Functional and Taxonomic Diversity of Avian Communities Across Land-Use Gradients in Wayanad Using eBird Data

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Abstract

Understanding bird diversity across land use and land cover (LULC) in fragmented landscapes is essential for effective conservation planning in human-modified landscapes. Using one year of eBird data from 2023, this study assessed bird species richness, diversity indices, and feeding guild composition across ten LULC classes in Wayanad, southern India. We employed rarefaction methods to estimate effort-adjusted species richness due to unequal sampling effort across classes, and analysed community composition using Jaccard dissimilarity and Principal Coordinates Analysis (PCoA). Natural habitats, primarily evergreen and moist deciduous forests, supported the most diverse and functionally specialised bird communities. In contrast, agricultural and urban areas were dominated by generalist guilds such as omnivores and granivores, indicating ecological simplification. Interestingly, tea plantations exhibited high rarefied richness despite lower overall diversity, likely due to uneven sampling patterns. The study demonstrates that citizen science data can reveal meaningful patterns in bird community structure across varied land use types with appropriate analytical corrections. These findings highlight the potential of eBird for landscape-scale biodiversity monitoring and support the value of integrating functional guild perspectives into conservation strategies.

Keywords: eBird, Citizen Science, Aves, Wayanad, Western Ghats. LULC

1 Introduction

Wayanad district lies within northern Kerala, India's ecologically significant Western Ghats. Covering approximately 2,131 km^2, the district exhibits substantial topographic variation. Elevations range from about 700 meters in the eastern plains to 2,100 meters in the western highlands, supporting diverse habitats (Das, 2024). The high-altitude Shola habitats in the Western Ghats gradually slope eastward to form the Wayanad Plateau, which merges into the Deccan Plateau. This transitional landscape encompasses montane forests and grasslands, mid-elevation evergreen forests, riparian zones, wetland marshes, and moist deciduous forests (Easa & Rajesh, 2025). The Wayanad

Plateau is a notable geomorphic feature within the otherwise dissected terrain of the Western Ghats (Sundarajan *et al.*, 2014). The diverse landscape of Wayanad, interspersed with a mosaic of urban settlements and fragmented habitats, has created a complex environment for its fauna. Over the past century, the region has experienced significant landscape fragmentation. Large-scale inward migration and agricultural expansion during the mid-1900s led to the widespread conversion of forests into farmland, disrupting the continuity of habitats and breaking up expansive forest tracts into narrow, isolated patches (Nair *et al.*, 1978). Human settlements and commercial plantations have increasingly separated the western evergreen forests from the eastern deciduous zones, intensifying habitat fragmentation (Anoop & Ganesh, 2020). Wayanad district supports a rich avian population comprising resident and migratory species, reflecting the region's ecological richness. The district's unique topography, varied microclimates, and a mosaic of habitat types influence the avian diversity. One notable species is the Banasura Chilappan (*Montecincla jerdoni*), listed as Endangered by the IUCN. Fewer than 2,000 individuals are estimated to survive, restricted to elevations above 1,200 meters in the mountainous shola forests of Wayanad. This species is a habitat specialist, highly adapted to dense shola vegetation (BirdLife International, 2024). Forested areas support such specialists, while agricultural and human-modified landscapes provide habitats for generalist species that often move between different habitats (Waltert *et al.*, 2005). Endemic flora and fauna further enhance habitat quality, contributing to Wayanad's significance as a key region for avian biodiversity conservation (Joseph, 2023). As of May 2025, citizen scientists and researchers have recorded over 360 bird species in Wayanad, based on 32,725 checklists submitted by 1,630 contributors to eBird, a citizen science platform managed by the Cornell Lab of Ornithology (eBird, 2025). Increasing landscape fragmentation poses significant challenges for bird communities by altering species composition, reducing abundance, disrupting movement patterns through limited resource access, and increasing edge effects. Understanding how avian diversity in such a fragmented landscape is crucial for effective conservation planning. This study aims to assess bird species diversity and habitat preference across different land-use types in Wayanad across seasons from the eBird-based data, thereby providing insights into citizen science-based data to see the land-use patterns of avian populations in this ecologically significant region.

2 Methodology

Study Area

The study area, Wayanad district in Kerala, lies along the escarpment of the Western Ghats between N Lat. 11° 26′ 54″ to 11° 58′ 52″ and E Long. 75° 46′ 11″ to 76° 25′ 8″(Achu *et al.*, 2021). Spanning 2,131 km^2, approximately 40 % of Wayanad is under forest cover, administered by the North Wayanad, South Wayanad, and Wayanad Wildlife Divisions (Census of India 2011). The district is an east-sloping plateau with elevations ranging from 700–2100 m asl and drained by the River Kabini, one of the three east-flowing rivers in Kerala, a major tributary of the River Cauvery. It forms ecological continuums with Coorg in Karnataka to the north-west, the Nilgiris in Tamil Nadu to the southeast, and the Malabar plains to the west (Logan, 1887). The region receives an

average annual rainfall of 2,322 mm with a distinct west-to-east rainfall gradient due to orographic effects (John *et al.*, 2020). During the summer months (March to May), temperatures range between 20°C and 36°C, with reduced rainfall supporting the breeding activities of birds in grasslands and deciduous forests (Daniels, 1997). The southwest monsoon season (June to September) brings heavy rainfall, averaging 2500-3000 mm annually, revitalising rivers and dense evergreen forests but posing challenges like soil erosion and habitat disruptions (Pascal, 1988). This period supports rainforest species such as hornbills and kingfishers. From October to November, the northeast monsoon starts with low rainfall intensity. The Dry season (December to February) is marked by cooler temperatures, ranging from 15°C to 25°C, attracting migratory species while endemic birds like the Wynaad Laughing Thrush and Nilgiri Wood Pigeon thrive in shola forests and wetlands (Ali & Ripley, 1987).

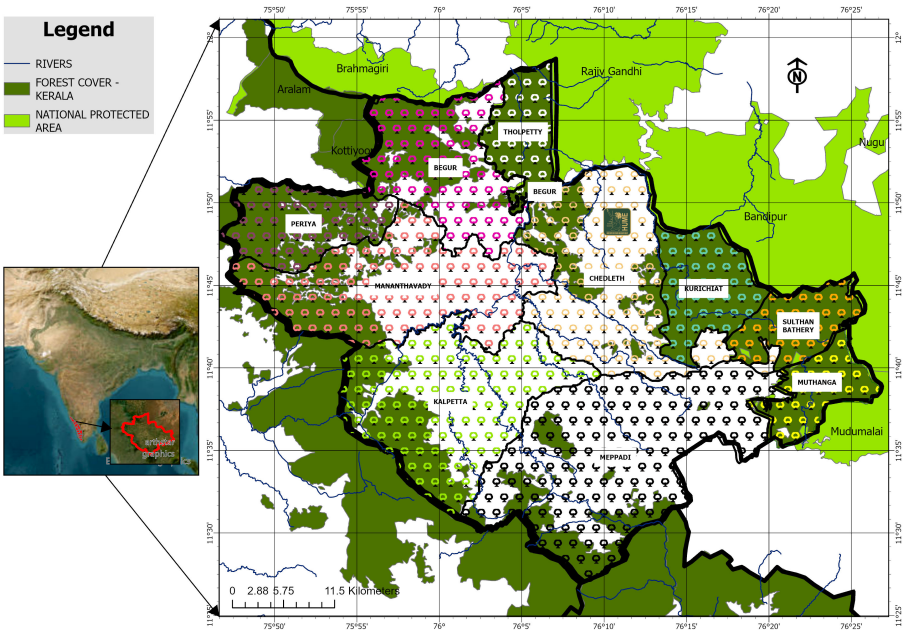


Figure 1: Map showing the study area.

Data Collection

Collecting eBird data

eBird Open Data, managed by the Cornell Lab of Ornithology, is a globally accessible platform aggregating real-time bird observation data. This platform leverages contributions from citizen scientists, birdwatchers, researchers, and conservationists to document bird sightings across diverse species and locations. For this study, eBird data from January to December 2023 were utilised. The raw dataset underwent a meticulous cleaning to ensure its quality and reliability. Duplicates and unnecessary columns were removed to streamline the data for analysis. The cleaned dataset was then sorted based on the seasonality in Western Ghats, processed in ArcGIS Pro (Fig.2), where

additional geographic information, such as elevation and land cover type, was extracted for each species.

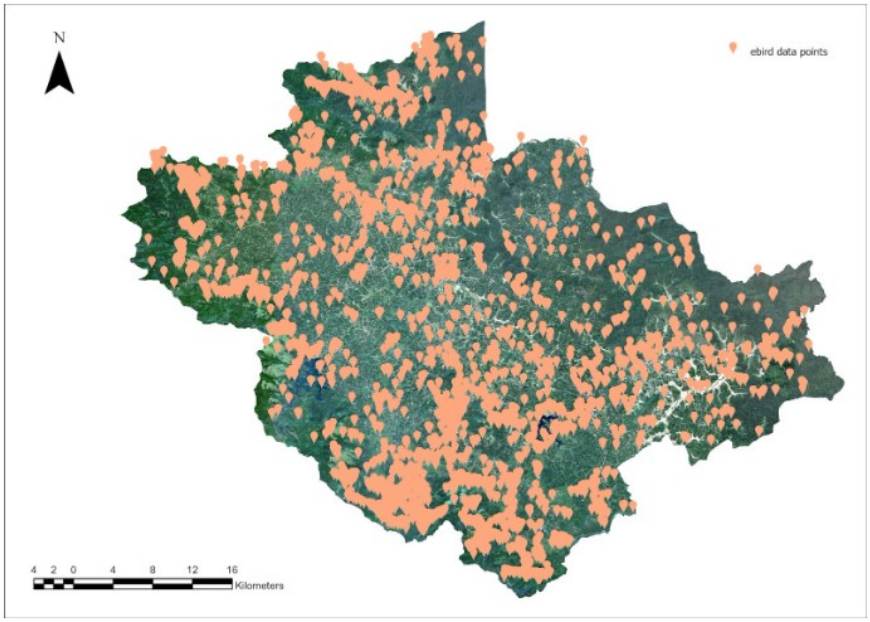


Figure 2: Map showing the distribution of eBird checklists submitted in Wayanad district, Kerala, India, from January 2023 to December 2023, illustrating spatial patterns of bird observation records.

