HIGHWAYS DEPARTMENT

From

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Divisional Engineer(H),
C&M Division,
Thiruvallur.

To

The Director,
Ministry of Environment,
Forest and Climate Change,
Indira ParayavaranBhawan,
Jorbagh Road,
New Delhi – 110 003.

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Letter No. 2656/JDO-1/2016/Dated:28.05.2018.

Sir,

Sub: Thiruvallur (H) C&M Division – Construction of high level bridge across Pulicat lake connecting km 0/4 of Chennai – Pulicat Road to Pasiyavaram Road – Supplementary marine EIA report with special focus on birds – Documents submission - Regarding.

Ref: 1. The Divisional Engineer (H) C&M, Thiruvallur, LetterNo. 2656/2016JDO-1/dt: 16.02.2018.

2. The Joint Director, Ministry of Environment, Forest and Climate Change, Government of India,New Delhi, Letter No. FNo 11-43/2017-1A-III dt: 08.03.2018.

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With reference to the letter 1st cited above, I submit that the Extension of time has been requested upto May'2018 for submitting the document of **"Supplementary marine EIA report with special focus on birds".**

In the 2nd reference cited, the Extension of time was granted upto 30th May'2018 for the above said documents. Now the report has been received from the reputed institute of **"Salim Ali Centre for Ornithology and Natural History"** Anaikatty, Coimbatore District and the same document is submitted herewith for taking further action.

Hence, I request that this document may please be included with the proposal of Ministry's portal for Environment Clearances already furnished by this department and consider the CRZ clearance for the work of Construction of high level bridge km 0/4 of Chennai – Pulicat Road to Pasiyavaram Road.

This is submitted for kind consideration and necessary action in this regard.

Encl: Supplementary marine EIA Report

28/5

Divisional Engineer(H)
C&M Division,Thiruvallur.

28/05/18

Copy submitted to the Chief Engineer (H) C&M, Guindy, Chennai-25 for favour of kind information.

Copy submitted to the Superintending Engineer (H) C&M, Chennai Circle, Chennai -06, for favour of kind information.

Copy submitted to the Principal Chief Conservator of Forest, PanagalMaligai, Saidapet, Chennai – 15 for favour of kind information.

Copy to the Assistant Divisional Engineer (H) C&M, Ponneri.

SACON Project Report # PR - 195

SUPPLEMENTARY ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED HIGH LEVEL BRIDGE ACROSS PULICAT LAKE, TAMIL NADU WITH SPECIAL FOCUS ON BIRDS

Final Report Submitted to

Highways Department, Thiruvallur

Sálim Ali Centre for Ornithology and Natural History
(A Centre of Excellence under the Ministry of Environment, Forest and Climate Change, Government of India)
P.O. Anaikatty, Coimbatore – 641108, Tamil Nadu

May 2018

SUPPLEMENTARY ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED HIGH LEVEL BRIDGE ACROSS PULICAT LAKE TAMIL NADU WITH SPECIAL FOCUS ON BIRDS

Final Report Submitted to

Highways Department, Thiruvallur

Project Investigators:

Dr. Riddhika Kalle, Dr. T. Ramesh & Dr. P. R. Arun

Project Biologist: Mr. V. Muthukrishnan

Sálim Ali Centre for Ornithology and Natural History
(A Centre of Excellence under the Ministry of Environment, Forest and Climate Change, Government of India)

P.O. Anaikatty, Coimbatore – 641108, Tamil Nadu

May 2018

Citation: Kalle, R., Ramesh, T., Arun, P.R. and Muthukrishnan, V. (2018). Supplementary Environmental Impact Assessment for the proposed High Level Bridge across Pulicat Lake, Tamil Nadu with special focus on birds. Project Report # PR – 195, SACON, Coimbatore, 75pp.

ACKNOWLEDGEMENTS

We sincerely thank Enviro Care India Private Limited, Chennai for their cooperation throughout the study. We thank the officials from the Highways Dept., Ponneri Town for providing logistic support. We sincerely thank the Forest Department Officials, especially Mr. P. Subbaiya, Forest Ranger, Mr. E. Samba Sivam, Forest Guard, Mr. U. Gunasekar, Anti-poaching watcher and Mr. N. Pugazhenthi, Anti-poaching Watcher for the initial orientation to the study site. We thank the local fishermen community especially Mr. Gandhi, and Mr. Yagub Ali for assisting us during fieldwork. We thank Mr. A. Srinivasan, SACON for formatting the report. We are thankful to Dr. K. Sankar, Director, SACON for his enthusiastic support and critical comments on the report.

EXECUTIVE SUMMARY

We conducted a two month study to document the impact of the proposed High Level Bridge on the avian diversity and composition across Pulicat Lake. Bird sampling was conducted at 86 vantage points of variable radius. We also conducted boat surveys and opportunistic encounters. Overall, we recorded a total count of 30,007 individuals belonging to 86 species of birds from 28 families and 13 orders across all surveys. Family Laridae had the highest proportion of individuals (46.5%) followed by Charadriidae (32.3%) and Scolopacidae (11%). Ardeidae, Phalacrocoracidae and Ciconiidae had relative proportions less than 4% while the remaining 22 families had the least proportion. The Little Ringed Plover *Charadrius dubius* had the highest proportion of abundance (22.35%) followed by both species of Terns (Lesser Crested Tern *Thalasseus bengalensis* and Greater Crested Tern *Thalasseus bergii* (11%), Common Sandpiper *Actitis hypoleucos* (10%), Pacific Golden Plover *Pluvialis fulva* (9.55%), Caspian Tern *Hydroprogne caspia* (8.41%), Black Headed Gull *Chroicocephalus ridibundus* (8.02%), Brown Headed Gull *Chroicocephalus brunnicephalus* (6.3%), and Little Egret *Egretta garzetta* (2.63%) while other species had low relative abundance (≤1.8%). Thirty-seven species were residents, 17 species were residents with local movements, 14 species were winter migrants, while a small proportion included residents with altitudinal movements, summer movements, and partial migrants. Out of 86 species recorded, six species of water birds; Great Thick-knee *Esacus recurvirostris*, Black-Tailed Godwit *Limosa limosa*, Eurasian Curlew *Numenius arquata*, Painted Stork *Mycteria leucocephala*, Spot-billed Pelican *Pelecanus philippensis* and Black-headed Ibis *Threskiornis melanocephalus* were categorised as “Near Threatened” according to the International Union for Conservation of Nature (IUCN) Red List. Five species of raptors Black-winged Kite *Elanus caeruleus*, Oriental Honey Buzzard *Pernis ptilorhynchus*, Shikra *Accipiter badius*, Brahminy Kite *Haliastur indus* and White-bellied Sea eagle *Haliaeetus leucogaster* were categorised as “Schedule I” according to the Wildlife Protection Act 1972. The maximum bird count ranging from 1952 to 4765 was recorded within a radius of 1.5 km close to the proposed High Level Bridge (HLB) site as well as existing Chennai-Pulicat Bridge. Particularly, the “Near-threatened species” like Painted Stork, Black-headed Ibis and Eurasian Curlew were observed foraging barely 50 m from the HLB site. Particularly, these species could be most vulnerable to the operation and construction phases of the bridge for which we have provided necessary guidelines to minimize the impact of the bridge on the avifauna.

1. INTRODUCTION

The Highways Department, Thiruvallur approached Sálim Ali Centre for Ornithology and Natural History (SACON), a Centre of Excellence under Ministry of Environment, Forest and Climate Change (MoEFCC), Govt. of India, through their consultancy Enviro Care India Private Limited to conduct a supplementary environmental impact assessment (EIA) study in order to address the impact of the High Level Bridge (HLB) on birds in Pulicat Lake and seek suggestions on appropriate management plans to minimize the said impact. Accordingly, a two month study was conducted by the research team of SACON at the proposed site in Pulicat Lake from March to April 2018.

1.1 BACKGROUND OF THE PROJECT

The proposed HLB will be situated on the back waters of Pulicat Lake and Buckingham canal near to the coast of Bay of Bengal. The Pulicat Lake is designated as an 'Important Bird Area (IBA)' by the Bombay Natural History Society and Birdlife International (Islam & Rahmani 2004) and 'Ramsar site' by Wetland International (Kannan et al., 2008) as it annually witnesses flocks of migratory birds and an ecologically rich wetland. The Pulicat Lake is placed under category I of Coastal Regulatory Zone, notified by the Government of India.

The Government of Tamil Nadu has proposed to construct a HLB in Tsunami affected areas (Anon 2011), to meet the requirements of the local public, for which a detailed environmental impact assessment is required. The proposed bridge (430 m) aims to provide connectivity to the people living in hamlets to Chennai-Pulicat Road and Pasiyavaram Road. Quite often children have no other alternative route but to wade through the knee-deep water to get to school. Therefore, it will be an escape route for those residing in Pasiyavaram island (18,000 people) and for transporting emergency response operations required for humanitarian aid, personnel and equipment to the affected site. The area gets inundated seasonally and the level of

water rises during North-east monsoon every year during which children and villagers are forced to wade through the knee-deep waters. Such situations are dangerous during natural disasters like tsunami, cyclones and storms resulting in many casualties.

The proposed HLB will be across the Pulicat Lake along with the approach roads on both sides of the Lake. The beginning of the approach road is in Pulicat Village and the end of the approach road is in Pasiyavaram Village. Pasiyavaram is an island in Pulicat Lake near Pazhaverkadu which is a market center and commercial hub for the local fishing community. The fishing community that lives in and around Pulicat Lake follows the “Padu system” of fishing, which traditionally, provides fishing rights to coastal communities throughout southern India and Sri Lanka over many generations. In addition they also follow the hand-picking method of fishing.

Pazhaverkadu is connected with bus services from Chennai and some towns of Andhra Pradesh. However, Pasiyavaram village has around 50 old settlements and newly built Tsunami housings but no connectivity to the mainland. Residents of Pasiyavaram use boats or wade through the water for their daily essentials. These residents face the maximum difficulty during monsoon and high tide as they have no other connecting road, but to wade through the water to get to the other village. The total population around this location is about 50,000 and their main occupation is fishing in the Bay of Bengal and Pulicat Lake. At present, people living in these villages (locally known as “kuppams”) travel to Ponneri town and Pulicat village for daily livelihood activities by boats. Additional materials are transported through bullock carts which are often heavily loaded in the standing water. The nearest highway, NH 16 is 20 km away from the project site. The nearest railway station is 15 km away from the project site. Ponneri is the nearest town to the project site. The bridge will be 432 m in length and 8 m wide.

