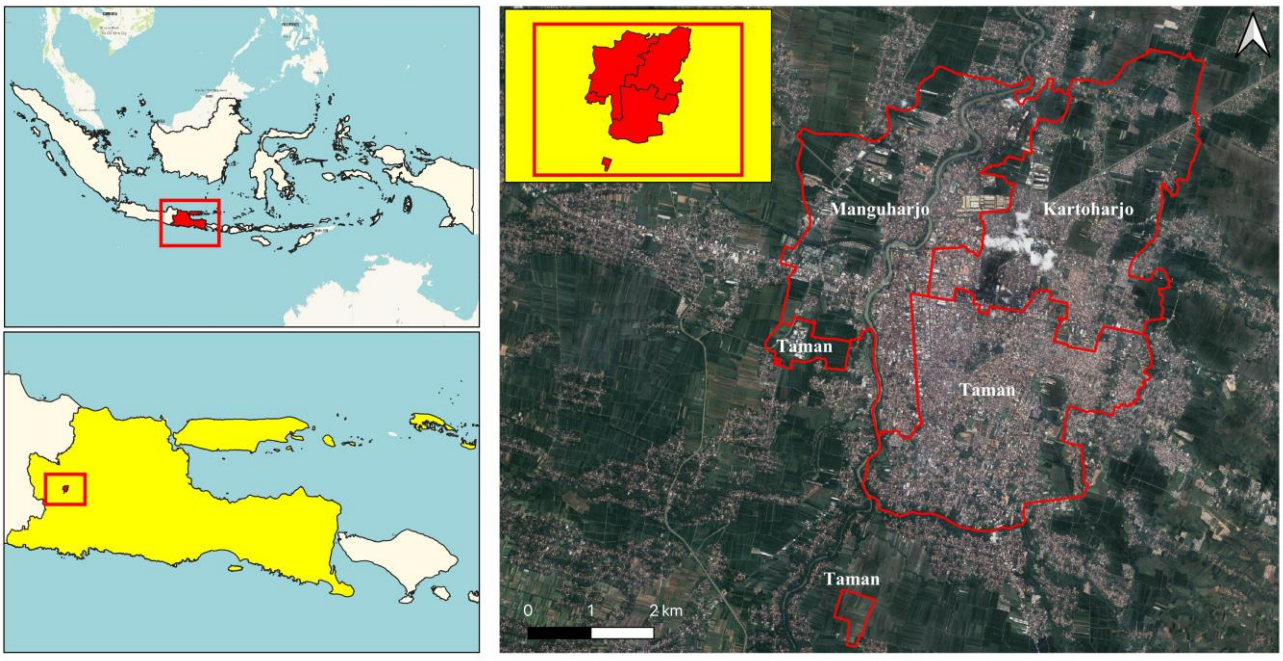

Figure 1. Map of study location in Madiun City, East Java Province, Indonesia

Data collection

We conducted surveys in 2020 in the Kutoharjo sub-district, 2021 in the Taman sub-district and 2022 in the Manguharjo sub-district. The methods employed included interviews, surveys, and field observations. Interviews on biodiversity were conducted in stages, from the village head to residents. Direct observations were performed using an exploratory, purposive, and random sampling method for animal and plant inventory (Astirin et al. 2025). Roadside shade plants were observed along the road for 1 km, as well as on the right and left edges of the road. Vegetation surveys of rice fields and watersheds were conducted using 1x1 transect data for weeds and cultivated plants. Animals were observed in the watershed, including amphibians and reptiles, while birds and mammals were observed in rice fields, moorlands, and yards. The data obtained were categorized based on three databases: IUCN (https://www.iucnredlist.org), CITES (https://checklist.cites.org/#/en), and the Decree of the Ministry of Environment and Forestry No. P106/2018 on Protected Plant and Animal Species. Data management results were reviewed to inform the formulation of management strategies and policies related to natural resources in Madiun City.

RESULTS AND DISCUSSION

Plant diversity and distribution in Madiun City

Observations recorded 122 tree species and 76 decorative plant species across Madiun City. Overall, the city has a Shannon-Wiener index value of 3.674, indicating a high level of plant species diversity. The evenness index is 0.765, indicating a stable community. All trees recorded in Madiun City generally serve as shade trees of which 18 tree species produce edible fruit. Mango trees *(Mangifera indica*), glodokan tiang *(Polyalthia longifolia*), and trembesi (*Albizia saman*) are the most commonly found trees in Madiun City, both in the Green Open Space (RTH) area and on the roadside.