Land Cover and Land Use Classification Using Sentinel-2 Imagery

Image Acquisition

The study utilised Sentinel-2 imagery with a 10-meter spatial resolution to classify land cover and land use (LULC) patterns. Sentinel-2, equipped with a Multispectral Instrument (MSI) (European Space Agency [ESA], 2015), provides high-resolution imagery across multiple spectral bands, making it suitable for detailed LULC analysis. Specifically, Level-2A surface reflectance products were employed, which are atmospherically corrected and ready for analysis. Initially, the Sentinel-2 imagery for the study area and period of December 2023 was downloaded as .SAFE format from the Copernicus Open Access Hub. The selected tiles were preprocessed to ensure data quality. Preprocessing steps included cloud masking using the Sentinel-2 Quality Assessment Band (QA60) and spectral correction to minimise atmospheric distortions. These steps were performed using the Sentinel Application Platform (SNAP).

Preprocessing

Key spectral bands were extracted at a 10-meter resolution (e.g., Blue, Green, Red, and Near-Infrared). Additional spectral indices, such as the Normalised Difference Vegetation Index (NDVI)

and Normalised Difference Water Index (NDWI), were calculated to enhance feature differentiation. These indices facilitated the classification of vegetation, water bodies, and built-up areas. The study utilised supervised classification methods to categorise the LULC types. Training samples for distinct land cover classes, including built-up areas, vegetation, water bodies, and barren land, were manually delineated based on ground truth data, satellite imagery, and ancillary datasets. A machine learning algorithm, maximum likelihood classification (MLC), was implemented for classification. The algorithm was chosen for its robustness in handling high-dimensional data and its proven performance in remote sensing applications.

Normalized Difference Vegetation Index (NDVI)

$$\text{NDVI} = \frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}}$$

Normalized Difference Water Index (NDWI)

$$\text{NDWI} = \frac{\text{Green} - \text{NIR}}{\text{Green} + \text{NIR}}$$

Post-classification

The results were validated using a confusion matrix and accuracy metrics. Validation was performed by comparing the classified results with independent ground truth data and high-resolution imagery. The confusion matrix was generated using the confusion_matrix function from the scikit-learn library. This matrix provides a detailed breakdown of classification results. Accuracy, a measure of overall classification performance, was calculated as the ratio of correctly classified instances to the total number of predictions. This was computed using the accuracy$_{s}corefunctionfromthesamelibrary.Theformulausedis:$

$$\text{Accuracy} = \frac{\text{Number of correct predictions}}{\text{Total number of predictions}}$$

To enhance interpretability, the confusion matrix was visualized as a heatmap using the seaborn library.

Statistical Packages

All analyses were conducted using Python. Data manipulation was performed using pandas and numpy. Diversity and dissimilarity metrics were computed using the scikit-bio package. Guild composition, rarefaction, and ordination results were visualised using seaborn and matplotlib.

Guild Assignment

All bird species were assigned to one of six major feeding guilds based on published ecological traits: carnivores, frugivores, granivores, insectivores, nectarivores, and omnivores. Guild assignments were conducted at the species level using regional field guides and trait databases (Tobias *et al.*, 2022). Guild composition was then aggregated by LULC class, and the relative abundance of each guild was computed per habitat type.

Rarefaction and Diversity Indices

Rarefaction was used to standardise species richness estimates to address variation in sampling effort across LULC classes. Rarefied richness was calculated to a common number of observations per LULC class, allowing for unbiased comparisons. In addition to richness, we calculated Shannon and Simpson diversity indices to quantify species richness and evenness. These indices were computed separately for raw and rarefied datasets to assess the influence of sampling effort. The expected number of species in a rarefied sample of size n is calculated as:

$$\hat{S}(n) = \sum_{i=1}^{S} \left[1 - \frac{\binom{N-n_i}{n}}{\binom{N}{n}} \right] \tag{1}$$

Where:

- $\hat{S}(n)$ is the expected number of species in a sample of size n,
- N is the total number of individuals across all species,
- n_i is the number of individuals of species i,
- S is the observed species richness,
- n is the rarefied subsample size.

Diversity was further quantified using the Shannon and Simpson indices. The Shannon Index is defined as:

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i) \tag{2}$$

Where p_i is the relative abundance of species i. A higher H' indicates greater species diversity and evenness.

The Simpson Index accounts for the probability that two individuals randomly selected from a sample belong to different species:

$$D = 1 - \sum_{i=1}^{S} p_i^2 \tag{3}$$

This index ranges from 0 to 1, where higher values denote greater diversity.

Dissimilarity and Community Ordination (PCoA)

We used the Bray-Curtis dissimilarity index to quantify differences in species composition among LULC classes. A Principal Coordinates Analysis (PCoA) was then conducted to visualise dissimilarity patterns in two-dimensional space. This method allowed us to detect similarities and differences in community structure across habitats, based on species abundances. In addition, a Jaccard similarity heatmap based on presence-absence data was generated to compare community overlap among habitats. To assess variation in bird community composition across LULC types, we used the Jaccard dissimilarity metric based on presence-absence data. The Jaccard Index between two sites is computed as:

$$J_{ij} = 1 - \frac{|A \cap B|}{|A \cup B|} \tag{4}$$

Where:

- A and B are the sets of species at sites i and j respectively,
- $|A \cap B|$ is the number of shared species,
- $|A \cup B|$ is the total number of unique species across both sites.

The resulting dissimilarity matrix was subjected to Principal Coordinates Analysis (PCoA) to visualize community structure in a reduced dimensional space. The PCoA is performed on a centered dissimilarity matrix $\mathbf{D}$, and its eigen decomposition yields the principal coordinate axes:

$$\mathbf{Y} = \text{Eigenvectors of centered } \mathbf{D} \tag{5}$$

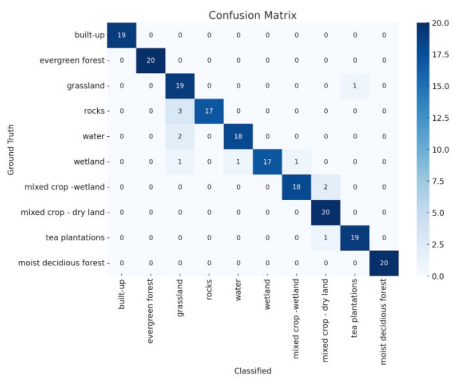
These eigenvectors represent sample scores in reduced dimensions and were used to identify clustering and compositional shifts among LULC classes.

3 Results

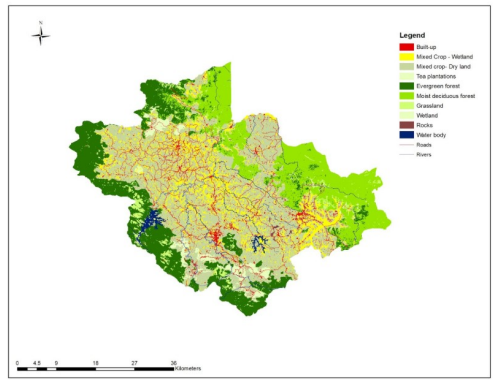
Land Cover and Land Use Classification Using Sentinel-2 Imagery

The classification achieved an overall accuracy of 93.5 %, indicating strong performance. Higher accuracy was observed in distinct and larger classes, such as Mixed Crop – Dry Land and Evergreen Forest (95%). In contrast, visually similar or underrepresented classes like Wetlands and Rocks (80%) showed more misclassifications. These errors were primarily due to overlapping spectral features and imbalanced training data. Enhancing class separability and improving sampling can further strengthen classification reliability. There is a significant variation in land cover sizes in the study area (Fig.3). The largest class, Mixed crop- Dry land, covers 930 sq. km, making it the dominant land cover type. This is followed by Moist deciduous at 412 sq. km and Evergreen forest at 381 sq. km. These three classes collectively account for a significant portion of the total land area. Built-up areas occupy 68 sq. km, representing a moderate contribution to the total land area. This class is significantly smaller than the largest categories but larger than the smallest ones. The

smallest classes, Rocks (4 sq. km), Wetlands (7 sq. km), and Water body (17 sq. km), make minimal contributions to the total area. The range of class sizes, from 4 sq. km to 930 sq. km, highlights the diversity of land cover types (Fig.3).



(a) Confusion Matrix



(b) LULC Map

Figure 3: a.Confusion matrix evaluating the classification accuracy for each Land Use and Land Cover (LULC) class in Wayanad district, Kerala, India, derived from Sentinel-2 imagery analysis. b.Map displaying the Land Use and Land Cover (LULC) classification of Wayanad district, Kerala, India, derived from Sentinel-2 imagery.

Rarefied Richness vs Raw Richness

Raw species richness was highest in dryland crop, moist deciduous forest, and evergreen forest habitats. However, after applying rarefaction to correct for sampling effort, evergreen forest, dryland crop, and mixed dryland crop maintained high species richness, while fallow and rocky habitats dropped in rank, reflecting low diversity after effort correction.

Table 1: Rarefied vs Raw Species Richness across LULC Classes. This figure shows how rarefaction alters perceived richness, highlighting effort-independent diversity estimates.

LULC Class	Species Richness	Rarefied Species Richness	Shannon Index	Simpson Index
Wetlands	80	49	4.209627	0.982596
Rocks	70	52	4.135557	0.981950
Water	103	55	4.389012	0.984588
Built-up	180	61	4.546687	0.984554
Grassland	193	66	4.789564	0.988090
Moist deciduous	230	66	4.892248	0.990031
Evergreen forest	223	69	4.808551	0.987741
Mixed crop – Dry land	255	69	4.834999	0.988806
Mixed crop – Wetland	217	71	4.866467	0.989532
Tea plantation	163	76	4.683415	0.988198

Feeding Guild Distributions

Feeding guild composition varied significantly across LULC types. Forest habitats (evergreen, moist deciduous) hosted more insectivores and frugivores, while granivores and omnivores dominated agricultural classes. Built-up areas had fewer specialised guilds and were primarily occupied by omnivores and generalists. Wetland and rocky areas showed limited guild diversity, often with dominance by a single group (e.g., carnivores in wetlands).

