Ecological factors and spatial heterogeneity of Terrestrial Birds in Peninsular Malaysia

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Abstract. In Malaysia, multiple land use by humans has opened the way to substantial loss of wetland ecosystem, and shrinkage of the populations, habitat and food bases of avian species. However, the study of the avian population especially terrestrial birds becomes eminent to understand the complexity of wetlands ecosystem structure, and also develop appropriate management with robust monitoring tools to ensure their ecological sustainability. The study aimed to determine the eco-climatic factors that influenced the occurrence of terrestrial birds and to develop their habitat suitability models in Paya Indah wetlands (PIW) and Putrajaya wetlands (PW), Malaysia. The distance sampling point count technique using stratified random design was employed to survey (from November 2016 to January 2019) and choose 57 and 54 point stations around 14 and 24 lakes of PIW and PW respectively. An automatic linear modelling algorithm and geographic information systems were employed to compute the importance ratios of seventeen eco-climatic factors (hydrology, 9; climatic, 5; waterscape, 1 and landscape, 2). The result showed that some of the observed terrestrial birds individual and estimated indices were significant. The model showed that more than 50% of the land mass were moderately suitable in Paya Indah wetland while 35.22 % were suitable in Putrajaya wetland. Thus, the models’ adoption as management tools would help in the sustenance of the wetlands’ habitat quality and management effectiveness of the terrestrial bird species.

1. Introduction
In Malaysia, multiple lands use by humans has opened the way to substantial loss of wetland ecosystem, and shrinkage of the populations, habitat and food bases of avian species. However, the study of avian population becomes eminent to understand the complexity of wetlands ecosystem structure, and also develop appropriate management with robust monitoring tools to ensure their ecological sustainability. Researchers have also begun to explore the potential influence of climate change on bird populations [1,2,3].

However, it is very important to establish the natural relics and distribution areas of terrestrial birds with immense scientific value. Some past studies revealed the direct and indirect relationship between birds distribution and environmental factors (rainfall, atmospheric temperature, relative humidity, water temperature, land use/land cover, wind speed, barometric pressure, flood level, tree species and height, food types, types of waterbody) of wetlands be [4,5,6,7,8,9]. This is due to the drastic reduction in birds population as well as shrinkage in wetlands globally [10,12]. The fluctuation in the distribution of
terrestrials birds had reflected the spatial variability in their environmental factors on micro and macro scales [6]. Also, the spatiotemporal variation in bird assemblages is associated with seasonal variations in ecological and environmental variables [13,14].

This study explored the integration of terrestrial birds presence and absence data with associated environmental variables to predict their habitat suitability using the Automatic Linear Modelling Algorithm (ALMA) and Geographic Information System methods. Yang [15] introduced the Automatic Linear Modelling Algorithm, a form of a regression model with various model selection methods (such as forward stepwise, best subsets, include all predictors) to rank the independent variables based on the computation of predictor importance coefficient (referred to importance ratios in this study). These predictor importance coefficients are relative values, sum up to 1.0 and rank each independent (predictor) variable according to its importance to the model [16]. Understand the habitat requirements of birds and successfully manage these species, researchers are dependent on standardized collection techniques. Hence, the study aims to determine the eco-climatic factors that influences the occurrence of terrestrial birds and to develop their habitat suitability model in Paya Indah Wetland and Putrajaya wetland.

2. Materials and methods

2.1 Study Area

The study was conducted in Paya Indah Wetland. The wetland reserve is made up of about 3050ha of lands out of which 450 ha are under the management of the Department of Wildlife and National Parks, Peninsular Malaysia. (Figure 1). Also the study was undertaken at the man-made Putrajaya wetlands. It is geographically situated within 2° 57’ 43” latitude and 101° 41’ 47” longitude. It is located at 26 km south to Kuala Lumpur (Figure 1) and covers a land cover mass of 200 ha (77.70 ha planted zone, 76.80 ha vast water bodies, 9.60 ha islands, 23.70 ha immersion region and 9.40 ha tracks). The wetland comprises of five arms (upper west, upper north, upper east, bring down east, upper bisa) and central swamp. It is highly diverse in plant species which provide a distinctive microhabitat to the avian species.

2.2 Bird surveys

The distance sampling point count technique was employed to survey the avian species of man-made Putrajaya wetlands from November 2016 to July 2018. This technique is a less demanding and more proficient approach to determine the population status of avian species [17,18,19]. It involves the visual and sound-related identification of winged animals with settled or variable radius plots, and this gives critical data on species abundance, diversity and density among various natural surroundings [20,21,22]. It enhances deductibility, which permits the estimation of density and abundance of wild creatures, including birds [23]. Information was collected for 19 consecutive months. 82 count stations were systematically placed at 300 m interval apart, to avoid the double count of the same avian species at more than one station. Each point count station was surveyed for 10min. The survey was taken from 0730–1100 h. The method was followed as delineated by [17,19,23,24].