Madiun City has a flora mascot of the Nambangan Orange *(Citrus maxima* cultivar nambangan) or pomelo orange (DIKPLHD Madiun City 2021). This orange is generally utilized as a source of vitamin C. It is characterized by its large size, fresh aroma, and shelf life of up to 4 months (Hardjono et al. 2021). The spheroid-shaped pomelo citrus cultivar Nambangan is potentially seedless, with the color of the fruit skin when ripe yellow, while the color of the juice bag is pink-red (Rahayu et al. 2012). The distribution of this citrus plant is most widely planted in the Taman sub-district.

Observations revealed that most tree species belonged to the Fabaceae family, followed by Moraceae and Apocynaceae (Figure 2). Meanwhile, the most dominant decorative plants come from the Asparagaceae family, followed by Asteraceae and Acanthaceae. Some of these plant species are included in the list of endangered species, as per the IUCN, CITES, and MoEF P106/2018, as presented in Table 1.

None of the plant species recorded in Madiun City are protected under the regulation of MoEF No. P106/2018, while eight are included in Appendix Two of CITES. Plants with critically endangered status include two species, *Hyophorbe lagenicaulis,* and *Beaucarnea recurvata*. Under the IUCN Red List, plant species with Vulnerable status is held by four species, including *Araucaria heterophylla, Agathis dammara, Veitchia merrillii*, and *Saraca asoca*. In addition, two species, namely *Pterocarpus indicus* and *Swietenia macrophylla*, are listed as endangered.

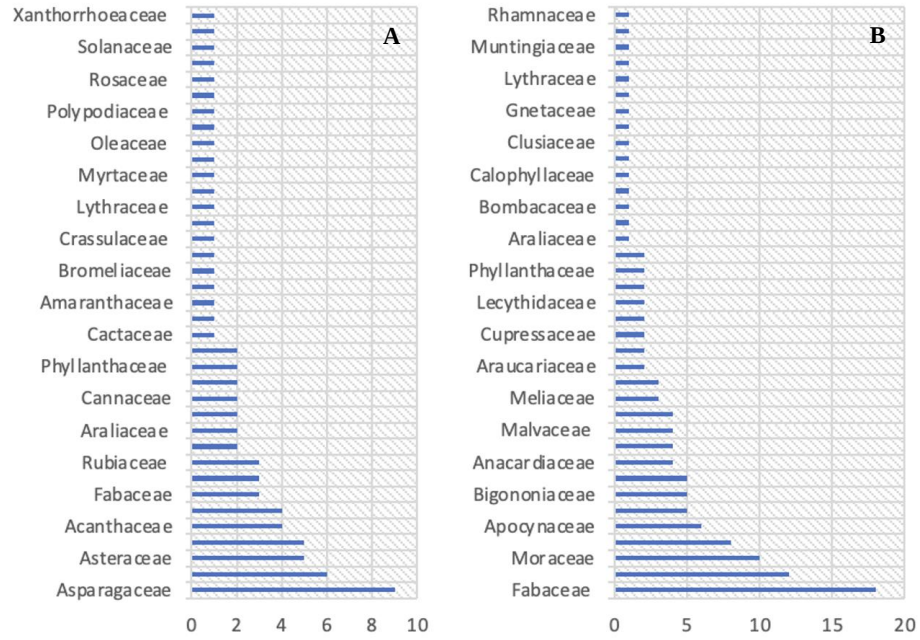

Figure 2. List of families of decorative plants (A) and trees (B) in Madiun City, East Java, Indonesia

Table 1. Protected and threatened plant species in Madiun City, East Java, Indonesia

	Local name	Family	Scientific name	MoEF P.106	CITES	IUCN
Tree	Cemara norfolk	Araucariaceae	*Araucaria heterophylla*	-	-	VU
	Damar	Araucariaceae	*Agathis dammara*	-	-	VU
	Palem botol	Arecaceae	*Hyophorbe lagenicaulis*	-	-	CR
	Palem putri	Arecaceae	*Veitchia merrillii*	-	-	VU
	Nolina	Asparagaceae	*Beaucarnea recurvata*	-	II	CR
	Tabebuya ungu	Bignoniaceae	*Tabebuia rosea*	-	II	LC
	Angsana	Fabaceae	*Pterocarpus indicus*	-	II	EN
	Mahoni	Meliaceae	*Swietenia macrophylla*	-	II	EN
Decorative plants	Asoka	Fabaceae	*Saraca asoca*	-		VU
	Anggrek aerides	Orchidaceae	*Aerides odorata*	-	II	-
	Anggrek bulan	Orchidaceae	*Phalaenopsis amabilis*	-	II	-
	Anggrek dendrobium	Orchidaceae	*Dendrobium aphyllum*	-	II	LC
	Vanda	Orchidaceae	*Vanda tricolor*	-	II	-

Agathis dammara is endemic to Indonesia, precisely in Sulawesi and Maluku. It has a limited population with a geographical distribution primarily in Asia, particularly in Indonesia and the Philippines (Figure 3). Its population is experiencing a downward trend due to overexploitation and is estimated to be at least 30% less. This plant is a natural producer of resin. The sap from this plant can be processed into copal (Setiawan et al. 2019). Various industries, such as paper coatings, varnish mixtures, adhesives in dental fillings, and plaster adhesives, can utilize the copal.