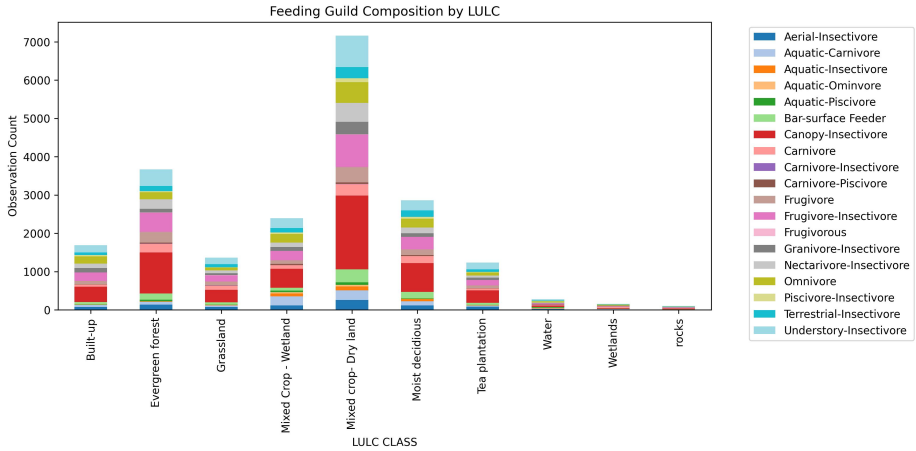
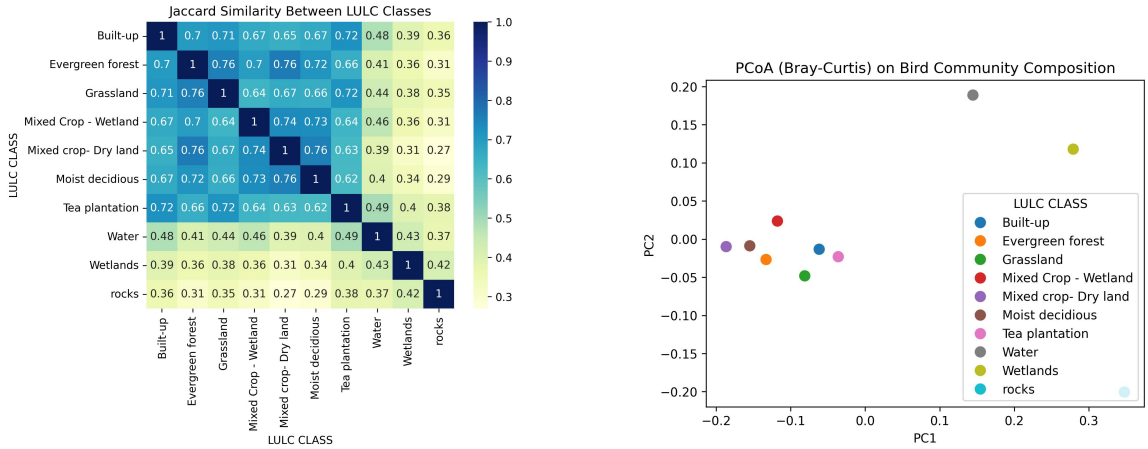


Figure 4: Feeding Guild Proportions across LULC Classes. This figure illustrates the proportional composition of feeding guilds in each land-use type, highlighting shifts in functional roles.

Community Composition (PCoA and Jaccard Index

PCoA revealed apparent clustering by LULC class, with wetlands, rocks, and fallow areas forming distinct communities, while forests and agricultural areas exhibited overlapping composition. The first two axes of the PCoA explained a substantial portion of the variation in species composition, indicating ecological separation based on habitat type. The Jaccard similarity heatmap indicated that built-up, evergreen forest, and dryland crops shared high species overlap. In contrast, wetlands and rocky areas had low similarity with other classes, suggesting habitat-specific species pools.



(a) Jaccard Dissimilarity

(b) Bray-Curtis Dissimilarity (NMDS)

Figure 5: a. Jaccard Similarity Heatmap (Presence-Absence Based) across LULC Classes. This heatmap reveals pairwise species overlap among habitats, highlighting core communities and distinct assemblages. b. PCoA of Bray-Curtis Dissimilarity in Bird Community Composition across LULC Classes. The figure shows how bird communities cluster based on habitat, reflecting community-level habitat preferences.

4 Discussion

The analysis of avian communities across varied land use and land cover (LULC) classes reveals notable species richness, diversity, and functional guild distribution patterns. Natural forest habitats, particularly evergreen and moist deciduous forests, consistently supported a rich and balanced representation of specialised feeding guilds such as insectivores, frugivores, and carnivores. These patterns suggest structurally complex habitats retain high functional integrity and ecological niches. In contrast, human-altered landscapes, including mixed crop fields, tea plantations, and built-up areas, exhibit shifts toward generalist guilds like omnivores and granivores. This shift indicates reduced habitat specialisation and complexity, potentially lowering ecological resilience. Interestingly, tea plantations showed high rarefied species richness despite having lower overall observed richness and moderate diversity indices. This anomaly is likely due to fewer checklists with high internal species diversity, illustrating how rarefaction can overestimate richness in sparsely sampled but compositionally variable habitats. Such insights emphasise the need to interpret effort-standardised metrics alongside raw diversity measures. Despite inherent biases in eBird data, such as unequal sampling, observer variability, and lack of detectability estimates, using rarefaction and presence-absence metrics allowed us to uncover consistent ecological signals. Community composition analyses using Jaccard distances and PCoA further supported the differentiation of bird assemblages across LULC classes, highlighting distinct ecological communities even in habitats with low species counts, such as wetlands and rocky outcrops.

5 Conclusion

This study demonstrates the viability of using citizen science data, when properly filtered and statistically adjusted, to detect meaningful patterns in avian diversity and guild structure across landscapes with varying degrees of human modification, despite unequal sampling effort among LULC classes, rarefaction and community dissimilarity analyses revealed clear distinctions in species richness, functional guild representation, and habitat specificity. Natural forests serve as crucial reservoirs for diverse and specialised bird communities, while specific agricultural systems like mixed cropping fields may offer complementary habitat value. Conversely, simplified environments such as urban and monoculture plantations tend to favour generalist species, underscoring the ecological cost of land-use intensification. The rarefied richness anomaly in tea plantations further highlights the importance of combining multiple indices and interpreting them within their sampling context. When analysed with effort-aware tools, citizen science platforms like eBird can play a pivotal role in large-scale biodiversity monitoring and conservation planning. These findings support integrating participatory data into conservation strategies, especially in regions where conventional ecological monitoring is logistically challenging.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article.

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Table 2: Abbreviations of classes and seasons used in Table 3

LULC Classes	
Built-up	BU
Evergreen forest	EVF
Grassland	GL
Mixed Crop - Wetland	MCW
Mixed crop - Dry land	MCD
Moist deciduous forest	MDF
Rocks	R
Tea plantation	TP
Water Body	WB
Wetlands	WL
Seasons	
Dry season	DS
North east Monsoon	NEM
Summer	S
Southwest monsoon	SWM

Table 3: Appendix

SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Accipiter nisus	BU, EVF, MDF	DS, S	601-700, 701-800	251
Acridotheres fuscus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 601-700, 701-800, 801-900, 901-1000	26
Acridotheres tristis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 1401-1500, 601-700, 701-800, 801-900, 901-1000	18
Acritillas indica	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 1601-1700, 601-700, 701-800, 801-900, 901-1000	74
Acrocephalus dumetorum	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	92
Acrocephalus stentoreus	EVF, GL, MCD, MDF, WB	DS, S	601-700, 701-800	182
Actitis hypoleucos	EVF, MCD, MDF	DS, NEM, SWM	601-700, 701-800, 801-900, 901-1000	66

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Aegithina tiphia	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	6
Aegypius monachus	MDF	S	601-700	246
Aerodramus unicolor	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 1601-1700, 601-700, 701-800, 801-900, 901-1000	60
Alauda gulgula	MCW, MCD	DS, NEM, SWM	601-700	42
Alcedo atthis	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	95
Alcippe poioicephala	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 601-700, 701-800, 801-900, 901-1000	174
Amandava amandava	MCD	S	701-800	289
Amaurornis phoenicurus	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	45
Anas poecilorhyncha	MCW, MCD	DS, NEM, S, SWM	601-700, 701-800, 901-1000	216
Anastomus oscitans	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	82
Anhinga melanogaster	BU, EVF, MCW, MCD, WB	DS, NEM, S, SWM	601-700, 701-800, 901-1000	21
Anthracoceros coronatus	EVF, MCD, MDF	DS, S	1301-1400, 601-700, 701-800	240
Anthus richardi	GL, MCD	DS	701-800, 801-900	277
Anthus rufulus	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	86
Anthus trivialis	MCD	DS	701-800	272
Apus affinis	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	29
Apus leuconyx	MCD	S	601-700	252
Aquila fasciata	BU, GL, MCW, MDF, R	DS, NEM, S	601-700, 701-800, 801-900, 901-1000	245

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Table 3 –Appendix

SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Arachnothera longirostra	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	71
Ardea alba	BU, EVF, GL, MCW, MCD, TP, WB	DS, NEM, S, SWM	601-700, 701-800, 801-900	97
Ardea cinerea	EVF, MCW, MCD, MDF	DS, S, SWM	601-700, 701-800, 801-900, 901-1000	96
Ardea coromanda	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 1601-1700, 601-700, 701-800, 801-900, 901-1000	5
Ardea intermedia	BU, EVF, GL, MCW, MCD, MDF, WB	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	7
Ardea purpurea	BU, EVF, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	103
Ardeola grayii	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	25
Argya striata	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	50
Argya subrufa	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	99
Artamus fuscus	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	77
Arundinax aedon	MCW, MCD, MDF, TP, WB	DS, S	601-700, 701-800, 801-900	199
Aviceda jerdoni	EVF, MCD, MDF, R, WL	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900	211
Aviceda leuphotes	MCD, MDF	DS, S	701-800	274
Batrachostomus moniliger	BU, EVF, GL	NEM, S	1101-1200, 601-700, 701-800, 801-900, 901-1000	209
Botaurus cinnamomeus	EVF, MCW	S, SWM	601-700, 701-800	109
Butastur teesa	BU, GL, MCD, MDF, TP	DS, NEM, S	701-800, 801-900	279
Buteo buteo	MCD, MDF	S	701-800	287
Butorides striata	MCW, MCD	DS, S	701-800	291
Cacomantis passerinus	BU, EVF, MCW, MCD, MDF, TP	DS, NEM, S, SWM	601-700, 701-800, 801-900	130
Cacomantis sonneratii	EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900	128
Calandrella dukhunensis	MCD	DS	701-800	282