1.2 ABOUT PULICAT LAKE

The Pulicat lake (13°24'-13°47'N; 80°03'-80°18'E) extends over Ponneri town and Gummidipundi taluk of Thiruvallur district in Tamil Nadu, and Sulurpet and Tada Mandals of Nellore district in Andhra Pradesh. It is connected to the Bay of Bengal about 1.6 kms north of the Pulicat light house. The area of Pulicat Lake in Tamil Nadu is 154 km^2. The Tamil Nadu part of Pulicat Lake has 13 villages; Pazhaverkadu, Knavanthurai, Avurivakkam, Pakkam, Sirulapakkam, Annamalaicheri, Kallur, Mangodu, Sunnampu kulam, Methipalayam, Pungulam etc. Eighty-four percent of the Lake falls in Andhra Pradesh while remaining 16% falls in Tamil Nadu. Pulicat Lagoon is said to be the second, largest lagoon in India. Pulicat Lake covers an area of 720 km^2 (Kannan & Pandiyan 2012). The lake has a number of islands. The mean annual rainfall ranges from 10 mm to 467 mm and temperature ranges from 28.2°C to 40.3°C (Kannan & Pandiyan 2012). Once this lagoon occupied nearly 55 km stretch north to south but presently it has shrunk to only 35 km stretch, with a maximum width of about 18 to 19 km. The average depth of the lake is 1–3 m which favours larval development of fishes and shrimps. This is extremely important for waders and seabirds during spring and autumn migrations (Hussain 1987). Pulicat lagoon is shallow with large areas of mudflats and sandflats. In general, the seawater enters the lagoon through the northern end near Sriharikota Island and flows back into the Bay of Bengal through the southern end. The salinity is greatly affected by rainfall. The inflow of seawater has led to the formation of bar mouth in the northern portion of the lagoon, however over time decreased rainfall has resulted in the depletion of fish stock (Saraswathy & Pandian 2016). The estuarine ecosystems in Pulicat Lake offer a substantial diversity of habitats, food resources and nursery areas for many species. Macroalgae are important primary producers along these coasts, serving as habitat or functioning as ecological engineering species. Seaweeds and seagrasses form small patches or larger vegetation beds which support epiphytic algae, as well as a variety of associated species and fish.

1.3 FAUNAL DIVERSITY OF PULICAT LAKE

Chacko et al. (1953), Kathirvel (2003) and Sanjeeva Raj, (1997, 2003, 2006) have given exhaustive accounts of the biodiversity of Pulicat Lake. Chacko et al. (1953) recorded 59 species of phytoplankton and 23 species of zooplankton, but Krishnan & Sampath (1973) have recorded 16 species of phytoplankton, but 35 species of zooplanktons. During monsoon about 75-85% of zooplankton belonged to copepoda and decapoda groups (Nagarjuna et al., 2010). Chacko et al. (1953) recorded 65 species of fish, including three elasmobranchs and 62 teleosts. Mohan et al., (2013) recorded six species of cultivable bivalve molluscs belonging to four families and five genus in Pulicat Lake. Twenty-one phytal fauna species associated with the macroalga *C. aerea* are mainly occupied by Gastropods followed by Amphipods, Decapods, Isopods and Polychaetes. The quantitative data indicates the dominant occurrence of Neritidae and Potamididae, followed by Corophiidae, Paguridae and Portunidae, Cirolanidae, Nereidae and Penaeidae (Raj et al., 2017). The population density of seaweed associated macrofauna ranges from 1156 -2004 nos/m^2 (Raj et al., 2017). The lake supports about 500 species of macro fauna including 168 species of fish (Chacko et al. 1953, Selvanathan & Kaliyamurthy 1972; Sanjeeva Raj 2006), 12 species of penaeid prawns (Chacko et al. 1953, Paul Raj 1976; Raj et al., 2017), 36 species of crabs (Kannan & Pandiyan 2012), 19 species of molluscs (Thangavelu & Sanjeeva Raj 1985, 1988) and 80 bird species with maximum number of species visiting during winter (Philip 1995; Kannan & Manakadan 2005; Samant & Rao 1996). Penaeid prawns constitute a major fishery in Pulicat estuary. Out of the 12 species of penaeid prawns, seven belong to the genus *Penaeus* and five belong to the genus *Metapenaeus* (Raj et al., 2017). The Edible Oyster (*Crassostrea madrasensis*) is the most extensively distributed bivalve and a keystone species in this lake (Thangavelu & Sanjeeva Raj 1988). However, Sanjeeva Raj et al. (2006) observed that with the loss of oyster beds in Pulicat Lake, biodiversity and fisheries was also getting depleted.

The distribution of polychaetes in Pulicat estuary is determined chiefly by water salinity and the nature of substratum. Polychaetes constitute important links in the food-chains of Pulicat Lake and they are the common food items for several species of top carnivores like fishes and waterbirds in the Lake (Philip 1995; Kannan & Manakadan 2005; Balachandran 1998; Samant & Rao 1996). The faunal register also recorded the feeding habits such as filter feeders, detritus feeders, scavengers or carnivores and algivores (Ranjitham et al. 2008). Pulicat is the third most important wetland for migratory bird population along the eastern seaboard of India and is especially important during the spring and autumn migratory seasons. According to the Forest Department's past records, about 60,000 to 80,000 water birds, belonging to 50 species visiting the lake in winters (Thirunavukkarasu et al., 2011), come from Ladakh, Tibet and China (Basha et al., 2012). In 2010 census the Forest Department recorded about 78-80 species of water birds in the same season. During the years 2007-2009 about 31 bird species visited Pulicat Lake feeding grounds (Nagarjuna et al., 2010). The banks of lagoons are suitable nesting sites for terns, gulls and waders. In Pulicat lagoon, 56 species of birds recorded belonged to 29 families and 11 orders (Govindan et al., 2015) but earlier reports by Asir Ramesh & Ramachandran (2005) showed 125 bird species recorded in the lagoon. Govindan et al., (2015) reported 13 species of migrants and 18 species of resident migrants. As per the IUCN status, 49 were Least Concern species, one each of Critically Endangered and Endangered species and five Near Threatened species (Govindan et al., 2015). The important migratory waterfowls are pelicans, herons, egrets, storks, flamingos, ducks, shorebirds, gulls and terns. Around 120 species of birds have been recorded so far from this area at various seasons and periods. However, despite the high diversity, large areas of mangroves in India are disappearing rapidly due to the booming shrimp aquaculture along its coasts. In brackish Pulicat Lake, the flamingo population has dropped from more than 10,000 to just 1000 due to the pollution of feeding grounds by shrimp farm effluents (Nagarajan & Thiyagesan

2006). Such losses and direct conflict with aquafarmers have resulted in a decline in the number and diversity of birds. The Asian Midwinter Waterfowl Census data over the past 10 years also reveals negative impacts on coastal bird life after aquaculture expansion in turn leading to the transmission of diseases to many endangered water birds (Mundkur et al., 2017). Herons appear to be the final hosts for fish tapeworms (cestodes) and gulls, grebes, and goosanders are the final hosts for fish flukes (trematodes) which infect both wild and farmed fish in larval stage. Due to the closure of sea mouths and quick drying up of Pulicat lake in several parts (Kumar et al., 2009, 2010) mainly in 2009-2010 the avian diversity had dropped to 31 species (Nagarjuna et al., 2010).

It is significant that the “Near-threatened” IUCN species like the Painted Stork and the White Ibis breed in the vicinity of Pulicat Lake (Pandian et al., 2006). The large amount of food (phytoplankton, zooplankton, polychaetes, invertebrates and fish) attracts numerous wetland birds especially Greater Flamingoes along with pelicans, kingfisher, herons, painted storks, spoon bills, ducks, black drongoes, blue jays, common teals, coots, cormorants, curlews, dabchicks, large egrets, little egrets, garganeys, little stints, open-billed storks, painted storks, pond herons, sandpipers, shovellers, white ibises, herring gulls etc (Phillip 1995, Kannan et al., 2008, Sankar 1986). The concentration of flamingoes depends on the water level along with high algal, fish and benthic diversity. Kudiri, Moolah Kuppam, and Annamalaicheri are three important places in Pulicat Lake where large number of flamingoes can be seen. The Oriental White-backed Vulture *Gyps bengalensis* is a “Critically Endangered” species and the Spot billed Pelican and Greater Spotted Eagle are IUCN Red listed “Vulnerable” species of Pulicat Lake (Basha et al., 2012). The checklist of birds prepared by the Wild Life Division of Andhra Pradesh listed 115 species of both aquatic and terrestrial birds in the Pulicat Lake. More than 60,000 migrant water birds feed and breed in the northern part of lagoon during winter. Surveys conducted from 1976-2008 in Sriharikota island adjoining the Pulicat Lake recorded a total of 125 species of land birds, comprising of 70 residents, 33 winter

migrants and 12 seasonal migrants (Manakadan et al., 2009). These coastal Southern Tropical Dry Evergreen Forests largely support the East Hill range birds. Other studies on this island recorded 28 species of mammals, 223 species of birds, 12 species of amphibians, 34 species of reptiles, 44 species of fish and 51 species of butterflies (Suryanarayana et al., 1989, 1998; Samant & Rao 1996; Rao 1998; Manakadan & Sivakumar 2004a, b; Sivakumar et al., 2004; Manakadan et al., 2013; David et al., 2011; Quadros et al., 2017).

1.4 FLORAL DIVERSITY OF PULICAT LAKE

Rooted and submerged aquatic macrophytes and filamentous algae constitute the benthic flora of the lake. A total of 57 species of algae recorded belonged to five families (Raghavaiah 2007). A total of 180 species of aquatic macrophytes are found in wetlands, of which 117 species are dicotyledonous plants, 51 species are monocotyledonous plants and 12 are found in mangroves (Rajyalakshmi & Basha 2016). The lake has several islands having a very significant forest type called as Southern Tropical Dry Evergreen Forest and several patches of *Prosopsis juliflora* (Champion & Seth 1968). Fifty-nine species of vegetation were recorded which includes 8 Cyanophyceae, 7 Chlorophyceae and 2 Rhodophyceae. The banks of the lake have mangrove forests which are patchy, largely belonging to 4 families; they include *Aegiceras corniculatum* of Myrsiraceae, *Avicennia marina* of Avicenniaceae, *Excoecaria agallocha* of Euphorbiaceae and *Lumintzera racemosa* of Combretaceae. At present mangrove plants of *Avicennia* species are very sparsely distributed in Pulicat Lake. Patches of dry evergreen forest and large areas of littoral scrub in fishing villages bordering the lagoon are also present. The palm tree along the shores and *Casuarina* and cashew plantations along the shoreline are shields during high waves. Common shrubs like *Azima tetracantha*, *Cassia auriculata*, *Excoecaria agallocha*, *Gmelina asiatica*, *Jatropha gossypifolia*, *Lawsonia inermes*, *Maytenus emarginatus*, *Pandanus tectorius*, *Salvodora persica*, and *Zyziphus mauritiana* grow on the margins of marshes and along the canals. On the bunds of the canals trees like *Azadirachta indica, Borassus flabellifer, Lepisanthus tetraphylla,*

Sapindus emarginatus, Syzigium cumini, Thespesia populnea have a scattered distribution. Submerged macrophytes include species of *Enteromorpha, Hypnea, Ulva*, *Halophila* and *Enhalus* (Basha et al., 2012; Oswin 1987). Along the shore and above high tide level, littoral forests (Champion & Seth 1968) occur where the dominant species are *Spinifex littoralis* and *Ipomea biloba* the pioneering sand binders; followed by the secondary colonizers like *Phyllanthus rotundifolius*, *Aristolochia bracteolata* and other species are *Calotropis procera, Solanum xanthocarpum, Caesalpinia bonduc* and *Opuntia dillenii.* Dominant species are *Manilkara hexandra**,** Albizzia amara, Albizzia lebbeck*, *Strychnos nux-vomica*, *Drypetes sepiaria*, *Borassus flabellifer*, *Memecylon umbellatum, Maba buxifolia, Garcinia spicata, Cordia dichotoma, Phoenix sylvestris*, and *Flacourtia indica.* The flora of Sriharikota Island has been well documented through a number of studies with 445 plant species of 117 families (Suryanarayana et al., 1989, 1998; Samant & Rao 1996; Rao 1998; Manakadan & Sivakumar 2004a, b; Sivakumar et al., 2004; Quadros et al., 2017).