2.3 Model Development

An automatic linear modelling algorithm (ALMA) and geographic information systems were employed to compute the importance ratios of seventeen environmental factors. These seventeen factors were Atmospheric Pressure, Wind Speed, Rainfall, Relative Humidity, Atmospheric Temperature, water temperature, pH, Dissolved Oxygen, Electrical conductivity, Salinity, Turbidity, Maximum depth, Minimum depth, Water Quality Index, NDWI, NDVI and LULC (hydrology, climatic, waterscape, and landscape factors) (Fig 2).
Figure 1. Location map of Paya Indah Wetlands and Putrajaya Reserve, Peninsular Malaysia

Figure 2. Framework for habitat suitability modelling of terrestrial birds in Paya Indah Wetland of Peninsular Malaysia.

3. Results and Discussion
We also recorded 104,872 observations of terrestrial birds belonging to 71 bird species and 30 families (See Appendices A and B) using point-count distance sampling techniques in Putrajaya wetland. Most of the terrestrial birds are Least concern according to IUCN.
Table 1. Diversity indices and densities of Terrestrial Birds in Paya Indah Peninsular Malaysia

| Estimate                              | Terrestrial Birds Wetlands |
|---------------------------------------|-----------------------------|
|                                       | Paya Indah | Putrajaya | t-value | P   |
| Observed birds’ individuals           | 104,872    | 97,340    | 7.44    | 0.00* |
| Shannon’s diversity index(N)          | 7.25       | 7.84      | 16.22   | 0.00* |
| Margalefs richness index(R)           | 13.25      | 24.00     | 28.32   | 0.00* |
| Pielou’s J evenness index(E)          | 0.92       | 0.93      | 1.55    | 0.12  |

Figure 3 shows the land use/land cover of Paya Indah wetland and Putrajaya wetland. The land use map was classified into the bare ground/built-up areas, lakes marsh swamp/aquatic grassy vegetation, Semi-closed secondary forest/aquatic herbaceous vegetation and wetland boundaries in both wetlands. The Semi-closed secondary forest/aquatic herbaceous vegetation had the highest coverage (395.79) followed by the Bare ground/Built-up areas (367.61). However, the Lakes had the lowest land use/land cover (Figure 3b).

Figure 3a. Land use cover metrics for Paya Indah wetland

Figure 3b. Land use cover metrics for Putrajaya Wetland
Table 2. Attributes of the environmental factors in Paya Indah wetland and Putrajaya wetlands

| Parameters                  | Wetlands          |                  |                  |
|-----------------------------|-------------------|------------------|------------------|
|                             | Paya Indah        | Putrajaya        |                  |
| **Climatic**                |                   |                  |                  |
| Atmospheric Pressure (Hpa)  | 1009.203 - 1009.325 | 1009.436 - 1009.935 |                  |
| Wind Speed (m/s)            | 1.487 - 1.618     | 1.361 - 1.383    |                  |
| Rainfall (mm)               | 9.976 - 10.691    | 8.525 - 9.027    |                  |
| Relative Humidity (%)       | 27.855 - 77.530   | 76.958 - 78.016  |                  |
| Atmospheric temperature (°C)| 27.741 - 27.773  | 27.309 - 27.564  |                  |
| **Hydrological**            |                   |                  |                  |
| Water temperature (°C)      | 24.45 - 30.79     | 29.94 - 30.72    |                  |
| pH                          | 5.73 - 9.05       | 7.35 - 7.58      |                  |
| Dissolved Oxygen (mg/L)     | 4.47 - 8.22       | 6.12 - 7.35      |                  |
| Electrical conductivity (µS/cm)| 15.49 - 41.18   | 59.78 - 152.31   |                  |
| Salinity (ppt)              | 0.50 - 5.04       | 0.03 - 0.08      |                  |
| Turbidity (NTU)             | 2.02 - 23.73      | 12.67 - 76.85    |                  |
| Maximum depth(m)            | 3.12 - 20.74      | -                |                  |
| Minimum depth (m)           | 0.65 - 5.92       | -                |                  |
Water Quality Index   50.66 - 80.24