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Caprimulgus affinis	MCD	DS	701-800	275
Caprimulgus asiaticus	MCD	S	701-800	264
Caprimulgus atripennis	EVF, GL, MCW, MCD, MDF	DS, S, SWM	1101-1200, 601-700, 701-800, 801-900	202
Caprimulgus indicus	BU, EVF, GL, MCD, MDF, TP	DS, NEM, S	1101-1200, 601-700, 701-800, 801-900, 901-1000	156
Carpodacus erythrinus	BU, EVF, MCD, MDF, TP	DS	1301-1400, 601-700, 701-800, 801-900	224
Cecropis daurica	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	16
Centropus bengalensis	EVF, GL, MDF	NEM, S, SWM	1201-1300, 1301-1400, 701-800, 901-1000	294
Centropus sinensis	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	47
Ceryle rudis	EVF, MCW, MCD	DS, NEM	601-700	151
Ceyx erithaca	EVF, MCD	DS, NEM	601-700, 701-800	228
Chalcophaps indica	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	168
Chlidonias hybrida	MCW, WB	S	601-700	107
Chloropsis aurifrons	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	135
Chloropsis jerdoni	BU, EVF, GL, MCW, MCD, MDF	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900, 901-1000	183
Chrysocolaptes socialis	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	136
Ciconia episcopus	GL, MCW, MCD, MDF, TP, WB	DS, NEM, S	601-700, 701-800, 801-900	80
Ciconia nigra	MDF	DS	701-800	286

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Cinnyris asiaticus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	52
Cinnyris lotenius	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900, 901-1000	40
Circus aeruginosus	EVF, MCW, MCD, MDF	DS	601-700, 701-800	101
Circus macrourus	EVF, GL, MCD	NEM, S	1201-1300, 601-700	227
Cisticola exilis	EVF, GL	DS, S, SWM	1101-1200, 1301-1400, 1401-1500, 1601-1700, 901-1000	299
Cisticola juncidis	GL, MCW, MDF	SWM	601-700, 701-800	38
Clamator jacobinus	BU, MCW, MCD, MDF	DS, NEM, S, SWM	601-700, 701-800	141
Clanga clanga	GL, MDF	DS, S	1101-1200, 601-700, 701-800	247
Columba elphinstonii	EVF, GL, MCD	DS, S	1001-1100, 1301-1400, 601-700, 701-800, 901-1000	170
Columba livia	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900	61
Copsychus fulicatus	BU, EVF, MCW, MCD, MDF	DS, S, SWM	1001-1100, 601-700, 701-800, 801-900	169
Copsychus malabaricus	BU, EVF, MCD, MDF, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900	56
Copsychus saularis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	31
Coracias benghalensis	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	1
Coracina macei	EVF, GL, MCD, MDF, TP	DS, NEM, S, SWM	701-800, 801-900	268
Corvus macrorhynchos	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	27
Corvus splendens	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 601-700, 701-800, 801-900, 901-1000	68
Cuculus canorus	MCD	NEM	701-800	280

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Cuculus micropterus	MCW, MDF	S, SWM	601-700, 701-800	192
Cuculus poliocephalus	GL, MCD, TP	NEM	701-800	281
Culicicapa ceylonensis	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 701-800, 801-900, 901-1000	261
Cyornis pallidipes	BU, EVF, GL, MCW, MCD	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	176
Cyornis rubeculoides	BU, EVF, MCD, MDF	DS, NEM, S	601-700, 701-800, 801-900	177
Cyornis tickelliae	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1301-1400, 601-700, 701-800, 801-900, 901-1000	115
Cypsiurus balasiensis	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1301-1400, 601-700, 701-800, 801-900, 901-1000	83
Dendrocitta leucogastra	BU, EVF, GL, MCW, MCD, MDF	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	210
Dendrocitta vagabunda	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1201-1300, 1301-1400, 601-700, 701-800, 801-900	55
Dendrocygna javanica	BU, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	601-700, 701-800	28
Dendronanthus indicus	EVF, MCW, MCD, MDF	DS, NEM, S	1001-1100, 601-700, 701-800, 801-900, 901-1000	222
Dicaeum concolor	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 601-700, 701-800, 801-900, 901-1000	121
Dicaeum erythrorhynchos	BU, EVF, GL, MCW, MCD, MDF, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 601-700, 701-800, 801-900	43
Dicrurus aeneus	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1001-1100, 1601-1700, 601-700, 701-800, 801-900, 901-1000	0
Dicrurus caerulescens	MCD, MDF	DS, S	601-700, 701-800	219
Dicrurus hottentottus	MCD, MDF	DS, S	701-800	271

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Dicrurus leucophaeus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	89
Dicrurus macrocercus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900, 901-1000	46
Dicrurus paradiseus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	48
Dinopium benghalense	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	129
Dinopium javanense	EVF, GL, MCD, MDF	DS, NEM, S	1101-1200, 1201-1300, 1301-1400, 601-700, 701-800	205
Dryocopus javensis	EVF, GL, MCW, MCD, MDF	DS, NEM, S, SWM	1301-1400, 601-700, 701-800, 801-900	157
Ducula aenea	EVF, MCW, MCD, MDF	DS, NEM, S	1301-1400, 601-700, 701-800, 801-900, 901-1000	206
Ducula cuprea	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	131
Dumetia atriceps	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 601-700, 701-800, 801-900, 901-1000	164
Dumetia hyperythra	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 601-700, 701-800, 801-900, 901-1000	126
Egretta garzetta	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	58

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Elanus caeruleus	BU, EVF, GL, MCW, MCD, MDF, R, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900	57
Eudynamys scolopaceus	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	132
Eumyias albicaudatus	BU, EVF, GL, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 601-700, 701-800, 901-1000	258
Eumyias thalassinus	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S	1301-1400, 601-700, 701-800, 801-900, 901-1000	213
Falco peregrinus	EVF, MCW, MCD, MDF, R, WL	DS, S	1001-1100, 1301-1400, 601-700, 701-800, 801-900	248
Falco tinnunculus	BU, EVF, GL, MCW, MCD, R, TP, WL	DS, NEM, S, SWM	1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	232
Ficedula albicilla	MCD, MDF	DS	701-800	273
Ficedula nigrorufa	EVF, GL, TP	DS, SWM	1001-1100, 1301-1400, 1401-1500, 1501-1600	302
Ficedula parva	GL, MCW, MDF	DS, NEM, S	701-800, 801-900, 901-1000	288
Ficedula ruficauda	EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S	1001-1100, 1301-1400, 601-700, 701-800, 801-900	214
Fulica atra	MCW, MCD	DS, NEM, S, SWM	601-700, 701-800	244
Galerida malabarica	GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	601-700	9
Gallinago gallinago	MCD, MDF	DS, S	601-700, 701-800	223
Gallinula chloropus	MCW, MCD, MDF	DS, NEM	601-700, 701-800	249
Galloperdix spadicea	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	53
Gallus sonneratii	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	147

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Geokichla citrina	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1301-1400, 601-700, 701-800, 801-900, 901-1000	154
Glaucidium radiatum	EVF, MCW, MCD, MDF, WL	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900	193
Gorsachius melanolophus	EVF, MCW, MCD	DS	701-800	260
Gracula indica	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1601-1700, 601-700, 701-800, 801-900, 901-1000	118
Gymnoris xanthocollis	BU, EVF, MCW, MCD, MDF	DS, S, SWM	601-700, 701-800, 801-900	134
Gyps bengalensis	EVF, GL, MCW, MCD, MDF, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	36
Gyps indicus	MDF	DS	601-700	218
Halcyon smyrnensis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1601-1700, 601-700, 701-800, 801-900, 901-1000	37
Haliastur indus	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1601-1700, 601-700, 701-800, 801-900, 901-1000	104
Harpactes fasciatus	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	149
Hemicircus canente	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	187
Hemiprocne coronata	BU, EVF, GL, MCW, MCD, MDF, R, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	194
Hemipus picatus	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	178
Hieraaetus pennatus	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S	1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	84
Hierococcyx sparverioides	MDF	DS, S	701-800	284
Hierococcyx varius	BU, EVF, GL, MCW, MCD, MDF	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	65
Hirundapus giganteus	EVF, GL, MCD, MDF	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	184

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Hirundo domicola	BU, EVF, GL, MCD, TP	DS, NEM, SWM	1001-1100, 1301-1400, 1401-1500, 601-700, 701-800, 801-900, 901-1000	255
Hirundo rustica	BU, EVF, GL, MCW, MCD, MDF, R, WB	DS, NEM, S, SWM	1601-1700, 601-700, 701-800, 801-900, 901-1000	39
Hirundo smithii	BU, EVF, MCW, MCD, MDF, WB	DS, NEM, S, SWM	601-700, 701-800	76
Hydrophasianus chirurgus	MCD, MDF	DS, NEM	601-700	72
Hypothymis azurea	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1201-1300, 1401-1500, 601-700, 701-800, 801-900, 901-1000	162
Hypsipetes ganeesa	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 601-700, 701-800, 801-900, 901-1000	171
Icthyophaga humilis	MCW, MDF	S, SWM	601-700, 701-800	235
Icthyophaga ichthyaetus	MDF	DS	701-800	285
Ictinaetus malaiensis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	63
Iduna caligata	GL, MCD	DS	701-800, 801-900	276
Irena puella	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	165
Ketupa nipalensis	BU, EVF, GL, MCD, MDF	DS, NEM, S	1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	204
Ketupa zeylonensis	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900	180
Lalage melanoptera	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1201-1300, 601-700, 701-800, 801-900, 901-1000	91
Lanius cristatus	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S	1301-1400, 601-700, 701-800, 801-900, 901-1000	93
Lanius schach	BU, EVF, GL, MCW, MCD, MDF, R, TP, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	30

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Lanius vittatus	MDF	S	701-800	295
Larvivora brunnea	EVF, GL, MCD, MDF, TP	DS, NEM, S	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	191
Leiopicus mahrattensis	BU, GL, MCW, MCD, MDF	DS, NEM, S, SWM	601-700, 701-800, 801-900	231
Leptocoma minima	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1601-1700, 601-700, 701-800, 801-900, 901-1000	20
Leptocoma zeylonica	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	51
Leptoptilos javanicus	EVF, MCW	DS	701-800, 901-1000	297
Lewinia striata	MCW, MDF	NEM, S	601-700, 701-800	236
Lonchura kelaarti	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1001-1100, 1201-1300, 1301-1400, 1401-1500, 601-700, 701-800, 801-900, 901-1000	160
Lonchura malacca	EVF, MCD, TP	NEM, S	601-700, 701-800	220
Lonchura punctulata	BU, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	601-700, 701-800, 801-900	143
Lonchura striata	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	75
Lophospiza trivirgata	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	163
Lophotriorchis kienerii	EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S	1101-1200, 1201-1300, 601-700, 701-800, 901-1000	207
Loriculus vernalis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SW	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	34