Pterocarpus indicus is also a tropical tree species experiencing population decline, especially in Southeast Asia (Figure 4). This tree can be easily found in Magetan along roads and private lands under agroforestry system combined with agricultural crops (Astirin et al. 2025). However, this plant is utilized its wood for construction, furniture, and the musical instrument industries. The threat posed by this plant is also linked to its low natural regeneration rate, resulting from low germination rates, limited fruit production, and a small number of trees capable of producing fruit (Danarto et al. 2021).

Animal diversity and distribution in Madiun City

Overall, Madiun City has a high animal diversity, with 143 species identified, comprising mammals, birds, reptiles, amphibians, fish, and insects. Most of the animals found are wild; some are domesticated/pet. Table 2 lists protected and endangered animals, based on the IUCN, CITES, and MoEF P106/2018. There are 64 species of birds found in Madiun City, including those that are wild, captive, cultivated, or traded. A total of six species are protected, with one included in Appendix 1 of CITES and four in Appendix 2. The Critically Endangered status is held by *Leucopsar rothschildi. Acridotheres javanicus* is vulnerable. Three species hold endangered status, including *Chloropsis sonnerati*, *Padda oryzivora*, *and Pavo muticus.* Figure 3 shows the distribution of protected and threatened animal species in Madiun City.

Indigenous fauna is commonly used to symbolize or characterize a region. Madiun City has an indigenous animal called the Kepodang Batu (*Oriolus chinensis maculatus*), also known as the black-billed kepodang. This bird is golden yellow with black wings and a tail. A distinctive feature of this bird species is a broad, black band across the eyes, accompanied by a pink beak.

The distribution of *Chloropsis sonnerati* is limited to Southeast Asia, especially in Indonesia, on the islands of Kalimantan, Sumatra, and Java (Figure 6). Unfortunately, this bird experienced a drastic increase in the Indonesian bird market due to its singing ability. This illegal hunting has resulted in a 55% decline in population (Symes et al. 2018). A 2018 bird ownership survey involving over 3,000 households in all six provinces of Java also estimated that 59,981±27,210 individuals and an unknown proportion of 1,448,692±448,600 leaf birds are currently kept in Java alone (Marshall et al. 2020).

Figure 3. Distribution of *Agathis dammara* in the world (GBIF 2025)

Figure 4. Map of *Pterocarpus indicus* distribution worldwide (GBIF 2025)

Table 2. Protected and endangered animals in Madiun City, East Java, Indonesia

	Local name	Family	Scientific name	MoEF P.106	CITES	IUCN
Aves	Cica daun besar	Chloropseidae	*Chloropsis sonnerati*	PP		EN
	Gelatik jawa	Estrildidae	*Padda oryzivora*	PP	II	EN
	Merak hijau	Phasianidae	*Pavo muticus*	PP	II	EN
	Kipasan bukit	Rhipiduridae	*Rhipidura euryura*	PP		LC
	Kipasan ekor merah	Rhipiduridae	*Rhipidura phoenicura*	PP		LC
	Kerak kerbau	Sturnidae	*Acridotheres javanicus*	TD		VU
	Jalak bali	Sturnidae	*Leucopsar rothschildi*	PP	I	CR
Herpetofauna	Tokek	Gekkonidae	*Gekko gecko*	TD	II	LC
	Biawak	Varanidae	*Varanus salvator*	TD	II	LC