**Land use/land cover classes (LULC)**

| Land Use/Land Cover                        | PIW       | PW       |
|--------------------------------------------|-----------|----------|
| Marsh swamp/lotus swamp/grassy vegetation  | 310.24 (19.64) | 345.38 (24.31) |
| Semi-closed secondary forest               | 391.77 (24.80) | 395.79 (27.87) |
| Shrubland                                  | 372.75 (23.60) | -        |
| Bare ground/built-up areas                 | 131.54 (8.33) | 367.61 (25.88) |
| Lakes                                      | 373.25 (23.63) | 311.57 (21.94) |

**Normalized Difference Water Index (NDWI)**

| Type      | PIW       | PW       |
|-----------|-----------|----------|
| Water areas | 1175.23 (74.40) | 1255.79 (88.41) |
| Non-water areas | 404.32 (25.60) | 164.56 (11.59) |

**Normalized Difference Vegetation Index (NDVI)**

| Type      | PIW       | PW       |
|-----------|-----------|----------|
| Vegetated areas | 1159.96 (73.44) | 1139.86 (80.25) |
| Non-vegetated areas | 419.59 (26.56) | 280.49 (19.75) |

Each cell in LULC, NDWI and NDVI signifies “land cover area in hectares” (proportion in %)

**Figure 5a.** The performance of the fitted habitat suitability models for (B) terrestrial bird species in Paya Indah Wetland

**Figure 5b.** The performance of the fitted habitat suitability models for (B) terrestrial bird species in Putrajaya Wetlands

The performance of the fitted habitat suitability models revealed that the two models had a robust performance (Figure 5) with AUC values significantly greater than 0.50 of a random model. The AUC values for terrestrial birds in PIW and PW were 0.962 and 0.958 respectively. Habitat suitability evaluation criteria importance judgment weights for terrestrial birds in PIW and PW are presented in Table 4. Based on the automatic linear modelling result in PIW, Turbidity had the highest contribution to the habitat suitability model of a terrestrial birds with importance ratio (0.252) and weight (25.2%). However, the contributions of six factors to the habitat suitability model of terrestrial in PIW were highly significant (p ≤ 0.05) based on the automatic linear modelling. Similarly, all climatic factors contributed significantly to the model especially Relative humidity which was the highest contributor (21.82%). Land use/land cover (a measure of vegetation cover, forage availability and human activity) also contributed to the habitat suitability model of terrestrial in PW with importance ratio (0.101) and weight (10.11).

Figure 5 shows the habitat suitability models of terrestrial birds in PIW and PW. From the habitat suitability map in PIW, it was observed that the moderately suitable area for terrestrial birds occupied the highest land cover mass of 535.40ha (33.90%), while the highly suitable area for terrestrial birds occupied the least land cover mass of 103.55ha (6.56%) (Table 3). The habitat suitability map for
terrestrial birds in PW showed that the suitable area for terrestrial birds occupied the highest land cover mass of 430.28 ha (30.29%), while the highly non-suitable area for terrestrial birds occupied the least land cover mass (<1%).

Figure 6. Habitat suitability models of Terrestrial birds in Paya Indah Wetlands and Putrajaya wetland of Peninsular Malaysia

Table 3. Habitat suitability evaluation criteria importance judgment weights for terrestrial birds in Paya Indah and Putrajaya wetlands

| Criteria      | Factors                  | Paya Indah Importance ratio | Weight (%) | Rank | Putrajaya Importance ratio | Weight (%) | Rank |
|---------------|--------------------------|----------------------------|------------|------|----------------------------|------------|------|
| Hydrology     | Econd(uS/cm)             | 0.000<sup>ns</sup>         | 0.00       | 14   | 0.021<sup>ns</sup>         | 2.10       | 8    |
|               | DO(mg/L)                 | 0.033<sup>ns</sup>         | 3.30       | 9    | 0.021<sup>ns</sup>         | 2.10       | 8    |
|               | WQI                      | 0.153<sup>*</sup>          | 15.30      | 2    |                            |            |      |
|               | Turbidity(NTU)           | 0.252<sup>*</sup>          | 25.20      | 1    | 0.021<sup>ns</sup>         | 2.10       | 8    |
|               | Temperature(°C)          | 0.000<sup>ns</sup>         | 0.00       | 14   | 0.021<sup>ns</sup>         | 2.10       | 8    |
|               | Salinity(ppt)            | 0.100<sup>*</sup>          | 10.00      | 5    | 0.021<sup>ns</sup>         | 2.10       | 8    |
|               | pH                       | 0.090<sup>*</sup>          | 9.00       | 6    | 0.021<sup>ns</sup>         | 2.10       | 8    |
|               | Minimum Depth(m)         | 0.038<sup>ns</sup>         | 3.80       | 8    |                            |            |      |
|               | Maximum Depth(m)         | 0.059<sup>ns</sup>         | 5.90       | 7    |                            |            |      |
| Climatic      | Relative humidity(%)     | 0.004<sup>ns</sup>         | 0.40       | 11   | 0.218<sup>*</sup>          | 21.82      | 1    |
|               | Rainfall(mm)             | 0.005<sup>ns</sup>         | 0.50       | 10   | 0.085<sup>*</sup>          | 8.51       | 6    |
|               | Wind Speed(m/s)          | 0.005<sup>ns</sup>         | 0.50       | 10   | 0.135<sup>*</sup>          | 13.51      | 4    |
Gross Arithmetic Mean (GAM) of importance ratio for terrestrial birds in Paya Indah = 0.063
Gross Arithmetic Mean (GAM) of importance ratio for terrestrial birds in Putrajaya = 0.071