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Table 3 –Appendix

SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Machlolophus aplonotus	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1501-1600, 601-700, 701-800, 801-900, 901-1000	138
Merops leschenaulti	BU, EVF, GL, MCW, MCD, MDF, R, TP, WL	DS, NEM, S, SWM	1601-1700, 601-700, 701-800, 801-900, 901-1000	122
Merops orientalis	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	23
Merops philippinus	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1001-1100, 601-00, 701-800, 801-900	94
Metopidius indicus	MCW, MCD, MDF	DS, NEM, S, SWM	601-700, 701-800	64
Microcarbo niger	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 1601-1700, 601-700, 701-800, 801-900, 901-1000	8
Micropternus brachyurus	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1301-1400, 601-700, 701-800, 801-900, 901-1000	155
Microtarsus priocephalus	EVF, GL, MCW, MCD, MDF, TP	DS, S, SWM	1001-1100, 1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	237
Milvus migrans	MCD	DS	701-800	278
Montecincla jerdoni	EVF, GL	DS, NEM, SWM	1201-1300, 1301-1400, 1401-1500, 1501-1600	303
Monticola cinclorhyncha	BU, EVF, GL, MCD, MDF, TP	DS, NEM, S	1101-1200, 601-700, 701-800, 801-900, 901-1000	166
Monticola solitarius	BU, EVF, GL, MCD, R, TP	DS, NEM, S	1301-1400, 701-800, 801-900	263
Motacilla alba	EVF, GL, MCW, MCD	DS, NEM, SWM	1601-1700, 601-700, 701-800, 901-1000	239
Motacilla cinerea	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1001-1100, 1201-1300, 1301-1400, 1401-1500, 601-700, 701-800, 801-900, 901-1000	85
Motacilla flava	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	196

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Motacilla maderaspatensis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1601-1700, 601-700, 701-800, 801-900, 901-1000	15
Muscicapa dauurica	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	153
Muscicapa muttui	EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	173
Mycteria leucocephala	EVF, MCW	DS	601-700, 701-800	140
Myophonus horsfieldii	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1601-1700, 601-700, 701-800, 801-900, 901-1000	139
Nettapus coromandelianus	MCW, MCD, TP	DS, NEM, S, SWM	601-700, 701-800	234
Ninox scutulata	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900	114
Nisaetus cirrhatus	BU, EVF, GL, MCD, MDF, TP	DS, NEM, S, SWM	1301-1400, 601-700, 701-800, 801-900	158
Nisaetus kelaarti	MCW, MCD, MDF	DS, S	601-700, 701-800, 801-900	241
Nycticorax nycticorax	BU, MCW, MCD, TP	NEM, S, SWM	601-700, 701-800	108
Nyctyornis athertoni	BU, EVF, MCW, MCD, MDF, TP	DS, NEM, S, SWM	701-800, 801-900, 901-1000	266
Ocyceros griseus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	120
Oriolus chinensis	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S	601-700, 701-800, 801-900	217
Oriolus kundoo	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S	1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	70
Oriolus xanthornus	EVF, MCW, MCD, MDF, WB	DS, NEM, S, SWM	1301-1400, 601-700, 701-800, 801-900	133

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Orthotomus sutorius	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	105
Ortygornis pondicerianus	MCW, MDF, WB	NEM, S	601-700, 701-800	200
Otus bakkamoena	BU, EVF, MCD	DS, S, SWM	601-700, 701-800, 801-900	229
Otus sunia	EVF, MCW, MCD, MDF	DS, S	601-700, 701-800, 801-900	203
Pachyglossa agilis	BU, EVF, GL, MCD, MDF	DS, S, SWM	1001-1100, 601-700, 701-800, 801-900	230
Pandion haliaetus	EVF, MCD	DS	601-700, 701-800	254
Parus cinereus	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900	123
Passer domesticus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 1601-1700, 601-700, 701-800, 801-900, 901-1000	69
Pastor roseus	BU	S	701-800	296
Pavo cristatus	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	19
Pelargopsis capensis	BU, EVF, MCW, MDF	DS, S, SWM	601-700, 701-800	100
Pellorneum ruficeps	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1501-1600, 601-700, 701-800, 801-900, 901-1000	33
Perdicula asiatica	MCW, MCD	DS, S	601-700, 901-1000	225
Perdicula erythrorhyncha	GL	S, SWM	1001-1100, 1201-1300, 1401-1500	301
Pericrocotus cinnamomeus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1201-1300, 601-700, 701-800, 801-900, 901-1000	144
Pericrocotus flammeus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	44
Pernis ptilorhynchus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	41

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Petrochelidon fluvicola	EVF, GL	DS	601-700, 801-900	259
Phaenicophaeus viridirostris	BU, MCW, MDF	DS, S	601-700, 701-800, 801-900	233
Phalacrocorax carbo	EVF, GL, MCW, MCD, WB	DS, NEM, S, SWM	601-700, 701-800	112
Phalacrocorax fuscicollis	EVF, MCW, MCD, MDF, TP, WB	DS, NEM, S	601-700, 701-800	197
Phodilus assimilis	EVF	S	701-800	267
Phylloscopus affinis	EVF, MCW, MCD	DS	1301-1400, 701-800, 901-1000	262
Phylloscopus magnirostris	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	175
Phylloscopus nitidus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	137
Phylloscopus occipitalis	BU, EVF, GL, MCD	DS, S	1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 901-1000	172
Phylloscopus trochiloides	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	98
Picumnus innominatus	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900	212
Picus chlorolophus	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	185
Picus xanthopygae	EVF, MCW, MCD, MDF	DS, NEM, S, SWM	701-800, 801-900, 901-1000	270
Pitta brachyura	BU, EVF, MCW, MCD, MDF, TP	DS, NEM, S	1201-1300, 601-700, 701-800, 801-900	159
Plegadis falcinellus	BU, MCW	DS, SWM	601-700, 701-800	127
Ploceus philippinus	BU, MCD, MDF	NEM, S, SWM	601-700, 701-800, 801-900	215

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Pomatorhinus horsfieldii	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 601-700, 701-800, 801-900, 901-1000	119
Porphyrio poliocephalus	MCW, MCD, WB	DS, NEM, S, SWM	601-700, 701-800	106
Prinia hodgsonii	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	24
Prinia inornata	BU, MCW, MCD, MDF	DS, NEM, S, SWM	601-700, 701-800, 801-900	11
Prinia socialis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900	111
Pseudibis papillosa	MCW, MDF	DS, S, SWM	601-700	59
Psilopogon haemacephalus	EVF, MCW, MCD, MDF, WL	DS, S, SWM	1001-1100, 601-700, 701-800, 801-900	124
Psilopogon malabaricus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	116
Psilopogon viridis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 1601-1700, 601-700, 701-800, 801-900, 901-1000	35
Psittacula columboides	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1101-1200, 1201-1300, 601-700, 701-800, 801-900, 901-1000	32
Psittacula cyanocephala	BU, EVF, GL, MCW, MCD, MF, R, TP, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	12
Psittacula eupatria	EVF, MCD, MDF	DS, SWM	601-700, 701-800	152
Psittacula krameri	BU, EVF, GL, MCW, MCD, MDF, TP, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900	54
Pterorhinus delesserti	EVF, GL, MCW, MCD, R, TP	DS, NEM, S	1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	243

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Ptyonoprogne concolor	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB	DS, NEM, S, SWM	1101-1200, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	22
Pycnonotus cafer	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	2
Pycnonotus jocosus	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 601-700, 701-800, 801-900, 901-1000	13
Pycnonotus luteolus	BU, GL, MCD	DS, NEM, S	1301-1400, 601-700, 701-800	242
Rhipidura aureola	EVF, MDF	DS	701-800	283
Rostratula benghalensis	MDF	S	701-800	292
Rubigula gularis	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1201-1300, 601-700, 701-800, 801-900, 901-1000	167
Sarcogyps calvus	EVF, GL, MCW, MCD, MDF	DS, NEM, S, SWM	601-700, 701-800, 801-900	188
Saxicola caprata	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 1301-1400, 601-700, 701-800, 801-900, 901-1000	10
Schoenicola platyurus	GL	DS	1301-1400	305
Sholicola major	EVF	DS, NEM, SWM	1201-1300, 1301-1400	304
Sitta castanea	EVF, GL, MCW, MCD, MDF, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900	208
Sitta frontalis	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 601-700, 701-800, 801-900, 901-1000	73
Spatula querquedula	MCW, MCD	NEM	601-700	250
Spilopelia chinensis	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1601-1700, 601-700, 701-800, 801-900, 901-1000	3

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SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Spilornis cheela	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1601-1700, 601-700, 701-800, 801-900, 901-1000	62
Sterna aurantia	BU, EVF, GL, MCW, MCD, WB	DS, NEM, S, SWM	601-700, 701-800	125
Streptopelia decaocto	MCD, MDF	DS, S, SWM	601-700, 701-800, 801-900	195
Streptopelia orientalis	EVF, GL	DS, S	701-800, 801-900	293
Strix leptogrammica	BU, EVF, GL, MCW, MCD, MDF	DS, NEM, S, SWM	1301-1400, 601-700, 701-800, 801-900, 901-1000	190
Strix ocellata	EVF, MCD	NEM, S, SWM	601-700, 701-800, 901-1000	256
Sturnia blythii	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 601-700, 701-800, 801-900	148
Sturnia malabarica	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S	601-700, 701-800	181
Sturnia pagodarum	MCW, MCD, MDF	DS, S, SWM	601-700, 701-800	142
Surniculus dicruroides	BU, EVF, GL, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 601-700, 701-800, 801-900	226
Tachybaptus ruficollis	MCW, MCD, TP, WB	DS, NEM, S, SWM	601-700, 701-800	110
Tachymarptis melba	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1101-1200, 1301-1400, 1401-1500, 601-700, 701-800, 801-900	88
Tachyspiza badia	BU, EVF, GL, MCW, MCD, MDF, R, TP, WB, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	117
Tachyspiza virgata	EVF, MCD, WB	DS, NEM, S	601-700, 701-800, 801-900	201
Tephrodornis pondicerianus	EVF, GL, MCD, MDF, TP	DS, S	1101-1200, 601-700, 701-800	238
Tephrodornis sylvicola	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	150
Terpsiphone paradisi	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S	1001-1100, 1301-1400, 1601-1700, 601-700, 701-800, 801-900, 901-1000	90
Thinornis dubius	MCW	DS	601-700	79
Threskiornis melanocephalus	BU, EVF, GL, MCW, MCD, MDF, WB, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900	4
Treron affinis	BU, EVF, GL, MCW, MCD, MDF, TP, WB	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	179