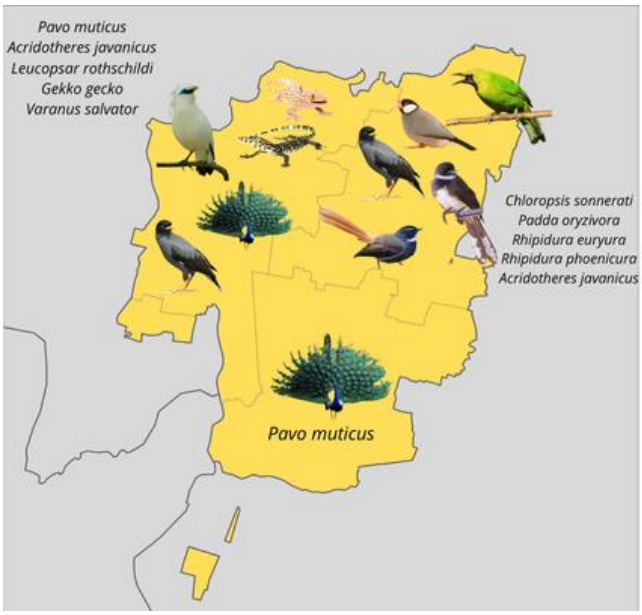

Figure 5. Distribution of protected and threatened animal species in Madiun City, East Java, Indonesia

Figure 6. Distribution and IUCN status of *Chloropsis sonnerati*

Padda oryzivora, or Gelatik Jawa, is an endemic native to Java and Bali. The Gelatik Jawa is experiencing a population decline in Indonesia. Besides being threatened by global trade, this species is also considered a significant agricultural pest due to its abundance and is routinely captured as a food source.

Pavo muticus (the Javan green peacock) is also found in Madiun City. Captive breeding of the bird has been conducted as an ex-situ conservation effort to preserve the bird. The main threats to the decline of the green peacock population are poaching and disturbance of its natural habitat. Parts of the animal that are taken are its meat and feathers. In 2008, this individual species was reported to be sold illegally in a Javanese animal market for IDR 200,000 (ProFauna Indonesia 2008).

Leucopsar rothschildi, the endemic bird of Bali, is experiencing a population decline due to illegal trade. This serious problem is exacerbated by habitat loss due to factors such as forest conversion to plantations and human settlements (Craig et al. 2020). Prices for the species continue to increase, with a recent survey revealing that the species is sold in several markets in Jakarta and Bandung for between US$752 and US$ 1,278 (Nijman et al. 2017). Captive breeding is an ex-situ conservation effort for this species, and one of the breeding locations is in the Manguharjo Sub-district, Madiun City.

Herpetofauna is a group of animals that has cold-blooded and slithering characteristics consisting of amphibians and reptiles. Herpetofauna plays a crucial role in maintaining the balance of the ecosystem, as it occupies the first and second-level consumers in the food chain and serves as a natural pest control in agriculture. A total of six species of amphibians and 16 species of reptiles are recorded in Madiun City, both in their natural habitats and in domesticated conditions. Two species, *Gekko gecko* and *Varanus salvator*, are included in Appendix II of CITES.

Other animals found in Madiun City include six species of freshwater fish. In addition, 33 species of Lepidoptera (Butterflies), 16 species of Odonata, one species of Coleoptera, and one species of Hymenoptera are found in Madiun City. Most of these insects play a role in the pollination process and pest control in agriculture and plantations. Mammals found in Madiun City are six species that are neither protected nor endangered.

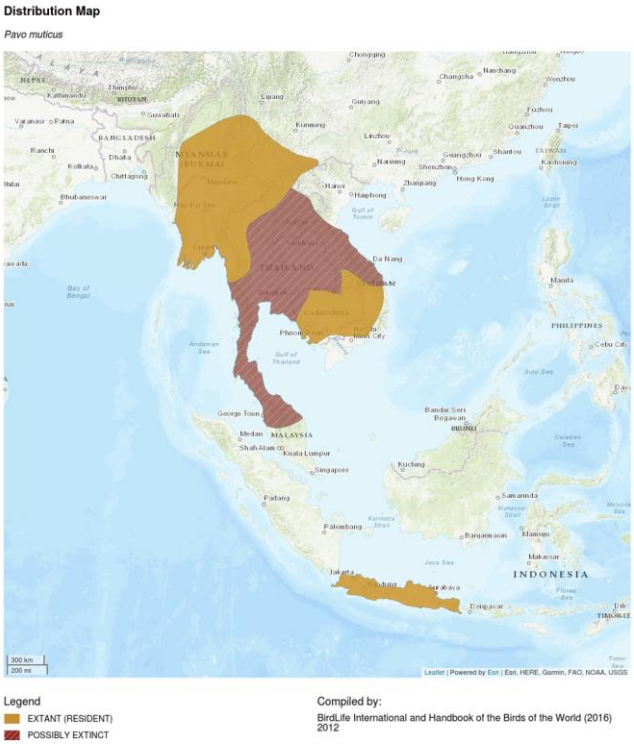

Figure 7. Distribution and IUCN status of *Pavo muticus*

Biodiversity conservation strategy in Madiun City

The problem of biodiversity in Madiun City is not significantly different from that in other urban areas in Indonesia; there is a decline in biodiversity. The threats to biodiversity arise from changes in land use and cover, the exploitation of species, the introduction of invasive species, air and water pollution, and climate change (Simkin et al. 2022). This decline is also caused by loss and degradation of habitats, as well as the continued decline in populations of various plant and animal species. All of this is the impact of human activities that cause multiple pressures on the condition of biodiversity.