Table 4. Attributes of habitat suitability models for terrestrial birds in Paya Indah and Putrajaya Wetland

| Suitability classes | Paya Indah | Putrajaya |
|---------------------|------------|-----------|
|                     | Area (Ha)  | Proportion (%) | Area (Ha)  | Proportion (%) |
| Highly suitable     | 0.10       | 0.01       | 423.85     | 29.84       |
| Suitable            | 298.33     | 18.89      | 500.22     | 35.22       |
| Moderately suitable | 800.62     | 50.69      | 318.34     | 22.41       |
| Non-suitable        | 480.25     | 30.40      | 177.11     | 12.47       |
| Highly non-suitable | 0.26       | 0.02       | 0.84       | 0.06        |
| Total               | 1,579.55   | 100.00     | 1,420.35   | 100.00      |

Hydrology variables such as WQI, turbidity salinity and pH significantly contributed to the abundance of terrestrial birds in Paya Indah Wetland. This may be due to its rich aquatic flora and fauna present in the lakes in the wetland. This agrees with Rajpar and Zakaria [25] that hydrology was an important criterion for wetland bird’s diversity. Also, all climatic variables studied significantly contributed to the occurrence of terrestrial birds in Putrajaya wetlands. Several studies like [17,19,26] have highlighted the influence of climatic variables on the habitat and wetlands which may influence the presence or absence of some bird species.

Both wetlands experienced one form of human activities or the other. Zakaria and Rajpar and La Sorte et al. [25,27], reported that agricultural activities coupled with tourism infrastructural development to be the major anthropogenic activities over the years in Paya Indah Wetland. Also, urban sprawling and water purification/supply could have attributed to the landscape dynamics and variation of Putrajaya Wetland. This study was supported by the findings of Rajpar and Zakaria and Jahanbakhsh et al. [28,29] that vegetation cover affected the habitat selection, distribution and diversity of wetland birds. Furthermore, the influence of climate change on wetlands’ vegetation composition, structure, hydro-morphological properties, and consequently the populations’ distribution and sustainability of waterbirds in wetlands cannot be underestimated. According to Shekhawat et al.; Paolini et al.; and Mundkur et al. [30,31,32], this global phenomenon had broad impacts on the distribution, morphology, carrying capacities and seasonal variations of wetlands connected to the feeding and breeding activities of birds.

Conclusion
The results of this study revealed that terrestrial birds had a rich diversity in Paya Indah Wetland and Putrajaya Wetlands. This is due to the rich vegetation and suitable aquatic food present in the wetlands. In addition, the occurrence and richness of food resources such as fruits, seeds, insects (locus, moths, butterflies, crickets, flies, termites and beetles), nectar, reptiles (lizards, snakes), mammals (mice and rats), amphibians and birds is also a key factor that affects diversity and richness of bird species [33]. This Model approach can be adopted as a management tool coupled with a robust population monitoring
database to enhance management effectiveness of terrestrial bird species in the wetland. We recommend that a meteorological station should be established in this wetlands in order to sample the microclimatic data such as rainfall, sunshine, relative humidity and wind speed in the area. These microclimatic data will be useful in future ecological studies.