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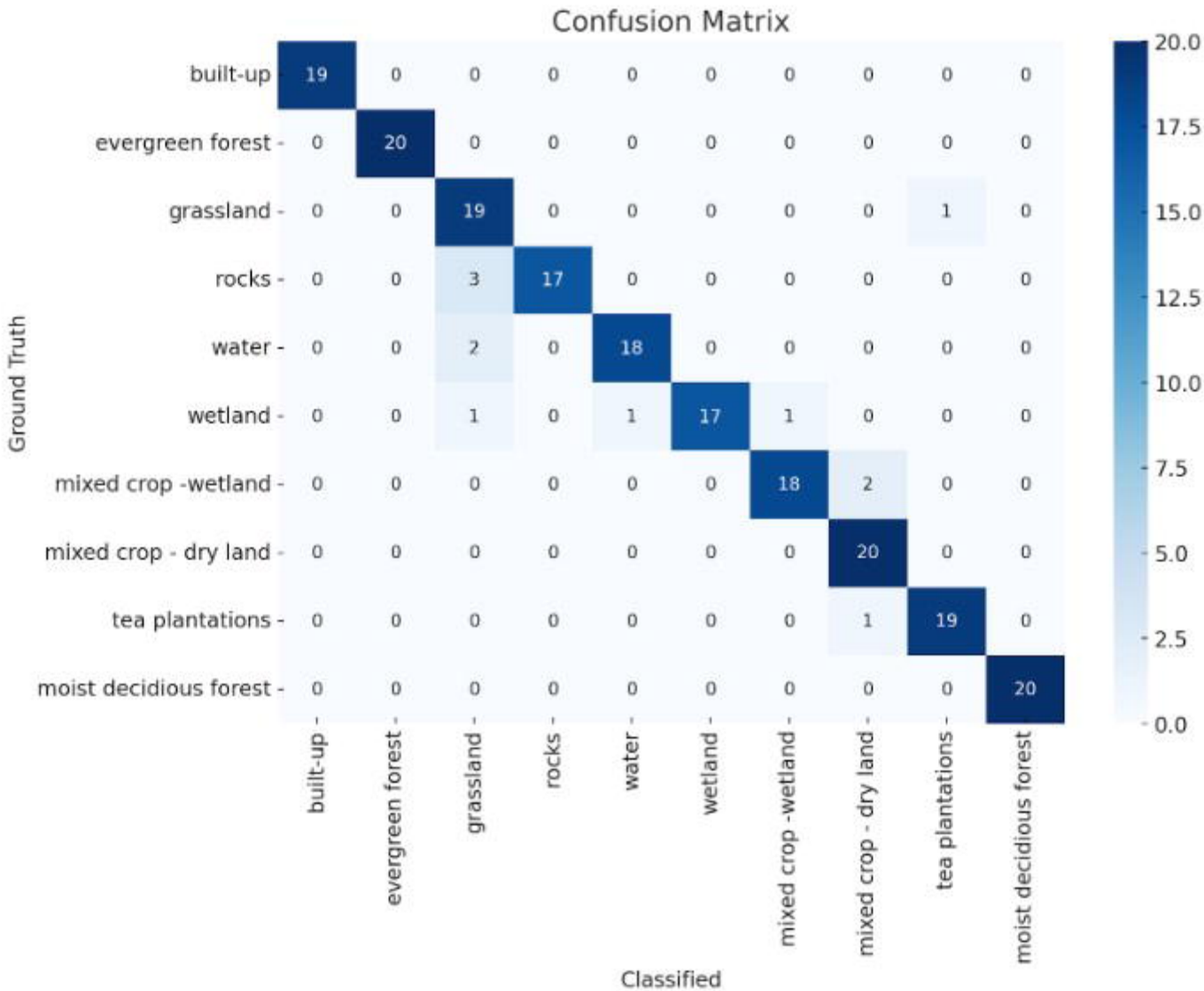
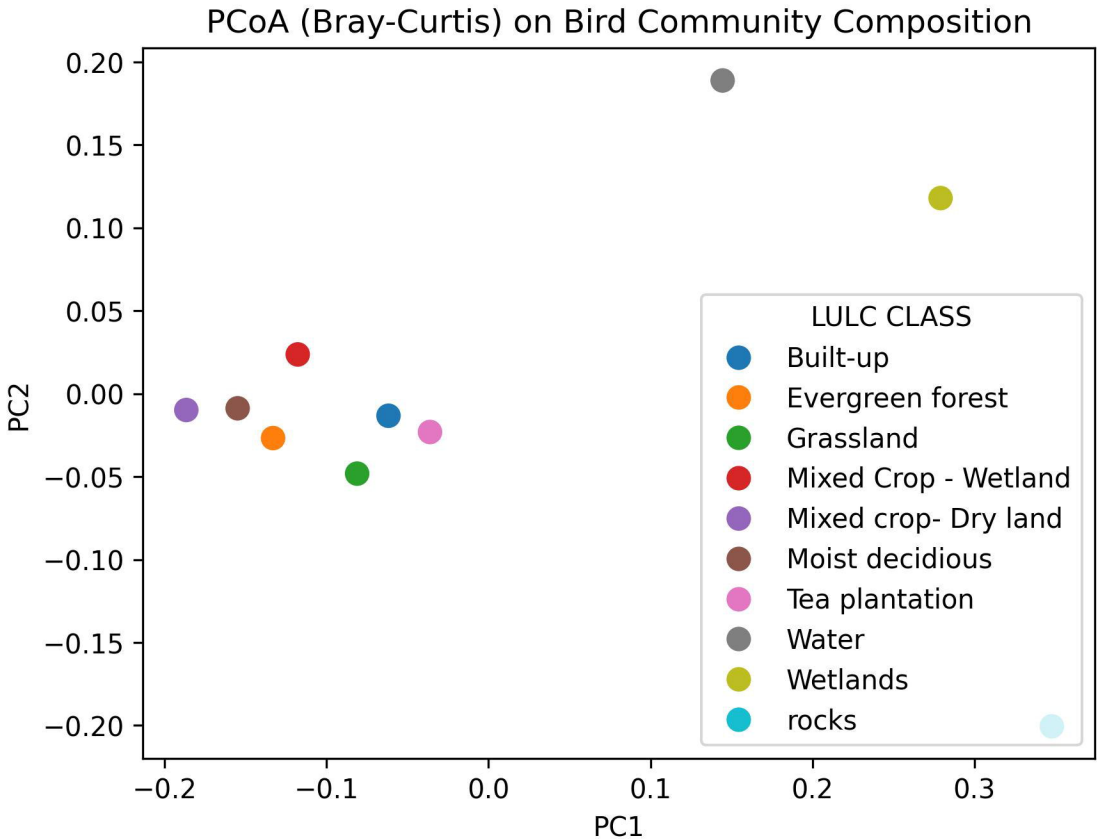
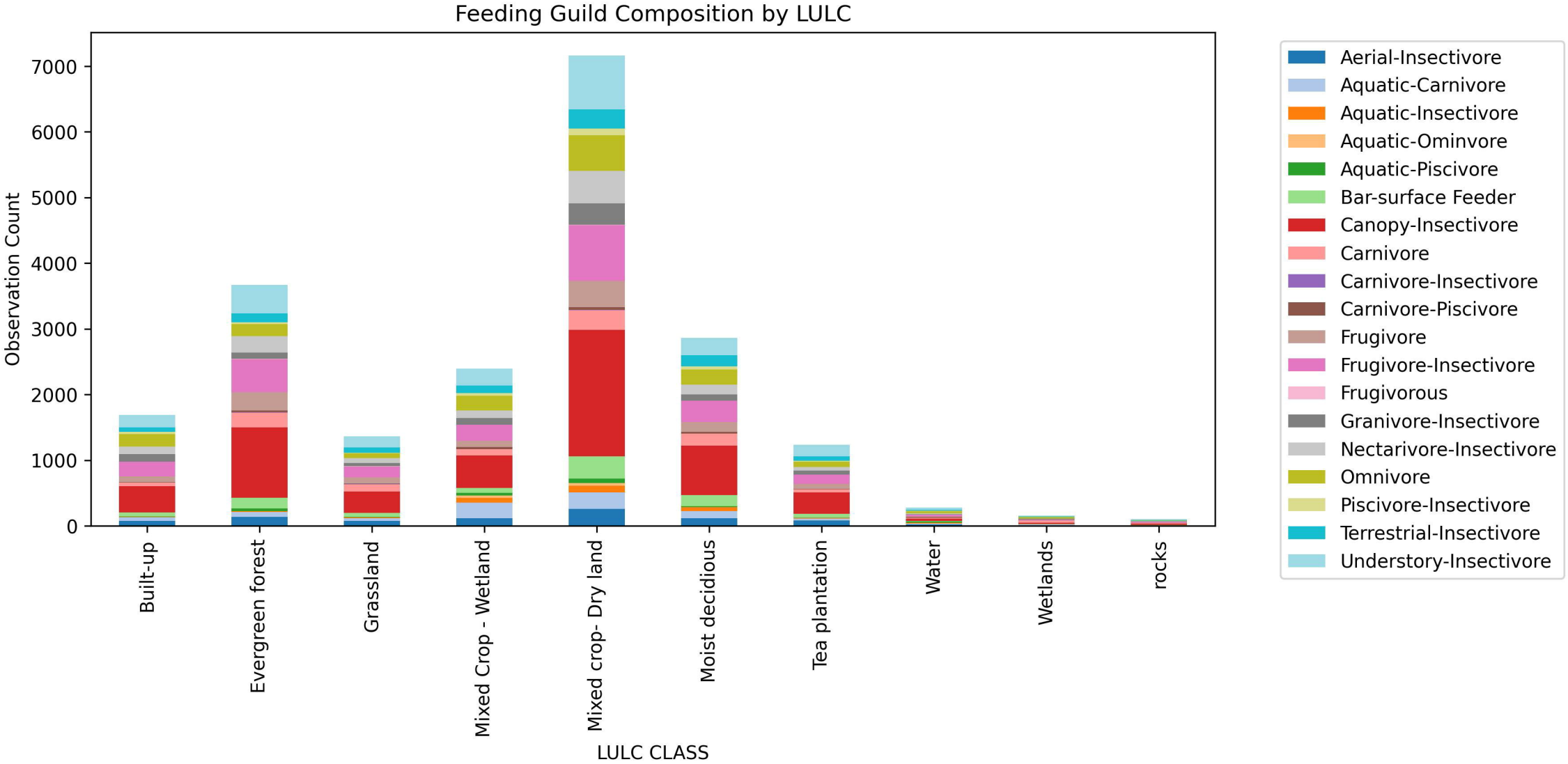
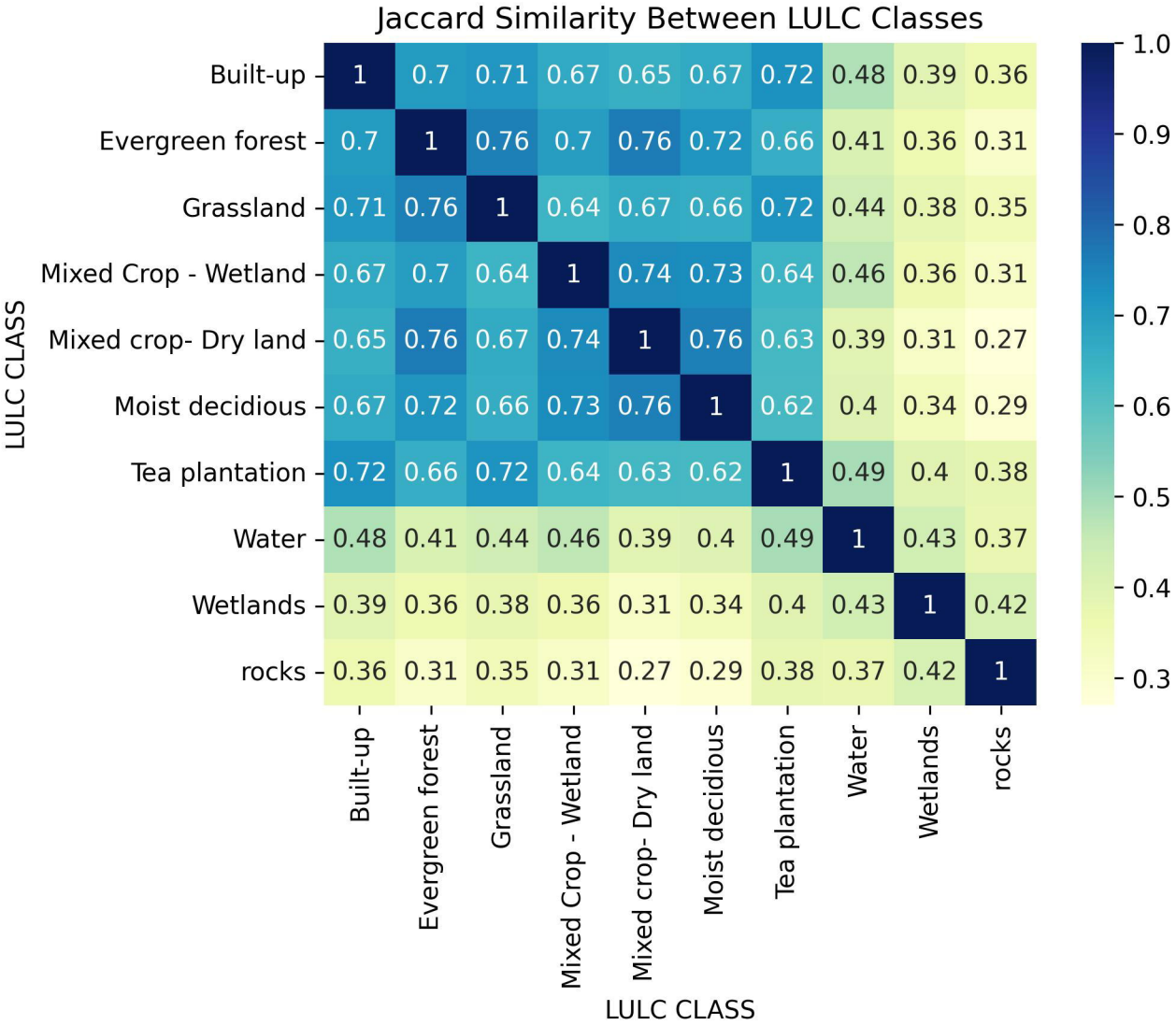
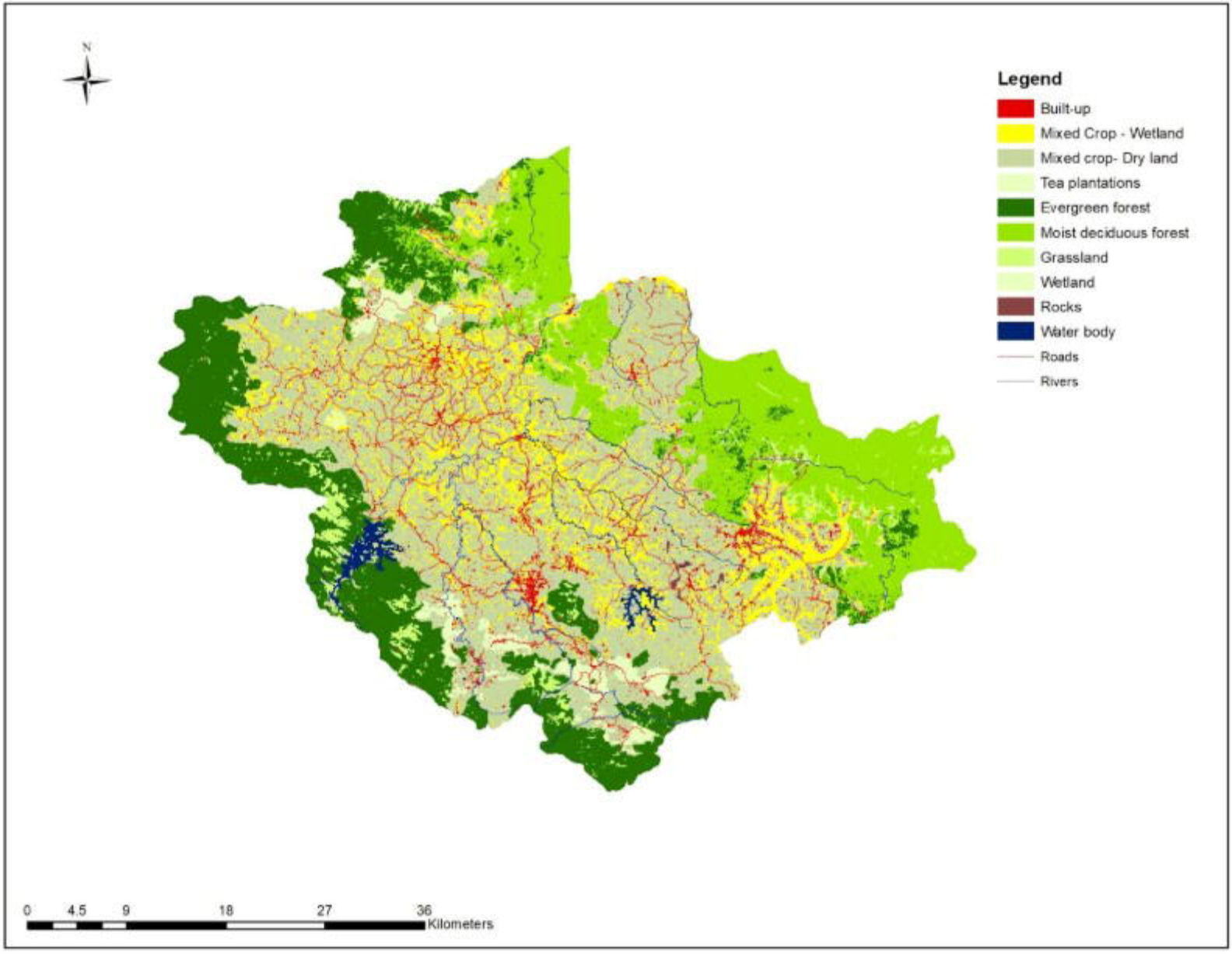
SCIENTIFIC NAME	LULC CLASSES	SEASON	ELEVATION (m asl)	ID NO
Treron phoenicopterus	BU, EVF, GL, MCW, MCD, MDF	DS, NEM, S	1201-1300, 601-700, 701-800, 801-900	257
Tringa glareola	MCW	DS	601-700	81
Tringa ochropus	MCW, MCD, MDF	DS, S, SWM	601-700, 701-800	78
Turdus simillimus	BU, EVF, GL, MCW, MCD, MDF, TP	DS, NEM, S, SWM	1001-1100, 1201-1300, 1301-1400, 601-700, 701-800, 801-900, 901-1000	146
Tyto javanica	BU, MCD	S	701-800	265
Upupa epops	BU, EVF, MCW, MCD, MDF, TP	DS, NEM, S, SWM	601-700, 701-800, 801-900	67
Vanellus indicus	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1101-1200, 601-700, 701-800, 801-900, 901-1000	14
Yungipicus nanus	BU, EVF, GL, MCW, MCD, MDF, R, TP	DS, NEM, S, SWM	1201-1300, 1601-1700, 601-700, 701-800, 801-900	17
Zapornia fusca	MCD, MDF	NEM, S, SWM	701-800, 801-900	269
Zoonavena sylvatica	EVF, GL, MCW, MCD, MDF, R, TP, WL	DS, NEM, S, SWM	601-700, 701-800, 801-900, 901-1000	113
Zoothera neilgherriensis	MCD	S	701-800	290
Zosterops palpebrosus	BU, EVF, GL, MCW, MCD, MDF, TP, WB, WL	DS, NEM, S, SWM	1001-1100, 1101-1200, 1201-1300, 1301-1400, 1401-1500, 1501-1600, 601-700, 701-800, 801-900, 901-1000	49