1.5 RATIONALE & OBJECTIVES

The present study emphasizes the need to identify different species of avifauna and its importance based on their IUCN Red List category, the protection status according to the Indian Wildlife Protection Act (1972) and other attributes sensitive to various developmental impacts including key sites where these could be under most potential pressure from the environment and ecological changes in Pulicat Lake.

Therefore the objectives are as follows:-

- Documentation of the avifauna of the Pulicat Lake area likely to be affected by the construction of the proposed High level bridge
- Study the impacts of the proposed High Level Bridge on the avifauna and suggest appropriate management plan to minimize the impacts

2. INTENSIVE STUDY SITE

The following villages occur within the 5 km radius of the proposed HLB site; Gunan Kuppam, Thirumalai Nagar, Sembasipalli Kuppam, Light House Nadu Kuppam, Arangam Kuppam, Vairavan Kuppam, Korai Kuppam, Pasiyavaram, Siru Pazhaverkadu, Sattan Kuppam, Madha Nadu Kuppam, Kottai Kuppam, Andi Kuppam, Thony Revu, Light house Kuppam, Edamani, Kulathu Medu, Andar madam, Thangal Perunkulam and Jameelabad. Pasiyavaram, Edamani, Kottai Kuppam villages which are closer to the proposed HLB site have mudflats and shallow water which attracts Plovers, Sandpipers and Painted Storks (Fig. 1 a-o). During low tide, the water depth is about 5-8 m. During high tide the water level rises to 15-20 m. During monsoon the water depth level further rises above 25 m. The “Padu system” of fishing is followed in 9 villages on a rotational basis. The intensive study site has farmlands where people cultivate watermelon, paddy and groundnut. While some fishermen use motor boats for fishing, others follow hand-picking and use nets. Kulathumedu area has bare dirt land and several prawn pond farms which draws water from the Arani River for culturing prawns. Jameelabad village has dense vegetation of *Prosopsis juliflora*. Kanavanthurai, Pakkam and Annamalaicheri have mudflats and shallow water. These fishermen also use Catamaran for fishing while hand-picking method is used to capture small fish, prawns and crabs. The *Scylla serrata* is the dominant crab in these villages. Dominant fish species are Mullets, Blow fish, Cat fish, Milk fish and Fin fish. The Gunan Kuppam, Thirumalai Nagar, Light house Kuppam, Arangam Kuppam, Vairavan Kuppam, Korai Kuppam villages have beaches. The estuary areas are located nearby Sriharikotta island however, the estuary opening has become narrower and now degraded and covered by sandy shore. The estuary attracts a large population of Greater Crested Tern, Lesser Crested Tern, Caspian Tern and Brown-headed Gulls.

Figure. 1 A-O. Livelihood dependency of local people and habitats in the study area

a. Prawn Farm at Andar Madam

b. Fishing at Avurivakkam

c. Hand-picking of fish at Arani River

d. Aerial view of the existing Pulicat bridge

e. View of Sriharikota from Pulicat estuary

f. Fishing dock near the proposed High Level Bridge site

g. Mangroves at Thangal Perumkulam

h. School children crossing the Lake

i. Pulicat estuary

j. Landscape of Edamani Kuppam

k. Pasiyavaram people crossing the lake

l. Fishing dock near the proposed High Level Bridge site

m. The proposed High Level Bridge site during low tide

n. The EIA team interviewing a fisherman

o. High tide at Pasiyavaram village

3. METHODOLOGY

3.1 FIELD DATA COLLECTION

Direct counting method was used where 86 variable radius vantage points were identified and all the birds observed within the 100 m range from the observer were counted for sampling (Vijayan et al., 2006). The latitude and longitude of each vantage point was recorded using a GPS device (GARMIN e-Trex 20). The GPS coordinates of the sampling points were marked over the basemap of Google Earth imagery of Pulicat Lake using ArcMap 10.3 (ESRI 2012). The sampling points were randomly selected based on the landscape features. During counts each visible range upto 100 m was divided into several sections and each section was counted. Birds flying behind the observer were excluded in the counts. The distance between the nearest vantage point was 200-300 m and spatially distributed at a radius of 7 km from the proposed HLB site (Fig. 2). During data collection at the sampling point, the species of birds, the number of individuals, and habitat were recorded. We referred to the following references for categorization of habitat variables (Raghavaiah 2007; Sankar 1986). The habitat was evaluated broadly into categories typically followed in wetland ecosystems i.e aerial, mudflats, beach, creek, electric line, *Prosopsis spp*, mangroves, neem tree, bare dirt, road, and bridge. Sampling was conducted during high and low tides. Systems of water bodies were categorized into open water, closed water, shallow water, pooled water and algal zone. We recorded the weather conditions as clear sky, windy, cloudy, and rainy. The degree of human-related disturbance at each vantage point was measured by quantifying the number of active/inactive fishing boats, number of moving vehicles, number of people, grazing activity, number of feral dogs, and fishing activity.

At every point, the duration of data collection was fixed for 30 minutes, and the distance (m) of the observed species from the observer was also recorded. Two repeats were made at each point. Birds were observed using an Olympus 8X40

DPSI binocular and identified to species level using standard books by Ali & Ripley (1987) and Grimmett et al., (1999). Sampling was conducted from 5:00 am to 18:00 pm in every 2 hour intervals. A frequency tally counter was used to count the number of individuals during observations. If birds were observed in flight then the flight direction was recorded in degrees using a SUUNTO hand-held compass. Data collection was conducted from March to April 2018.

For identification of mammals, we referred to Menon (2014), for butterflies Kehimkar & Ugra (2016), for damselflies and dragonflies Subramanian (2009) and for reptiles and amphibians Daniel (2002). The checklist of birds of India by Praveen et al. (2016) was followed for scientific and common names of the birds used in this report. Based on our findings the positive and negative impacts of the proposed HLB on the avifauna and management recommendations to minimize the disturbance to avifauna are discussed.

Figure 2. Study area showing the sampling locations

3.2 DATA ANALYSIS

Relative proportion of abundance (%) of each species was calculated by a ratio of the number of individuals observed for each species to the total number of individuals observed. The relative proportion (%) of each avian family was calculated by a ratio of the number of observations for each family to the total number of families recorded. To avoid overestimate or underestimate of counts we repeated the counts of the flock for a maximum of two times at each sample point, of which the highest count was taken as the final count of the flock thereby a complete count of each species was obtained. Therefore, species abundance was calculated based on the maximum count data obtained from two repeats for each species. We also calculated the species richness, diversity index, evenness index and dominance index. The total number of species in an area was calculated as the species richness. All analysis was done using the program PAST (Hammer et al., 2001). Avian community structure was compared between different habitat types. Overall species richness and abundance of birds in all habitats were discussed in relation to the environmental and human related disturbance variables.

The equations for the two indices are as follows:

Shannon Diversity index (H) = $-\sum_{i=1}^{s} p_i \ln p_i$

The Shannon index is an information statistic index, which assumes all species represented are randomly sampled. In the Shannon index, *p* is the proportion (*n*/*N*) of individuals of one particular species found (*n*) divided by the total number of individuals found (*N*), ln is the natural log, *Σ* is the sum of the calculations, and *s* is the number of species.

Simpson index (D) = $\frac{1}{\sum_{i=1}^{s} p_i^{\,2}}$

The Simpson index is a dominance index as it gives more weight to common or dominant species. In the Simpson index, *p* is the proportion (*n/N*) of individuals of one particular species found (*n*) divided by the total number of individuals found (*N*), *Σ* is still the sum of the calculations, and *s* is the number of species.

Dominance = 1 - Simpson index. Ranges from 0 (all taxa are equally present) to 1 (one taxon dominates the community completely).

For calculating the evenness of species, the Pielou's Evenness Index (*e*) was used: **e = H / ln S** where H = Shannon – Wiener diversity index; S = total number of species in the sample

Margalef's index was used as a simple measure of species richness (Margalef 1958). **Margalef's index = (S – 1) / ln N** where S = total number of species; N = total number of individuals in the sample and ln = natural logarithm

4. RESULTS

4.1 BIRD ASSEMBLAGES AND SPECIES ACCOUNTS

Overall, we recorded 86 species of birds belonging to 28 families and 13 orders. The total number of birds recorded was 30,007 of which family Laridae had the highest proportion (46.5%) followed by Charadriidae (32.3%) and Scolopacidae (11%). Ardeidae, Phalacrocoracidae and Ciconiidae had relative proportions less than 4% while the remaining 22 families had the least proportion (Fig. 3). In terms of the proportion of number of species according to avian orders recorded, 23 species

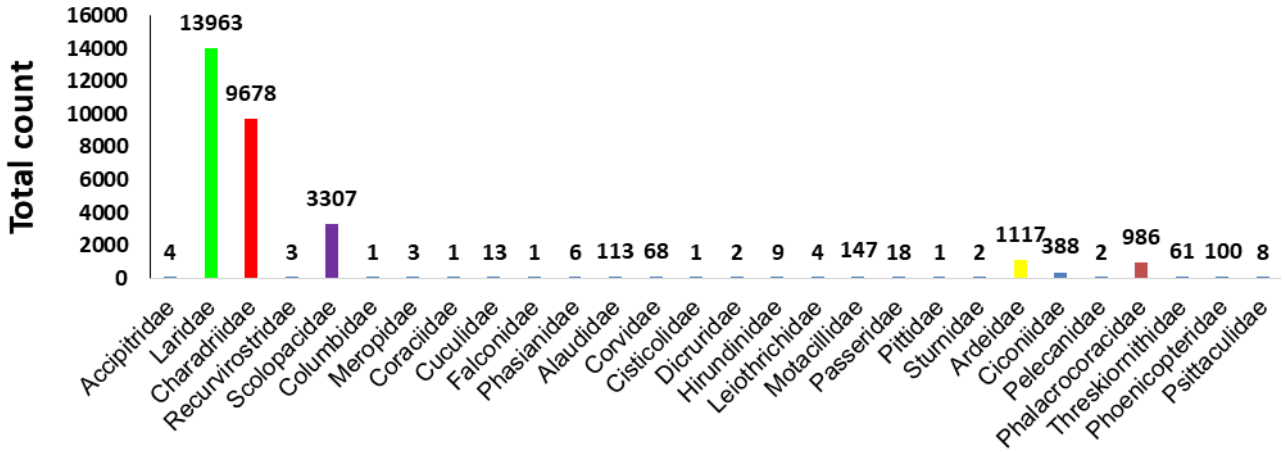

Figure 3. The total count of avian species from different families

belonged to Charadriiformes and Passeriformes, each followed by Pelecaniformes (n=14), Coraciiformes (n=6), Cuculiformes (n=5), and Accipitriformes (n=5). Falconiformes, Galliformes, Phoenicopteriformes, Psittaciformes, Strigiformes, Gruiformes, and Columbiformes (Fig. 4).