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Appendix A

Table A1. Terrestrial birds and their IUNC Status in Putrajaya Wetland

| Family          | Scientific Name     | Common Names                  | IUCN Status | Total Observation | Rank(%) |
|-----------------|---------------------|-------------------------------|-------------|-------------------|---------|
| Pycnonotidae    | *Pycnonotus goiavier* | Yellow-vented Bulbul          | LC          | 16,079            | 16.52   |
| Columbidae      | *Treron vernans*    | Pink-necked Green Pigeon      | LC          | 10,986            | 11.29   |
| Sturnidae       | *Aplonis panayensis*| Philippine Glossy Starling    | LC          | 10,943            | 11.24   |
| Columbidae      | *Streptopelia chinensis* | Spotted Dove                | LC          | 5,496             | 5.65    |
| Sturnidae       | *Acroderhues fuscus* | Jungle Myna                  | LC          | 5,553             | 5.29    |
| Columbidae      | *Geopelia striata*  | Peaceful Dove                | LC          | 4,805             | 4.94    |
| Passeridae      | *Passer montanus*   | Eurasian Tree Sparrow        | LC          | 4,177             | 4.29    |
| Sturnidae       | *Acridotheres tristis* | Common Myna                | LC          | 4,415             | 4.21    |
| Turdidae        | *Copsychus saularis*| Oriental Magpie Robin        | LC          | 3,563             | 3.65    |
| Ploceidae       | *Ploceus philippinus* | Baya Weaver                | LC          | 2,300             | 2.36    |
| Rhipiduridae    | *Rhipidura javanica* | Pied Fantail                | LC          | 2,053             | 2.11    |
| Estrildidae     | *Lonchura punctulat*| Scaly-breasted Munia        | LC          | 2,018             | 2.07    |
| Columbidae      | *Columba livia*     | Rock Pigeon                 | LC          | 1,757             | 1.80    |
| Phasianidae     | *Gallus gallus*     | Red Junglefowl              | LC          | 1,715             | 1.76    |
| Sturnidae       | *Acridotheres javanicus* | White-vented Myna        | VU          | 1672              | 1.72    |
| Oriolidae       | *Oriolus chinensis* | Black-naped Oriole          | LC          | 1,731             | 1.65    |
| Chloropseidae   | *Aegithina viridissima* | Green Iora              | NT          | 1,595             | 1.52    |
| Laniidae        | *Lanius cristatus*  | Brown Shrike                | LC          | 1,556             | 1.48    |
| Estrildidae     | *Lonchura maja*     | White-headed Munia          | LC          | 1,376             | 1.41    |
| Meropidae       | *Merops philippinus*| Blue-tailed Bee-eater       | LC          | 1,256             | 1.29    |
| Cisticolidae    | *Prinia flavigentris* | Yellow-bellied Prinia     | LC          | 960               | 0.99    |
| Motacillidae    | *Anthus novaeseelandiae* | Richards Pipit          | LC          | 896               | 0.92    |
| Sylvidae        | *Orthotomus ruficeps* | Ashy Tailoredbird          | LC          | 811               | 0.83    |
| Chloropseidae   | *Aegithina tipher*  | Common Iora                 | LC          | 613               | 0.58    |
| Coracidae       | *Eurystomus orientalis* | Dollar Bird          | LC          | 389               | 0.37    |
| Nectarinidae    | *Nectarinia jugularis* | Olive-backed Sunbird      | LC          | 360               | 0.37    |
| Corvidae        | *Corvus splendens*  | House Crow                  | LC          | 296               | 0.30    |
| Sylvidae        | *Orthotomus sutorius* | Common Tailorbird         | LC          | 282               | 0.27    |
| Corvidae        | *Corvus macrorynchos* | Large-billed Crow         | LC          | 282               | 0.27    |
| Nectarinidae    | *Anthreptes malacensis* | Brown-throated Sunbird   | LC          | 272               | 0.26    |
| Cuculidae       | *Cacomantis merulinus* | Plaintive Cuckoo        | LC          | 263               | 0.25    |
| Cuculidae       | *Eudynamys scolopacea* | Common Asian Koel        | LC          | 219               | 0.22    |
| Sylvidae        | *Acrocephalus orientalis* | Oriental Reed Warbler | LC          | 205               | 0.21    |
| Family          | Scientific Name          | Common Names                  | IUCN Status | Total Observation | Rank(%) |
|----------------|--------------------------|-------------------------------|-------------|-------------------|---------|