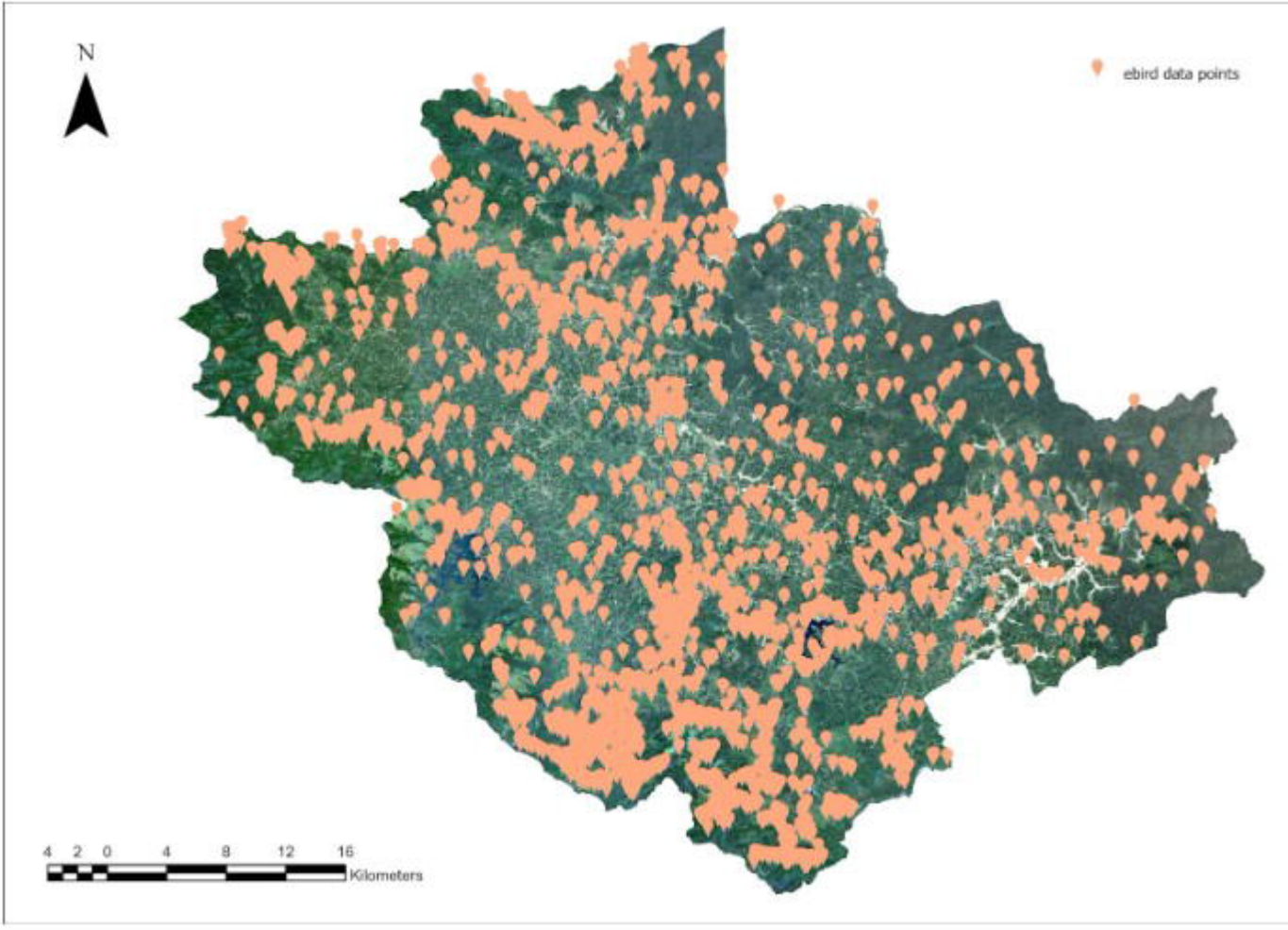

Confusion Matrix
Ground Truth
Classified
built-up
evergreen forest
grassland
rocks
water
wetland
mixed crop -wetland
mixed crop - dry land
tea plantations
moist decidious forest
19 0 0 0 0 0 0 0 0 0
0 20 0 0 0 0 0 0 0 0
0 0 19 0 0 0 0 0 1 0
0 0 3 17 0 0 0 0 0 0
0 0 2 0 18 0 0 0 0 0
0 0 1 0 1 17 1 0 0 0
0 0 0 0 0 0 18 2 0 0
0 0 0 0 0 0 0 20 0 0
0 0 0 0 0 0 0 1 19 0
0 0 0 0 0 0 0 0 0 20
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0

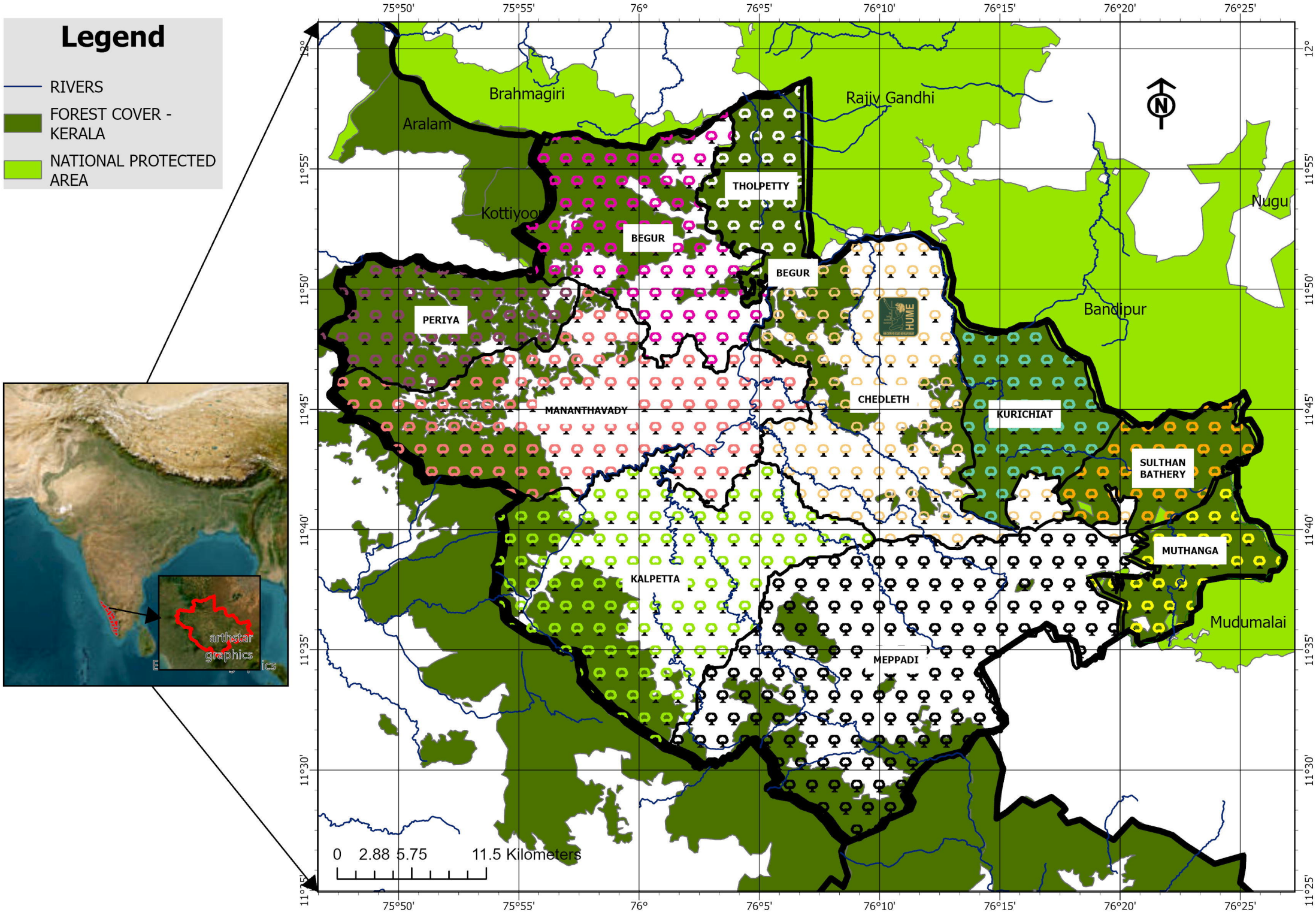

PCoA (Bray-Curtis) on Bird Community Composition
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
PC2
−0.2
−0.1
0.0
0.1
0.2
0.3
PC1
LULC CLASS
Built-up
Evergreen forest
Grassland
Mixed Crop - Wetland
Mixed crop- Dry land
Moist decidious
Tea plantation
Water
Wetlands
rocks


Feeding Guild Composition by LULC
Observation Count
0
1000
2000
3000
4000
5000
6000
7000
Built-up
Evergreen forest
Grassland
Mixed Crop - Wetland
Mixed crop- Dry land
Moist decidious
Tea plantation
Water
Wetlands
rocks
LULC CLASS
Aerial-Insectivore
Aquatic-Carnivore
Aquatic-Insectivore
Aquatic-Ominvore
Aquatic-Piscivore
Bar-surface Feeder
Canopy-Insectivore
Carnivore
Carnivore-Insectivore
Carnivore-Piscivore
Frugivore
Frugivore-Insectivore
Frugivorous
Granivore-Insectivore
Nectarivore-Insectivore
Omnivore
Piscivore-Insectivore
Terrestrial-Insectivore
Understory-Insectivore


Jaccard Similarity Between LULC Classes
LULC CLASS
Built-up 1 0.7 0.71 0.67 0.65 0.67 0.72 0.48 0.39 0.36
Evergreen forest 0.7 1 0.76 0.7 0.76 0.72 0.66 0.41 0.36 0.31
Grassland 0.71 0.76 1 0.64 0.67 0.66 0.72 0.44 0.38 0.35
Mixed Crop - Wetland 0.67 0.7 0.64 1 0.74 0.73 0.64 0.46 0.36 0.31
Mixed crop- Dry land 0.65 0.76 0.67 0.74 1 0.76 0.63 0.39 0.31 0.27
Moist decidious 0.67 0.72 0.66 0.73 0.76 1 0.62 0.4 0.34 0.29
Tea plantation 0.72 0.66 0.72 0.64 0.63 0.62 1 0.49 0.4 0.38
Water 0.48 0.41 0.44 0.46 0.39 0.4 0.49 1 0.43 0.37
Wetlands 0.39 0.36 0.38 0.36 0.31 0.34 0.4 0.43 1 0.42
rocks 0.36 0.31 0.35 0.31 0.27 0.29 0.38 0.37 0.42 1
Built-up
Evergreen forest
Grassland
Mixed Crop - Wetland
Mixed crop- Dry land
Moist decidious
Tea plantation
Water
Wetlands
rocks
LULC CLASS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3


N
Legend
Built-up
Mixed Crop - Wetland
Mixed crop- Dry land
Tea plantations
Evergreen forest
Moist deciduous forest
Grassland
Wetland
Rocks
Water body
Roads
Rivers
0
4.5
9
18
27
36
Kilometers


N
ebird data points
4 2 0 4 8 12 16
Kilometers


Legend
RIVERS
FOREST COVER - KERALA
NATIONAL PROTECTED AREA
Brahmagiri
Rajiv Gandhi
Aralam
Kottiyoor
Nugu
Bandipur
Mudumalai
THOLPETTY
BEGUR
BEGUR
PERIYA
MANANTHAVADY
CHEDLETH
KURICHIAT
SULTHAN BATHERY
MUTHANGA
KALPETTA
MEPPADI
HUME
N
0 2.88 5.75 11.5 Kilometers
75°50'
75°55'
76°
76°5'
76°10'
76°15'
76°20'
76°25'
12°
11°55'
11°50'
11°45'
11°40'
11°35'
11°30'
11°25'
arthstar graphics