The Little Ringed Plover *Charadrius dubius* had the highest proportion of abundance (22.35%) followed by both species of Terns (Lesser Crested Tern *Thalasseus bengalensis* and Greater Crested Tern *Thalasseus bergii* (11%)), Common

Sandpiper *Actitis hypoleucos* (10%), Pacific Golden Plover *Pluvialis fulva* (9.55%), Caspian Tern *Hydroprogne caspia* (8.41%), Black Headed Gull *Chroicocephalus ridibundus* (8.02%), Brown Headed Gull *Chroicocephalus brunnicephalus* (6.3%), and Little Egret *Egretta garzetta* (2.63%) while other species had low relative abundance (≤1.8%) (Fig. 5, Table 1).

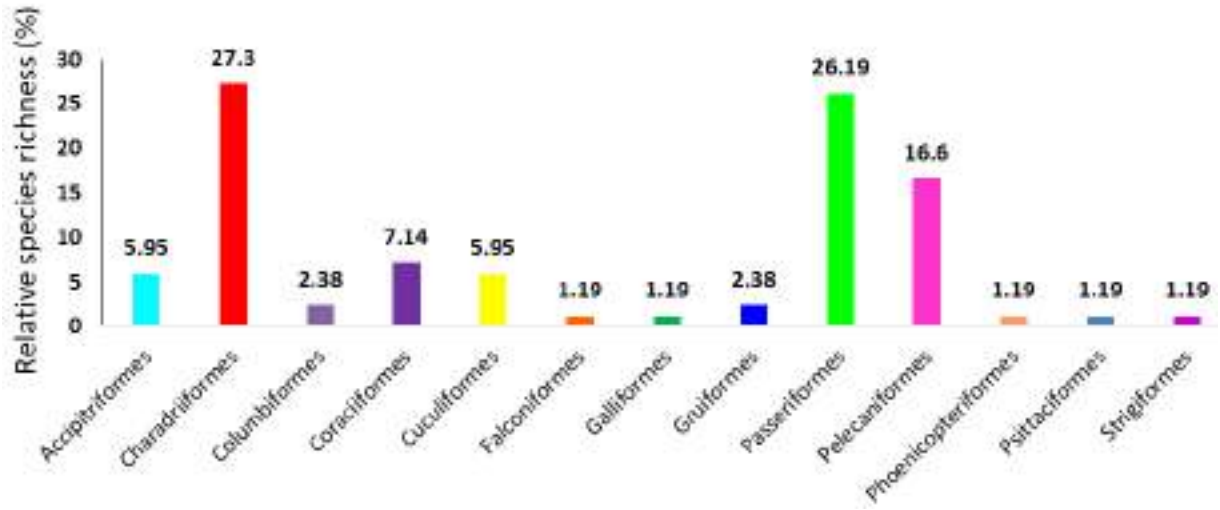

Figure 4. Relative species richness of avian orders in the study site

Table 1. The total count of bird species recorded in the study site

Order	**Family**	**Common name**	**Scientific name**	**Total count**
Charadriiformes	Charadriidae	Little Ringed Plover	*Charadrius dubius*	6707
Charadriiformes	Laridae	Lesser Crested Tern	*Thalasseus bengalensis*	3300
Charadriiformes	Laridae	Greater Crested Tern	*Thalasseus bergii*	3300
Charadriiformes	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	2917
Charadriiformes	Charadriidae	Pacific Golden Plover	*Pluvialis fulva*	2865
Charadriiformes	Laridae	Caspian Tern	*Hydroprogne caspia*	2523
Charadriiformes	Laridae	Black-headed Gull	*Chroicocephalus ridibundus*	2408
Charadriiformes	Laridae	Brown-headed Gull	*Chroicocephalus brunnicephalus*	1890

Pelecaniformes	Ardeidae	Little Egret	*Egretta garzetta*	791
Charadriiformes	Laridae	Whiskered Tern	*Chlidonias hybrida*	542
Pelecaniformes	Phalacrocoracidae	Little Cormorant	*Microcarbo niger*	494
Pelecaniformes	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	492
Pelecaniformes	Ciconiidae	Painted Stork	*Mycteria leucocephala*	330
Charadriiformes	Scolopacidae	Little Stint	*Calidris minuta*	238
Pelecaniformes	Ardeidae	Intermediate Egret	*Ardea intermedia*	175
Passeriformes	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	147
Charadriiformes	Scolopacidae	Black-Tailed Godwit	*Limosa limosa*	140
Pelecaniformes	Ardeidae	Great Egret	*Ardea alba*	102
Phoenicopteriformes	Phoenicopteridae	Greater Flamingo	*Phoenicopterus roseus*	100
Charadriiformes	Charadriidae	Kentish Plover	*Charadrius alexandrinus*	92
Passeriformes	Corvidae	House Crow	*Corvus splendens*	66
Pelecaniformes	Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus*	61
Pelecaniformes	Ciconiidae	Asian Openbill	*Anastomus oscitans*	58
Passeriformes	Alaudidae	Oriental Skylark	*Alauda gulgula*	57
Passeriformes	Alaudidae	Ashy-crowned Sparrow Lark	*Eremopterix griseus*	56
Pelecaniformes	Ardeidae	Cattle Egret	*Bubulcus ibis*	27
Passeriformes	Passeridae	House Sparrow	Passer domesticus	18
Charadriiformes	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	14
Pelecaniformes	Ardeidae	Indian Pond Heron	*Ardeola grayii*	13
Charadriiformes	Scolopacidae	Eurasian Curlew	*Numenius arquatus*	11
Cuculiformes	Cuculidae	Blue-faced Malkoha	*Phaenicophaeus viridirostris*	9
Passeriformes	Hirundinidae	Barn Swallow	*Hirundo rustica*	9
Psittaciformes	Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	8
Pelecaniformes	Ardeidae	Grey Heron	*Ardea cinerea*	7
Galliformes	Phasianidae	Grey Francolin	*Francolinus pondicerianus*	6*

Coraciiformes	Meropidae	Green Bee-eater	*Merops orientalis*	4
Passeriformes	Leiothrichidae	Yellow-billed Babbler	*Turdoides affinis*	4
Charadriiformes	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	3
Passeriformes	Pycnonotidae	White-browed Bulbul	*Pycnonotus luteolus*	3*
Accipitriformes	Accipitridae	Shikra	*Accipiter badius*	2
Coraciiformes	Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	2*
Cuculiformes	Cuculidae	Asian Koel	*Eudynamys scolopaceus*	2
Passeriformes	Corvidae	Large-billed Crow	*Corvus macrorhynchos*	2
Passeriformes	Dicruridae	Black Drongo	*Dicrurus macrocercus*	2
Passeriformes	Sturnidae	Common Myna	*Acridotheres tristis*	2
Pelecaniformes	Ardeidae	Western Reef Egret	*Egretta gularis*	2
Pelecaniformes	Pelecanidae	Spot-billed Pelican	*Pelecanus philippensis*	2
Strigiformes	Strigidae	Spotted Owlet	*Athene brama*	2*
Accipitriformes	Accipitridae	Black-winged Kite	*Elanus caeruleus*	1
Accipitriformes	Accipitridae	Oriental Honey Buzzard	*Pernis ptilorhynchus*	1
Accipitriformes	Accipitridae	Brahminy Kite	*Haliastur indus*	1*
Accipitriformes	Accipitridae	White-bellied sea eagle	*Haliaetus leucogaster*	1*
Charadriiformes	Burhinidae	Eurasian Thick-knee	*Burhinus oedicnemus*	1*
Charadriiformes	Burhinidae	Great Thick-knee	*Esacus recurvirostris*	1*
Charadriiformes	Charadriidae	Yellow-wattled Lapwing	*Vanellus malabaricus*	1*
Charadriiformes	Scolopacidae	Wood Sandpiper	*Tringa glareola*	1
Charadriiformes	Scolopacidae	Common Redshank	*Tringa totanus*	1*
Charadriiformes	Scolopacidae	Common Greenshank	*Tringa nebularia*	1*
Charadriiformes	Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis*	1*
Charadriiformes	Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	1*

Columbiformes	Columbidae	Spotted Dove	*Streptopelia chinensis*	1
Columbiformes	Columbidae	Rock Pigeon	*Columba livia*	1*
Coraciiformes	Alcedinidae	Pied Kingfisher	*Ceryle rudis*	1*
Coraciiformes	Alcedinidae	Common Kingfisher	*Alcedo atthis*	1*
Coraciiformes	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	1*
Coraciiformes	Coraciidae	Indian Roller	*Coracias benghalensis*	1
Cuculiformes	Cuculidae	Greater Coucal	*Centropus sinensis*	1
Cuculiformes	Cuculidae	Pied Cuckoo	*Clamator jacobinus*	1
Cuculiformes	Cuculidae	Common Hawk Cuckoo	*Hierococcyx varius*	1*
Falconiformes	Falconidae	Common Kestrel	*Falco tinnunculus*	1
Gruiformes	Rallidae	Common Moorhen	*Gallinula chloropus*	1*
Gruiformes	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	1*
Passeriformes	Alaudidae	Jerdon's Bushlark	*Mirafra affinis*	1*
Passeriformes	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	1*
Passeriformes	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	1
Passeriformes	Cisticolidae	Ashy Prinia	*Prinia socialis*	1*
Passeriformes	Cisticolidae	Plain Prinia	*Prinia inornata*	1*
Passeriformes	Laniidae	Brown Shrike	*Lanius cristatus*	1*
Passeriformes	Motacillidae	Forest Wagtail	*Dendronanthus indicus*	1*
Passeriformes	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	1*
Passeriformes	Muscicapidae	Pied Bushchat	*Saxicola caprata*	1*
Passeriformes	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	1*
Passeriformes	Pittidae	Indian Pitta	Pitta brachyura	1
Passeriformes	Oriolidae	Eurasian Golden Oriole	*Oriolus oriolus*	1*
Pelecaniformes	Ardeidae	Striated Heron	*Butorides striata*	1*