| Meropidae      | *Merops viridis*         | Blue-throated Bee-eater      | LC          | 198               | 0.20    |
| Campephagidae  | *Lalage nigra*           | Pied Triller                 | LC          | 137               | 0.17    |
| Nectarinidae   | *Anithreptes simplex*    | Plain Sunbird                | LC          | 175               | 0.17    |
| Pycnonotidae   | *Pycnonotus plumosus*    | Olive-winged Bulbul          | LC          | 155               | 0.16    |
| Megalaimidae   | *Megalaima haemacephala* | Copper-smith Barbet          | LC          | 148               | 0.15    |
| Cisticolidae   | *Cisticola juncidis*     | Zitting Cisticola            | LC          | 126               | 0.12    |
| Picidae        | *Celeus brachyurus*      | Rufous Woodpecker            | LC          | 120               | 0.12    |
| Sturnidae      | *Sturnus sturninus*      | Asian Pied Starling          | LC          | 113               | 0.12    |
| Zosteropidae   | *Zosterops palpebranosus*| Oriental White-eye           | LC          | 106               | 0.11    |
| Muscicapidae   | *Muscicapa dauaurica*    | Asian Brown                  | LC          | 106               | 0.11    |
| Cisticolidae   | *Cisticola juncidis*     | Zitting Cisticola            | LC          | 85                | 0.09    |
| Picidae        | *Dinopium javanense*     | Common Flameback             | LC          | 92                | 0.09    |
| Phasianidae    | *Turnix suscitator*      | Barred Button Quail          | LC          | 92                | 0.09    |
| Columbidae     | *Chalcophaps indica*     | Emerald Dove                 | LC          | 78                | 0.08    |
| Dicaeidae      | *Dicaeum cruentatum*     | Scarlet-backed Flowerpecker  | LC          | 78                | 0.08    |
| Estrildidae    | *Lonchura malacca*       | Black-headed Munia           | LC          | 71                | 0.07    |
| Nectarinidae   | *Arachnothera longirostra*| Little Speiderhunter         | LC          | 49                | 0.05    |
| Nectarinidae   | *Anithreptes rhodolaema* | Red-throated Sunbird         | NT          | 49                | 0.05    |
| Picidae        | *Centropus sinensis*     | Greater Coucal               | LC          | 42                | 0.04    |
| Picidae        | *Picumnus innomintus*    | Speekled Piculet             | LC          | 42                | 0.04    |
| Timaliidae     | *Argya earlei*           | Striated Babbler             | LC          | 28                | 0.03    |
| Pycnonotidae   | *Pycnonotus jocosus*     | Red-whiskered Bulbul         | LC          | 28                | 0.03    |
| Picidae        | *Cacomantis solleraitii* | Banded Bay Cuckoo            | LC          | 28                | 0.03    |
| Picidae        | *Passer domesticus*      | House Sparrow                | LC          | 28                | 0.03    |
| Dicuridae      | *Dicrurus macrocerus*    | Black Drongo                 | LC          | 21                | 0.02    |
| Nectarinidae   | *Arachnothera flavigaster*| Spectacled Spiderhunter     | LC          | 21                | 0.02    |
| Accipitridae   | *Elanus caeruleus*       | Black-shouldered Kite        | LC          | 21                | 0.02    |
| Accipitridae   | *Accipiter gularis*      | Japanese Sparrow Hawk       | LC          | 14                | 0.01    |
| Accipitridae   | *Avicea leophotes*       | Black Baza                  | LC          | 14                | 0.01    |
| Estrildidae    | *Lonchura leucogastroides*| Javan Munia               | LC          | 14                | 0.01    |
| Columbidae     | *Treron curvirostra*     | Thick-billed Green Pigeon    | LC          | 14                | 0.01    |
| Picidae        | *Cuculus Micropterus*    | Indian Cuckoo               | LC          | 14                | 0.01    |
| Picidae        | *Chrysococcyx xanthorhynchus*| Violet Cuckoo           | LC          | 14                | 0.01    |
| Laniidae       | *Lanius schach*          | Long-tailed Shrike           | LC          | 14                | 0.01    |
| Caprimulgidae  | *Caprimulgus macrurus*   | Large-tailed Nightjar        | LC          | 14                | 0.01    |
| Nectarinidae   | *Arachnothera chrysogenys*| Yellow-eared Spiderhunter   | LC          | 14                | 0.01    |
| Accipitridae   | *Spilornis cheela*       | Serpent Eagle               | LC          | 7                 | 0.00    |
## Appendix B