Green open spaces can be a solution to preserve the biodiversity of a region while still considering various ecological, economic, and aesthetic functions. Urban greening can enhance biodiversity protection and has various benefits for humans, especially in reducing the urban heat island effect (Jansen et al. 2025). Green open spaces in Madiun City are primarily located in densely populated settlements, parks, courtyards, and green lanes. There are two types of green open spaces in Madiun City: active green open spaces and passive green open spaces. Active green open space is a type of green open space that features supporting facilities for community activities, such as gazebos, playgrounds, ponds, and other amenities. Examples of active green open spaces in Madiun City are Madiun City Square Park, Ngegong City Forest Park, Patihan City Forest Park (Madiun City Forest Park), Patihan City Park Rest Area, Banda Street Park, Kartini Park, Winongo Field Park, Madiun Kali Bantaran Traffic Park, Bantaran Park, and Gedongan KB Village Park (Gedongan Eduwisata). The condition of active open spaces in Madiun City is illustrated in Figure 8.

Passive open spaces are green open spaces that are not equipped with facilities to support citizen activities. They are only composed by vegetation community as green elements, so their existence is more of a visual urban component. Passive green open spaces include Pecel UKS Statue Park, Mie Kocok Park, East Park of the Police Post, RTH Bunderan West Ring Road Interchange, Front Park of Madiun Class 1 Prison, and Pecel Gading Statue Park. The condition of passive open space in the Manguharjo Sub-district is illustrated in Figure 9.

Green open space in residential areas is not only a visual element but also plays a role in maintaining or improving environmental health quality. Ecological health conditions tend to decline due to the reduction of green elements and open spaces. Green open spaces with many trees provide shade in an environment and help maintain coolness in the area. Trees will keep air circulation by producing oxygen and absorbing carbon dioxide. They will also absorb pollution and reduce noise. This is a function of the comfort value associated with green open spaces. Urban Green Space areas are also found in several major cities in Indonesia, with Bandung, Surabaya, and Semarang having more prominent urban green areas than Central Jakarta and Yogyakarta. This is certainly influenced by geographical conditions and population density (Agustiyara et al. 2025).

Green open spaces can fulfil the needs of animals and plants, as well as the community's social, economic, and cultural needs. The green belt can serve as a catchment area to absorb and store rainwater, helping to maintain water supplies and providing a habitat for animals to find food or shelter (Castaneda et al. 2024). Establishing biodiversity park, aviary, insectarium or arboretum can also be an option for urban areas. An aviary can be constructed with a size of 40 m², featuring plants (trees) presented as crowns within the aviary. The choice of tree species adds aesthetic value, and the aviary becomes a source of food for various bird species. For example, Talok (*Muntingia calabura*) might serve as a food source for fruit-eating birds, such as the Javanese Chili (*Dicaeum trochileum*) and other bird species (Choi et al. 2025).

Communities and local governments are key stakeholders in conservation programs in urban areas because they are the subjects that play an active role in biodiversity management. One of the legal programs in Indonesia to protect animals is the Regulation of the Indonesian Minister of Environment and Forestry No. 17 of 2024 on the rescue of animal species. The socialization of programs and laws for environmental protection and conservation within the community is a crucial process that must be carried out systematically, monitored, and regularly evaluated. Community involvement in conservation and legislation for the preservation of ecosystems and biodiversity needs to be built and strengthened through socialization and active community participation, such as the Flora-Fauna Friends program and the Biodiversity Awareness program.

Figure 8. Active green open space in Madiun City, East Java, Indonesia. A. Alun-Alun Madiun City Park, B. Ngegong City Forest Park

Figure 9. Passive green open space in Madiun City, East Java, Indonesia. A. Pecel UKS Statue Park, B. Front Park of Madiun Class 1 Prison

In conclusion, *Leucopsar rothschildi*, *Padda oryzivora*, and *Pavo muticus* are birds that are in all three categories, as CITES, IUCN, and MoeF. Green open spaces with aviaries are crucial for conserving biodiversity, as they offer a range of ecological, aesthetic, social, and economic benefits. Community participation with the local government is vital to conservation programs in urban areas. Active community involvement in conservation programs and socialization can significantly support the success of biodiversity conservation.

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