* = Opportunistic sightings

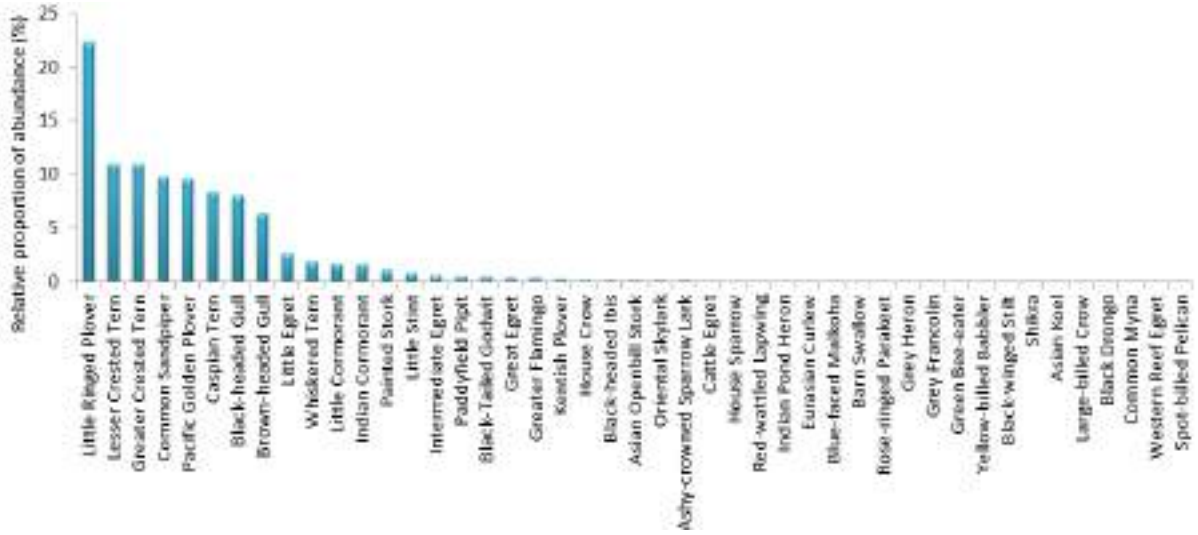

Figure 5. Relative abundance (%) of various avian species recorded in the study site

In terms of relative proportion of abundance of avian orders Charadriiformes had the highest proportion (89.75%) followed by Pelecaniformes (8.51%), Passeriformes (1.25%) while the relative proportion of abundance was low (≤0.33%) for Phoenicopteriformes, Cuculiformes, Coraciiformes, Psittaciformes, Accipitriformes, Galliformes, Columbiformes, Gruiformes, Falconiformes and Strigiformes. A major proportion of abundance of avian species was recorded in mudflats (59%) and beach areas (28%) followed by shallow water (5.8%), aerial (4.3%), while a low proportion of abundance (≤1%) was recorded in bare dirt, bridge, open water, electric lines, *Prosopsis spp* vegetation, creeks, neem vegetation, pond water and mangrove vegetation (Fig. 6). High species richness was recorded in mudflats (20), aerially (19), and in shallow waters (17), while richness was lower in other habitats (Fig 7). The Shannon diversity index (H') was high (2.49), Dominance index (D) was 0.11, Simson's index (1-D) was 0.88, Evenness index was 0.22, and Margalef's species richness index was high (5.24). In terms of the feeding habitats of bird species the maximum proportion of individuals recorded were marine carnivorous feeders followed by omnivores and piscivores (Fig. 8). The spatial map of total count of birds at sampling points showed that the maximum count (1952-4765) were recorded within a radius of 1.5 km close to the proposed HLB site as well as existing Chennai-

Pulicat bridge which was the control site (Fig. 8). A lower total count was recorded towards the southerly areas of the study site.