### Table B1. Terrestrial birds and their IUCN Status in Paya Indah Wetland

| Family       | Scientific Name            | Common Names                  | IUCN Status | Total Observation | Rank(%) |
|--------------|----------------------------|-------------------------------|-------------|-------------------|--------|
| Pycnonotidae | *Pycnonotus goiavier*      | Yellow-vented Bulbul          | LC          | 16,367            | 15.61  |
| Columbidae   | *Treron vernans*           | Pink-necked Green Pigeon      | LC          | 16,756            | 15.98  |
| Columbidae   | *Geopelia striata*         | Zebra Dove                    | LC          | 10,230            | 9.76   |
| Columbidae   | *Streptopelia chinensis*   | Spotted Dove                  | LC          | 8,548             | 8.15   |
| Sturnidae    | *Acridotheres fuscus*      | Jungle Myna                   | LC          | 5,553             | 5.29   |
| Sturnidae    | *Acridotheres tristis*     | Common Myna                   | LC          | 4,415             | 4.21   |
| Estrildidae  | *Lonchura punctulata*      | Scaly-breasted Munia          | LC          | 3,987             | 3.80   |
| Ploceidae    | *Ploceus philippinus*      | Baya Weaver                   | LC          | 3,676             | 3.51   |
| Hirundinidae | *Hirundo tahitica*         | Pacific Swallow               | LC          | 3,433             | 3.27   |
| Meropidae    | *Merops philippinus*       | Blue-tailed Bee-eater         | LC          | 3,394             | 3.24   |
| Motacillidae | *Anthus richardi*          | Richard's Pipit               | LC          | 2,499             | 2.38   |
| Oriolidae    | *Oriolus chinensis*        | Black-naped Oriole            | LC          | 2,081             | 1.98   |
| Passeridae   | *Lonchura malacca*         | Black-headed Munia            | LC          | 2,081             | 1.98   |
| Muscipicidae | *Copsychus saularis*       | Oriental Magpie Robin         | LC          | 1,974             | 1.88   |
| Sturnidae    | *Aplonis panayensis*       | Philippine Glossy Starling    | LC          | 1,886             | 1.80   |
| Rhipiduridae | *Rhipidura javanica*       | Pied Fantail                  | LC          | 1,624             | 1.55   |
| Aegithinidae | *Aegithina virdissima*     | Green Iora                    | NT          | 1,595             | 1.52   |
| Laniidae     | *Lanius cristatus*         | Brown Shrike                  | LC          | 1,556             | 1.48   |
| Passeridae   | *Passer montanus*          | Eurasian Tree Sparrow         | LC          | 1,089             | 1.04   |
| Sturnidae    | *Acrocephalus grangis*     | Great myna                    | LC          | 1,050             | 1.00   |
| Cuculidae    | *Centropus bengalensis*    | Lesser Coucal                 | LC          | 1,031             | 0.98   |
| Campephagida | *Lalage nigra*             | Pied Triller                  | LC          | 535               | 0.51   |
| Columbidae   | *Treron bicincta*          | Orange-breasted Green Pigeon  | LC          | 535               | 0.51   |
| Coraciidae   | *Eurystomus orientalis*    | Dollar Bird                   | LC          | 389               | 0.37   |
| Meropidae    | *Merops viridis*           | Blue-throated Bee-eater       | LC          | 360               | 0.34   |
| Acrocephalidae | *Acrocephalus orientalis* | Oriental Reed Warbler         | LC          | 340               | 0.32   |
| Cisticolidae | *Orthotormus sutorias*     | Common Tailorbird             | LC          | 282               | 0.27   |