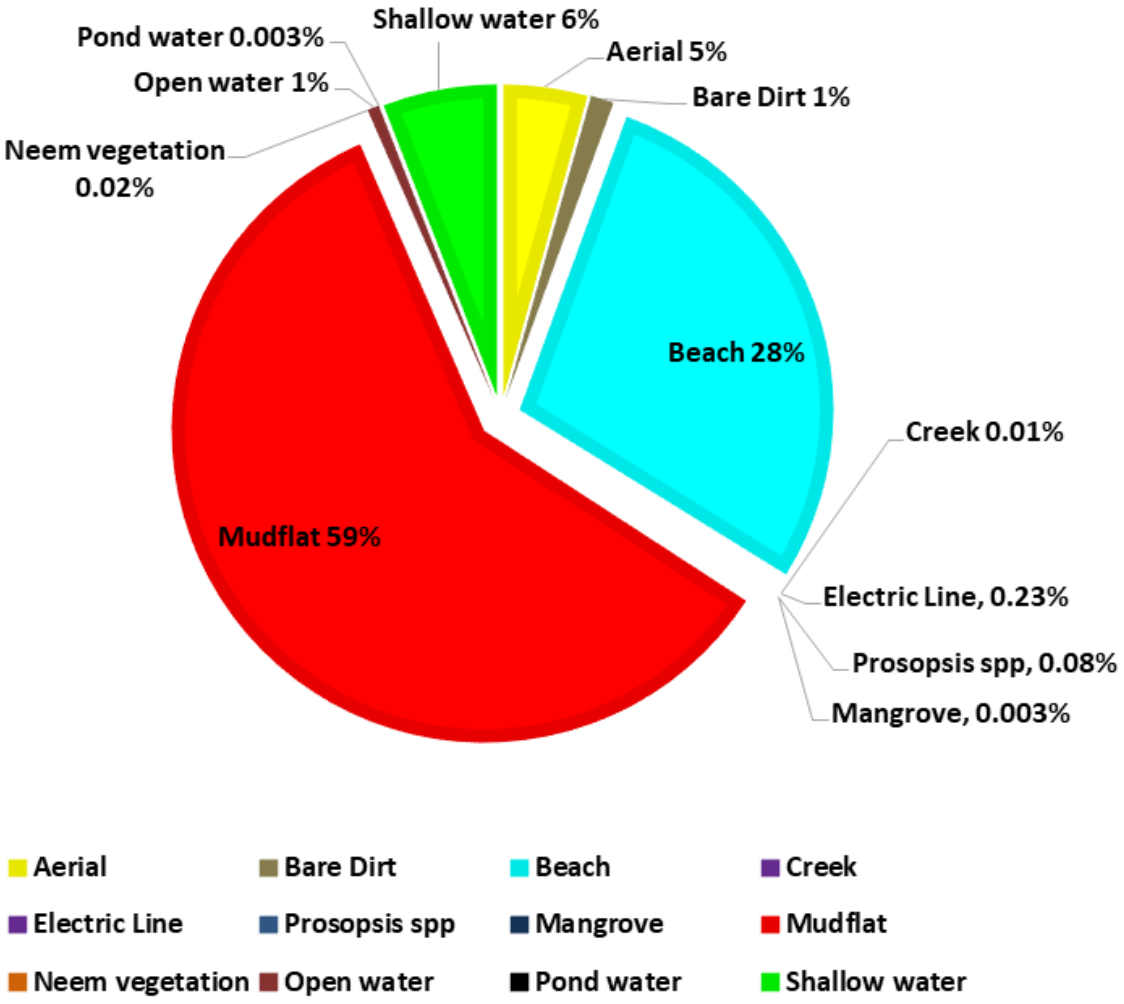

Figure 6. Proportion of species recorded in different habitats in the study area

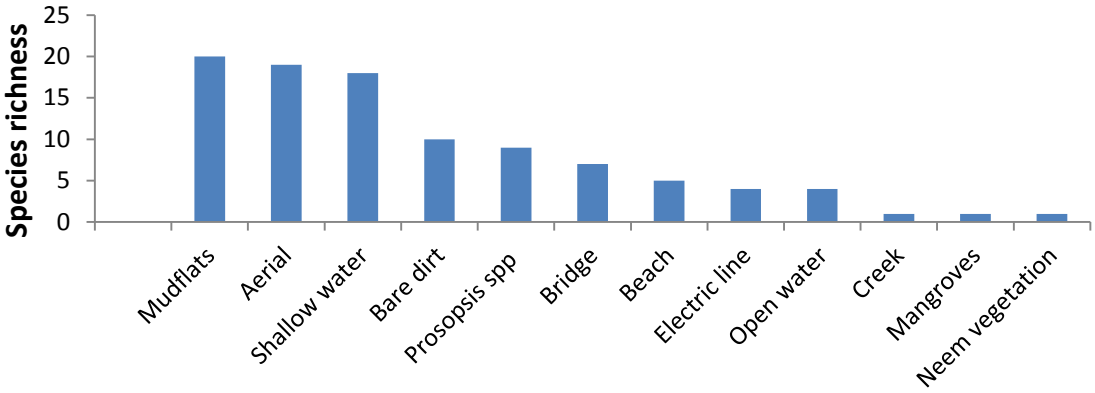

Figure 7. Avian richness recorded in different habitats in the study site

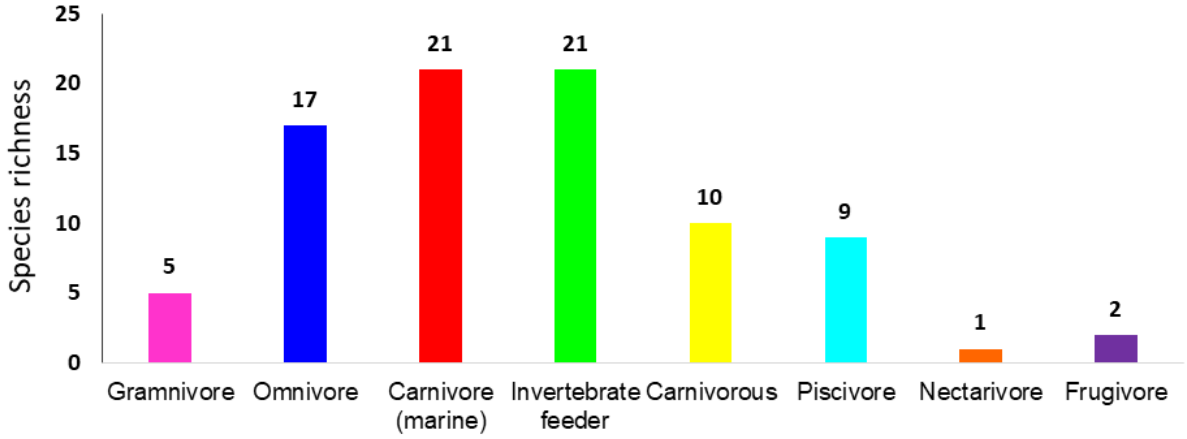

Figure 8. Different feeding guilds of avian species recorded in the study site

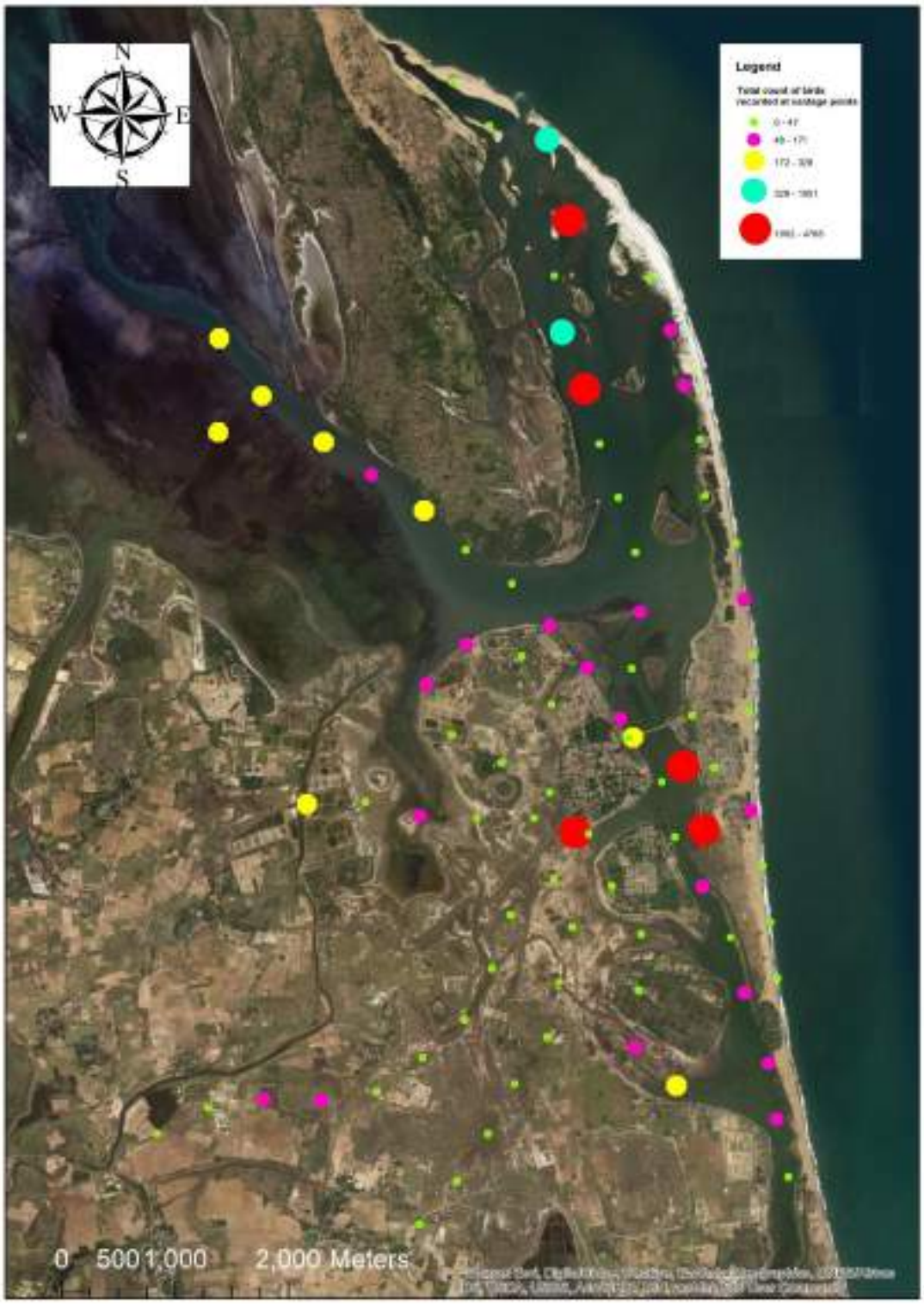

Figure. 9. Spatial map of the total count of birds at sampled vantage points in the study site within a radius of 7 km from the proposed HLB.

4.2 OTHER FAUNA

During the study we opportunistically recorded twelve species of butterflies, two species of moths, four species of dragonflies, two species of damselflies, a beetle, bug, wasp, spider, two species of crustaceans, an Echinodermata, two species of amphibians, four species of reptiles and four species of mammals (Table 2).

Table 2. Other faunal species recorded in the study area and their status of protection

Taxa	Common name	Scientific name	IUCN status	WPA (1972) STATUS
Butterflies	Angled Castor	*Ariadne Ariadne*	LC	*
	Blue Pansy	*Junonia orithiya*	LC	*
	Blue Tiger	*Tirumala limniace*	LC	*
	Common Cerulean	*Jamides celeno*	LC	*
	Common Mormon	*Papilio polytes*	LC	*
	Common Pierrot	*Castalius rosimon*	LC	Sch. I
	Common Rose	*Pachliopta aristolochiae*	LC	*
	Common Sailer	*Neptis hylas*	LC	*
	Crimson Rose	*Pachliopta hector*	LC	Sch. I
	Plain Tiger	*Danaus chrysippus*	LC	Sch. I
	Forget- me- not	*Catochrysops strabo*	LC	*
	Tricoloured pied flat	*Coladenia indrani*	LC	*
Moths	Crimson-speckled moth	*Utetheisa pulchella*	LC	*
	Indian Wasp Moth	*Euchromia spp*	LC	*
Dragonflies	Scarlet Rock Glider	*Trithemis kirbyi*	LC	*
	Common Picture Wing	*Rhyothemis variegata*	LC	*
	Black stream Glider	*Trithemis festiva*	LC	*
	Ditch Jewel	*Brachythemis contamina*	LC	*

Damselflies	Coromandel marsh Dart	*Ceriagrion coromandelianum*	LC	*
	Three striped Blue Dart	*Pseudagrion decorum*	LC	*
Bugs	Red Cotton Stainer	*Dysdercus cingulatus*	LC	*
Beetles	Jewel Bug	*Chrysocoris stollii*	LC	*
Wasp	Orange Spider Wasp	*Cryptocheilus bicolor*	LC	*
Spider	Two Striped Jumper	*Telamonia dimidata*	LC	*
Crustacean	Hermit Crab	Paguroidea (S.Fsmily)	LC	*
	Fiddler Crab	*Uca annulipes*	LC	*
Echinodermata	Starfish	Osteroideae (Class)	LC	*
Amphibian	Asian Common Toad	*Duttaphrynus melanostictus*	LC	*
	Indian Tree frog	*Polypedates maculatus*	LC	*
Reptiles	Oriental Garden Lizard	*Calotes versicolor*	LC	*
	Olive Ridley Sea Turtle	*Lepidochelys olivacea*	VU	Sch. I
	Beaked Sea Snake	*Enhydrina schistosa*	LC	Sch. IV
Mammals	Golden Jackal	*Canis aureus indicus*	LC	Sch. II
	Wild Pig	*Sus scrofa*	LC	Sch. III
	Flying Fox	*Pteropus (Genus)*	LC	Sch. V
	Dolphin	Unidentified		

LC = Least concern; VU = Vulnerable, * = information unavailable

4.3 STATUS OF PROTECTION

Out of 86 species recorded, six species of water birds; Great Thick-knee *Esacus recurvirostris*, Black-Tailed Godwit *Limosa limosa*, Eurasian Curlew *Numenius arquata*, Painted Stork *Mycteria leucocephala*, Spot-billed Pelican *Pelecanus philippensis* and Black-headed Ibis *Threskiornis melanocephalus* were categorised as "Near Threatened" according to the IUCN Red List. Five species of raptors Black-winged Kite *Elanus caeruleus*, Oriental Honey Buzzard *Pernis ptilorhynchus*, Shikra *Accipiter badius*, Brahminy Kite *Haliastur indus* and White-bellied Sea eagle *Haliaeetus leucogaster* were categorised as "Schedule I" according to the Wildlife Protection Act (WPA) 1972. Out of the other fauna recorded, five species (three species of butterflies and a reptile) were listed in "Schedule I" category according to the Wildlife Protection Act 1972. Mammals, Golden Jackal and Wild Pig were placed in "Schedule II and III" categories respectively while a snake species was listed under the "Schedule III" category and a bat species in "Schedule IV" category (Table 2). "Schedule I and Schedule II" categories of species receive the highest status of protection (WPA 1972).

5. DISCUSSION

Given the anthropogenic pressure on the biodiversity, the favourable habitats for various species are getting diminished. Management of the wetlands is therefore crucial for conservation of avian species that require high protection status and conservation decisions concerning endangered or vulnerable bird species are often based on species abundance. As a wetland ecosystem the Pulicat lake area is important for the breeding and roosting birds and several other fauna and flora.

The avian diversity measured in our study was comparable with estimates reported from other wetlands of Tamil Nadu (Vijayan et al., 2006) and are within the range of high diversity index. In our study 86 species of birds were recorded out of which a major proportion comprised of wetland birds than forest birds. A total of 113 species of water birds were recorded in the Pulicat lake area (inclusive of those in the adjoining wetlands and heronries) by Kannan et al., (2008) over a three year study duration (2004-2007). In the past the Bombay Natural History Society had initiated bird ringing programmes in Pulicat in 1990-91 where they had ringed 1568 birds belonging to 31 species (Hussain 1991). Totally, 215 avian species have been recorded in Pulicat, 100 of which were aquatic and 115 terrestrial (Raghavaiah 2001; Manakadan & Sivakumar 2004a,b). Surveys in Pulicat Lagoon by Govindan et al., (2015) recorded 56 avian species belonging to 29 families and 11 orders which is comparatively lesser than our results. Therefore our study site supports approximately 70-80% of the total richness of water bird species in Pulicat Lake. Raghavaiah (2007) recorded 27 aquatic bird species of which the Greater Flamingo was the most abundant followed by Sandpiper and Brown-headed Gull. However, our short term survey showed a major decline in the Greater Flamingo numbers (100) compared to earlier studies (Raghavaiah 2007; Asir Ramesh & Ramachandran 2005). Raghavaiah (2007) recorded Phoenicopteridae as the most dominant family followed by Scolopacidae, Ardeidae, Anatidae, Ciconiidae, Laridae, Pelecanidae, Phalacrocoracidae, Charadriidae, Recurvirostridae, Rallidae, Podicipedidae and Threskiomithidae. On the contrary, we recorded Laridae family having the highest

proportion of abundance followed by Charadriidae, Scolopacidae, Ardeidae, Phalacrocoracidae and Ciconiidae. Our study showed that the Little Ringed Plover had the highest abundance followed by both species of Terns (Lesser Crested Tern and Greater Crested Tern), Common Sandpiper, Pacific Golden Plover, Caspian Tern, Black Headed Gull, Brown Headed Gull and Little Egret. The descending order of abundance of species and families varied in our study compared to earlier studies. The Spot-billed Pelican in the Pulicat Lake-Nelapattu area had a higher population density ranging from 0.56-0.65 birds/sqkm (Kannan & Pandiyan 2016) than the abundance of the species from our surveys. In contrast to earlier studies by Kannan & Pandian (2016), Nagulu (1983), Perennou (1990), Santharam (1993), and Johnson et al. (1993), the abundance of Spot-billed Pelican recorded in our study was extremely low which is probably indicative of the site supporting low prey base for the species and also because our surveys were conducted from March to April when maximum emigration of water birds takes place. In addition, the southern-most region of Pulicat Lake area which includes our study site is highly disturbed compared with the northern and central portion of the lake (Kannan & Pandiyan 2016).

Various studies reported that water level and bird abundance were inter-related (Colwell & Taft 2000). The total number of birds recorded at vantage points varied in each location depending on the water level, tidal conditions and food availability. We recorded two “Near threatened” species close to the proposed HLB site. Therefore, it is important for the Highways department to ensure that construction activities do not disturb the water levels or alter the food availability for these species. Even otherwise, there has been a general decline in the productivity of Pulicat lake over the past few years, contributing to increased pollution levels due to an array of human-driven activities, population pressure and nearby industries (Sanjeeva Raj 1996). The population of waterbird species is important and the areas used by these species for various activities must be protected. It is important for the development authorities to note that any construction activity must commence and complete

before the bird migratory season. Necessary mitigation measures must be undertaken to reduce indirect impact on the HLB site at various phases of development to the surrounding wetland habitat, woody vegetative cover and the overall ecology of the site. The indirect impact may be due to the release of contaminated, polluted or untreated water, debris, or other materials from the construction phase.

5.1 MANAGEMENT RECOMMENDATIONS

Careful consideration by following appropriate guidelines should be practiced to minimize any loss of biological resources in critical ecosystems of the Pulicat Lake.

- The tertiary organisms like fish are mobile and sensitive to environmental stress. They easily avoid the polluted systems and move to other regions. The indiscriminate influx of untreated domestic and industrial wastes into the coastal waters has ecologically deteriorated the region. The oxygen level in the waters is low therefore the waters do not sustain adequate biotic life. The turbidity of the waters limit the primary production in the seas thereby the food chain in the system is affected. Various activities like excavation, uprooting of woody vegetation, transportation of cement material for bridge construction, solid and liquid wastes, and operational equipment could be harmful and hazardous to the surrounding biodiversity.
- If any vegetation is uprooted, particular vegetative species must be replanted after the construction has completed.
- Construction activities involving generation of high noise should be avoided between 5 and 8 am and between 16 and 18 pm as these timings coincide with the peak foraging activities of wetland birds. During construction, equipment, including dozers, scrapers, concrete mixers, generators, vibrators and power tools, and vehicles will be the major noise sources. Construction noise is difficult to predict or even regulate because the level of activity will constantly change depending upon the kind of activity involved. Therefore the noise could be considerably reduced by adoption of low noise equipment or installation of sound insulation fences or silencers alongside the length of the bridge. Transmission of noise and vibration are limited by the distance from avian species. Noise barriers shall be installed as this may reduce the disturbance to avian species.

- The Highway authorities must ensure proper drainage facility within the project site such that the effluents do not alter the slope of the terrain and increase/alter turbidity/salinity/pH of the lake as this could have major consequences on the soil and aquatic biota that provides a rich source of food for avian species, especially waders, filter feeders, plankton feeders, and probing species. For eg: Pelicans feed on fishes and other migrant waders feed on zooplankton and phytoplankton. During the monsoon period, the lake is normally filled with nutrient-rich water and large numbers of both phytoplankton and zooplankton constitute essential food for invertebrates and juvenile shrimps and migratory fishes from sea to lake which in turn attracts numerous wetland birds like Pelicans, Flamingoes and a variety of waders. We observed large flocks of Lesser Crested and Greater Crested Terns, Brown-headed Gulls, Ruddy Turnstone, Painted Stork, Black-headed Ibis, and a few individuals of Eurasian Curlew were often the most frequently observed species close to the proposed HLB site. These species are omnivores and carnivores feeding on pelagic fish, crustaceans, etc and are mostly shallow water feeders.
- Construction of bridge may even modify the relationships of phytoplankton and zooplankton and invertebrate communities, changing the existing biodiversity in the soil and water. Therefore, proper mitigation measures shall be taken such as soft-scraping of the soil. There may be temporary decrease or change in the faunal population due to this disturbance caused.
- The shallow waters of the north of the Annamalaicheri village which is the only known and recorded habitat of flamingos in the Tamil Nadu part of the Pulicat Lake may not be vulnerable to the proposed HLB construction since it is 10 kms away.
- Large-scale restoration of mangroves could be undertaken in severely degraded areas surrounding the HLB site as this also serves as a natural

fence or barrier against loud noise from traffic or movement of people on the bridge.

- Strict measures should be taken not to leave any debris during bridge construction.
- Following the Swachh Bharath Mission program, public toilets must be set up and maintained regularly to prevent deposition and creation of open defecation sites alongside the Lake.
- Domestic dogs were sighted frequently predating on water birds and their nests. Therefore, removal of feral dogs will minimize predation rates.
- A designated site or a proper disposal site for treatment of garbage at worker's camp site, waste oil or grease from the construction machines and storage work must be identified.
- It has been observed that during high tide period on the mudflats many water birds move to other areas and return during low tide. Particularly, the proposed HLB site receives high tide in certain seasons therefore the bridge must be constructed at a height above the rising water level to allow easy movement of the people during rough tidal conditions and to allow many bird species to use the water below the bridge. The bridge should be constructed at a height which is significantly higher above the upper most limit of the water level such that it does not become a physical barrier for avian species having aquatic feeding habits.
- Even during movements of boats the water birds tend to move to other foraging sites which indicated that these birds are sensitive to noise levels. Lighting may be appropriately placed along the bridge so as to minimize any disturbance to roosting birds nearby.
- Ensure safety measures during bridge construction such as removal of debris frequently during construction.

- To avoid any operational disturbances to water birds, bridge construction activity should not be done between November-April because this is usually the period when many migratory birds visit the site for food to replenish their energy already lost from long distance flights during migration.
- Must prohibit the use of vehicle horn by commuters over the bridge.
- Implementation of periodical long-term monitoring of migratory birds in the study area is important to monitor the long-term impacts of developmental activities on water birds.

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APPENDICES

Appendix 1. Geographic locations of vantage points for sampling avifauna

ID	North-Latitude	East-Longitude	ID	North-Latitude	East-Longitude	ID	North-Latitude	East-Longitude
1	13.41146	80.31555	31	13.41956	80.3046	61	13.4071	80.32471
2	13.4073	80.31732	32	13.42362	80.30263	62	13.40298	80.32689
3	13.40341	80.31964	33	13.42675	80.30595	63	13.39856	80.32794
4	13.39892	80.31935	34	13.42568	80.31043	64	13.39291	80.32973
5	13.39444	80.31896	35	13.42181	80.31277	65	13.38846	80.33034
6	13.39129	80.32225	36	13.4206	80.31834	66	13.38386	80.33118
7	13.40795	80.31265	37	13.42466	80.3157	67	13.4207	80.32414
8	13.40514	80.30904	38	13.42808	80.31277	68	13.42088	80.32876
9	13.40092	80.30745	39	13.43147	80.30975	69	13.42536	80.32922
10	13.39691	80.30515	40	13.43424	80.30605	70	13.42983	80.3286
11	13.39397	80.30166	41	13.43745	80.30274	71	13.43429	80.3281
12	13.39134	80.29791	42	13.4404	80.29852	72	13.4381	80.32561
13	13.39073	80.29334	43	13.44305	80.29471	73	13.44259	80.32525
14	13.39095	80.28872	44	13.44682	80.28977	74	13.44693	80.32405
15	13.39034	80.28415	45	13.44401	80.28618	75	13.45133	80.32309
16	13.38837	80.27999	46	13.45147	80.28641	76	13.45558	80.32157
17	13.40409	80.31407	47	13.42451	80.31935	77	13.41653	80.32588
18	13.39973	80.31295	48	13.42902	80.32011	78	13.41303	80.32879
19	13.39538	80.31178	49	13.43377	80.31985	79	13.40861	80.32962
20	13.39172	80.30911	50	13.43812	80.31854	80	13.40413	80.33018
21	13.38779	80.30686	51	13.44241	80.31713	81	13.39967	80.33065
22	13.38409	80.30423	52	13.44682	80.31601	82	13.41906	80.31935
23	13.38074	80.30114	53	13.45136	80.31428	83	13.41899	80.31898
24	13.41282	80.31112	54	13.45585	80.31373	84	13.41665	80.32337
25	13.41287	80.3065	55	13.46022	80.31502	85	13.41159	80.31445
26	13.41317	80.30189	56	13.46668	80.31342	86	13.41159	80.32492
27	13.4144	80.29744	57	13.41544	80.32157			
28	13.41431	80.29271	58	13.46788	80.30873			
29	13.41482	80.31246	59	13.47143	80.30583			
30	13.41728	80.30859	60	13.41106	80.32255			

Appendix 2. Checklist of Birds recorded during the study

Sl No.	Order Name	Family Name	Common Name	Species Name	IUCN Status	WPA 1972	Residential Status	Feeding guild
1	Accipitriformes	Accipitridae	Black-winged Kite	*Elanus caeruleus*	LC	Sch. I	R	CA
2	Accipitriformes	Accipitridae	Oriental Honey Buzzard	*Pernis ptilorhynchus*	LC	Sch. I	R	IN
3	Accipitriformes	Accipitridae	Shikra	*Accipiter badius*	LC	Sch. I	R	CA
4	Accipitriformes	Accipitridae	Brahminy Kite	*Haliastur indus*	LC	Sch. I	R/LM	CA
5	Accipitriformes	Accipitridae	White-bellied sea eagle	*Haliaetus leucogaster*	LC	Sch. I	R	CA (marine)
6	Charadriiformes	Laridae	Caspian Tern	*Hydroprogne caspia*	LC	Sch. IV	WM/R	PI
7	Charadriiformes	Laridae	Whiskered Tern	*Chlidonias hybrida*	LC	Sch. IV	R/WM/PM	CA (marine)
8	Charadriiformes	Laridae	Black-headed Gull	*Chroicocephalus ridibundus*	LC	Sch. IV	WM	OM
9	Charadriiformes	Laridae	Brown-headed Gull	*Chroicocephalus brunnicephalus*	LC	Sch. IV	R/WM	OM
10	Charadriiformes	Laridae	Lesser Crested Tern	*Thalasseus bengalensis*	LC	Sch. IV	R/WM	CA (marine)
11	Charadriiformes	Laridae	Greater Crested Tern	Thalasseus bergii	LC	Sch. IV	R/WM	CA (marine)
12	Charadriiformes	Burhinidae	Eurasian Thick-knee	*Burhinus oedicnemus*	LC	Sch. IV	R	CA

13	Charadriiformes	Burhinidae	Great Thick-knee	*Esacus recurvirostris*	NT	Sch. IV	R	CA
14	Charadriiformes	Charadriidae	Yellow-wattled Lapwing	*Vanellus malabaricus*	LC	Sch. IV	R/LM	IN
15	Charadriiformes	Charadriidae	Pacific Golden Plover	*Pluvialis fulva*	LC	Sch. IV	WM	OM
16	Charadriiformes	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	LC	Sch. IV	R/LM	CA (marine)
17	Charadriiformes	Charadriidae	Kentish Plover	*Charadrius alexandrinus*	LC	Sch. IV	R/WM	CA (marine)
18	Charadriiformes	Charadriidae	Little Ringed Plover	*Charadrius dubius*	LC	Sch. IV	R/WM	CA (marine)
19	Charadriiformes	Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	LC	Sch. IV	R/LM	CA (marine)
20	Charadriiformes	Scolopacidae	Black-Tailed Godwit	*Limosa limosa*	NT	Sch. IV	WM	OM
21	Charadriiformes	Scolopacidae	Common Sandpiper	*Actitis hypoleucos*	LC	Sch. IV	R/WM	CA (marine)
22	Charadriiformes	Scolopacidae	Eurasian Curlew	*Numenius arquatus*	NT	Sch. IV	WM	OM
23	Charadriiformes	Scolopacidae	Little Stint	*Calidris minuta*	LC	Sch. IV	WM	CA (marine)
24	Charadriiformes	Scolopacidae	Wood Sandpiper	*Tringa glareola*	LC	Sch. IV	WM	IN