**LC =Least Concern, NT= Near Threatened, VU= Vulnerable, IUCN= International Union for Conservation of Nature,**
| Family             | Scientific Name                  | Common Names                  | IUCN Status | Total Observation | Rank(%) |
|--------------------|----------------------------------|-------------------------------|-------------|-------------------|---------|
| Corvidae           | *Corvus macrorhynchos*           | Large-billed Crow             | LC          | 282               | 0.27    |
| Nectariniidae      | *Anthreptes malacensis*          | Brown-throated Sunbird        | LC          | 272               | 0.26    |
| Cuculidae          | *Cacomantis meralinus*           | Plaintive Cuckoo              | LC          | 263               | 0.25    |
| Cuculidae          | *Cacomantis meralinus*           | Plaintive Cuckoo              | LC          | 263               | 0.25    |
| Cisticolidae       | *Orthotomus ruficeps*            | Ashy Tailorbird               | LC          | 243               | 0.23    |
| Campephagidae      | *Pericrocotus diversicatus*      | Ashy Minivet                  | LC          | 243               | 0.23    |
| Nectariniidae      | *Nectarinia jugularis*           | Olive-backed Sunbird          | LC          | 224               | 0.21    |
| Pycnonotidae       | *Pycnonotus plumosus*            | Olive-winged Bulbul           | LC          | 224               | 0.21    |
| Nectariniidae      | *Cinnyris jugularis*             | Olive-backed Sunbird          | LC          | 224               | 0.21    |
| Corvidae           | *Corvus splendens*               | House Crow                    | LC          | 204               | 0.19    |
| Cuculidae          | *Chrysococcyx minutillus*        | Little Bronze Cuckoo          | LC          | 195               | 0.19    |
| Turnicidae         | *Turnix suscitator*              | Barred Button Quail           | LC          | 195               | 0.19    |
| Accipitridae       | *Elanus caeruleus*               | Black-shouldered Kite         | LC          | 165               | 0.16    |
| Cuculidae          | *Centropus sinensis*             | Greater Coucal                | LC          | 146               | 0.14    |
| Muscicapidae       | *Muscicapa dauurica*             | Asian Brown Flycatcher        | LC          | 136               | 0.13    |
| Estrildidae        | *Lonchura maja*                  | White-headed Munia            | LC          | 126               | 0.12    |
| Caprimulgidae      | *Caprimulgus macrurus*           | Large-tailed Nightjar         | LC          | 117               | 0.11    |
| Caprimulgidae      | *Caprimulgus affinis*            | Savanna Nightjar              | LC          | 117               | 0.11    |
| Cisticolidae       | *Cisticola juncidis*             | Zitting Cisticola             | LC          | 113               | 0.12    |
| Columbidae         | *Treron olax*                    | Little Green Pigeon           | LC          | 107               | 0.10    |
| Pachycephalidae    | *Pachycephala grisola*           | Mangrove Whistler             | LC          | 78                | 0.07    |
| Cisticolidae       | *Orthotomus sericeus*            | Rufous-tailed Tailorbird      | LC          | 58                | 0.06    |
| Sturnidae          | *Gracula religiosa*              | Common Hill Myna              | LC          | 58                | 0.06    |
| Nectariniidae      | *Aethopyga christinae*           | Fork-tailed sunbird           | LC          | 58                | 0.06    |
| Phasianidae        | *Coturnix chinensis*             | King quail                    | LC          | 58                | 0.06    |
| Picidae            | *Celeus brachyurus*              | Rufous Woodpecker             | LC          | 58                | 0.06    |
| Nectariniidae      | *Arachnothera longirostra*       | Little Spiderhunter           | LC          | 49                | 0.05    |
| Laniidae           | *Lanius schach*                  | Long-tailed Shrike            | LC          | 29                | 0.03    |
| Locustellidae      | *Locustella certhiola*           | Pallas's grasshopper warbler  | LC          | 29                | 0.03    |
| Nectariniidae      | *Nectarinia calcostetha*         | Copper-throated Sunbird       | LC          | 29                | 0.03    |
| Picidae            | *Picus flavinucha*               | Greater Yellow-nape           | LC          | 29                | 0.03    |
| Accipitridae       | *Avicea leuophotes*              | Black Baza                    | LC          | 14                | 0.01    |
| Accipitridae       | *Haliastur indus*                | Brahminy Kite                 | LC          | 10                | 0.01    |
| Accipitridae       | *Circus aeruginosus*             | Western Marsh Harrier         | LC          | 10                | 0.01    |
| Accipitridae       | *Haliaetus leucogaster*          | White-bellied sea Eagle       | LC          | 10                | 0.01    |
| Cisticolidae       | *Prinia rufescens*               | Rufescent Prinia              | LC          | 10                | 0.01    |
| Columbidae         | *Treron curvirostra*             | Thick-billed Green Pigeon     | LC          | 10                | 0.01    |
| Family         | Scientific Name                  | Common Names                | IUCN Status | Total Observation | Rank(%) |
|---------------|----------------------------------|-----------------------------|-------------|-------------------|---------|
| Cuculidae     | Clamator coromandus              | Chestnut-winged Cuckoo      | LC          | 10                | 0.01    |
| Cuculidae     | Eudynamys scolopacea             | Common Koel                 | LC          | 10                | 0.01    |
| Emberizidae.  | Emberiza aureola                 | Yellow-breasted Bunting     | LC          | 10                | 0.01    |
| Nectariniidae | Nectarinia sperata               | Purple-throated Sunbird     | LC          | 10                | 0.01    |
| Phylloscopidae| Phylloscopus inornatus           | Yellow-browed Warbler       | LC          | 10                | 0.01    |
| Picidae       | Picumnus innominatus             | Speckled Piculet            | LC          | 10                | 0.01    |
| Phylloscopidae| Phylloscopus borealis            | Arctic Warbler              | LC          | 7                 | 0.00    |
| Dicruridae    | Dicrurus leucophaeus             | Ashy Drongo                 | LC          | 0.00              | 0.00    |

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