25	Charadriiformes	Scolopacidae	Common Redshank	*Tringa totanus*	LC	Sch. IV	R/WM	CA (marine)
26	Charadriiformes	Scolopacidae	Common Greenshank	*Tringa nebularia*	LC	Sch. IV	WM	CA (marine)
27	Charadriiformes	Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis*	LC	Sch. IV	WM	CA (marine)
28	Charadriiformes	Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	LC	Sch. IV	WM	OM
29	Columbiformes	Columbidae	Spotted Dove	*Streptopelia chinensis*	LC	Sch. IV	R	GR
30	Columbiformes	Columbidae	Rock Pigeon	*Columba livia*	LC	Sch. IV	R	GR
31	Coraciiformes	Alcedinidae	Pied Kingfisher	*Ceryle rudis*	LC	Sch. IV	R	PI
32	Coraciiformes	Alcedinidae	Common Kingfisher	*Alcedo atthis*	LC	Sch. IV	R/WM/SM	PI
33	Coraciiformes	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	LC	Sch. IV	R/LM	CA
34	Coraciiformes	Meropidae	Green Bee-eater	*Merops orientalis*	LC	Sch. IV	R/WM	IN
35	Coraciiformes	Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	LC	Sch. IV	R/SM	IN
36	Coraciiformes	Coraciidae	Indian Roller	*Coracias benghalensis*	LC	Sch. IV	R	IN

37	Cuculiformes	Cuculidae	Aaian Koel	*Eudynamys scolopaceus*	LC	Sch. IV	R	OM
38	Cuculiformes	Cuculidae	Blue-faced Malkoha	*Phaenicophaeus viridirostris*	LC	Sch. IV	R	CA
39	Cuculiformes	Cuculidae	Greater Coucal	*Centropus sinensis*	LC	Sch. IV	R	OM
40	Cuculiformes	Cuculidae	Pied Cuckoo	*Clamator jacobinus*	LC	Sch. IV	R/M	IN
41	Cuculiformes	Cuculidae	Common Hawk Cuckoo	*Hierococcyx varius*	LC	Sch. IV	R/M	IN
42	Falconiformes	Falconidae	Common Kestrel	*Falco tinnunculus*	LC	Sch. IV	R	CA
43	Galliformes	Phasianidae	Grey Francolin	*Francolinus pondicerianus*	LC	Sch. IV	R	OM
44	Gruiformes	Rallidae	Common Moorhen	*Gallinula chloropus*	LC	Sch. IV	R/WM	OM
45	Gruiformes	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	LC	Sch. IV	R	IN
46	Passeriformes	Alaudidae	Ashy-crowned Sparrow Lark	*Eremopterix griseus*	LC	Sch. IV	R	GR
47	Passeriformes	Alaudidae	Oriental Skylark	*Alauda gulgula*	LC	Sch. IV	R/WM	OM
48	Passeriformes	Alaudidae	Jerdon's Bushlark	*Mirafra affinis*	LC	Sch. IV	R	IN

49	Passeriformes	Corvidae	House Crow	*Corvus splendens*	LC	Sch. V	R	OM
50	Passeriformes	Corvidae	Large-billed Crow	*Corvus macrorhynchos*	LC	Sch. IV	R	OM
51	Passeriformes	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	LC	Sch. IV	R	OM
52	Passeriformes	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	LC	Sch. IV	R	IN
53	Passeriformes	Cisticolidae	Ashy Prinia	*Prinia socialis*	LC	Sch. IV	R	IN
54	Passeriformes	Cisticolidae	Plain Prinia	*Prinia inornata*	LC	Sch. IV	R	IN
55	Passeriformes	Dicruridae	Black Drongo	Dicrurus macrocercus	LC	Sch. IV	R	IN
56	Passeriformes	Hirundinidae	Barn Swallow	*Hirundo rustica*	LC	Sch. IV	R/LM	IN
57	Passeriformes	Leiothrichidae	Yellow-billed Babbler	*Turdoides affinis*	LC	Sch. IV	R	IN
58	Passeriformes	Laniidae	Brown Shrike	*Lanius cristatus*	LC	Sch. IV	WM	CA
59	Passeriformes	Motacillidae	Forest Wagtail	*Dendronanthus indicus*	LC	Sch. IV	WM	IN
60	Passeriformes	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	LC	Sch. IV	R	IN
61	Passeriformes	Muscicapidae	Oriental Magpie Robin	*Copsychus saularis*	LC	Sch.	R	IN

						IV		
62	Passeriformes	Muscicapidae	Pied Bushchat	*Saxicola caprata*	LC	Sch. IV	R	IN
63	Passeriformes	Nectariniidae	Purple Sunbird	*Cinnyris asiaticus*	LC	Sch. IV	R	NE
64	Passeriformes	Pycnonotidae	White-browed Bulbul	*Pycnonotus luteolus*	LC	Sch. IV	R	GR
65	Passeriformes	Passeridae	House Sparrow	Passer domesticus	LC	Sch. IV	R	GR
66	Passeriformes	Pittidae	Indian Pitta	*Pitta brachyura*	LC	Sch. IV	R/WM	OM
67	Passeriformes	Oriolidae	Eurasian Golden Oriole	*Oriolus oriolus*	LC	Sch. IV	SM	FR
68	Passeriformes	Sturnidae	Common Myna	*Acridotheres tristis*	LC	Sch. IV	R	OM
69	Pelecaniformes	Ardeidae	Cattle Egret	*Bubulcus ibis*	LC	Sch. IV	R/AM	CA (marine)
70			Great Egret	*Ardea alba*	LC	Sch. IV	R/LM	CA (marine)
71			Grey Heron	*Ardea cinerea*	LC	Sch. IV	R/WM	CA (marine)
72			Intermediate Egret	*Ardea intermedia*	LC	Sch. IV	R/LM	CA (marine)
73			Little Egret	*Egretta garzetta*	LC	Sch.	R/LM	PI

						IV		
74			Indian Pond Heron	*Ardeola grayii*	LC	Sch. IV	R/LM	PI
75			Western Reef Egret	*Egretta gularis*	LC	Sch. IV	R/LM	CA (marine)
76			Striated Heron	*Butorides striata*	LC	Sch. IV	R	CA (marine)
77		Ciconiidae	Asian Openbill Stork	*Anastomus oscitans*	LC	Sch. IV	R/LM	CA (marine)
78			Painted Stork	*Mycteria leucocephala*	NT	Sch. IV	R/LM	PI
79		Pelecanidae	Spot-billed Pelican	*Pelecanus philippensis*	NT	Sch. IV	R/LM	PI
80		Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	LC	Sch. IV	R/LM	PI
81			Little Cormorant	*Microcarbo niger*	LC	Sch. IV	R/LM	PI
82		Threskiornithidae	Black-headed Ibis	*Threskiornis melanocephalus*	NT	Sch. IV	R/LM	OM
83	Phoenicopteriformes	Phoenicopteridae	Greater Flamingo	*Phoenicopterus roseus*	LC	Sch. IV	R/WM/LM	OM
84	Psittaciformes	Psittaculidae	Rose-ringed Parakeet	*Psittacula krameri*	LC	Sch. IV	R	GR
85	Strigiformes	Strigidae	Spotted Owlet	*Athene brama*	LC	Sch.	R	CA

						IV		

LC = Least concern; NT = Near threatened, CA = Generally carnivorous, OM = Omnivorous, GR = Gramnivorous, PI = Piscivorous, CA(marine) = marine carnivore feeder, FR = Frugivorous, NE = Nectarivorous, IN = Invertebrate feeder, R = Resident, R/LM = Resident with local movements, R/AM = Resident with altitudinal movements, R/WM = Resident with winter influx, R/WM/SM = Resident with winter influx as well as summer movements, R/WM/LM = Resident with winter influx as well as local movements, R/WM/PM = Resident with winter influx as well as passage movements, WM = Winter migrant, WM/R = Largely winter migrant and partly resident, R/M = Resident and Partially Migrant, SM = Summer Migrant

PHOTO PLATES

PLATE I - AVIAN SPECIES

Black Drongo (*Dicrurus macrocercus*)

Wood Sandpiper (*Tringaglare glareola*)

Paddyfield Pipit (Anthus *rufulus*)

Ruddy Turnstone (*Arenaria interpres*)

Asian Openbill Stork (*Anastomus oscitans*)

Jerdon's Bushlark (*Mirafra affinis*)

Black-headed Ibis (*Threskiornis melanocephalus*)

Eurasian Curlew (*Numenius arquata*)

Cattle Egret (*Bubulcus ibis*)

Pied Kingfisher (*Ceryle rudis*)

Indian Pitta (*Pitta brachyuran)*

Common Kingfisher (*Alcedo atthis*)

Common Greenshank (*Tringa nebularia*)

Black-winged Stilt (*Himantopus himantopus*)

Little Ringed Plover (*Charadrius dubius*)

Pacific Golden Plover (*Pluvialis fulva)*

White-bellied Sea Eagle (*Haliaeetus leucogaster*)

Grey Heron (*Ardea cinerea*)

Greater Flamingo (*Phoenicopterus roseus*)

Little Stint (*Calidris minuta*)

Marsh Sandpiper (*Tringa stagnatilis*)

Common Redshank (*Tringa tetanus*)

Spot-billed Pelican (*Pelecanus philippensis)*

Brown-headed Gull (*Chroicocephalus brunnicephalus*)

Great Egret (*Ardea alba*)

Painted Stork (*Mycteria leucocephala*)

Plain Prinia (*Prinia inornata*)

Pied Cuckoo (*Clamator jacobinus*)

House Sparrow (*Passer domesticus*)

House Crow (*Corvus splendens*)

Ashy Prinia (*Prinia socialis*)

Indian Roller (*Coracias benghalensis*)

Little Cormorant (*Microcarbo niger*)

Brown Shrike (*Lanius cristatus*)

Indian Cormorant (*Phalacrocorax fuscicollis*)

Spotted Owlet (*Athene brama*)

Common Myna (*Acridotheres tristis*)

Indian Pond Heron (*Ardeola grayii*)

Eurasian Golden Oriole (*Oriolus oriolus*)

Greater Coucal (*Centropus sinensis*)

Asian Koel (*Eudynamys scolopaceus*)

PLATE II - BUTTERFLY SPECIES

Common Cerulean (*Jamides celeno)*

Common Pierrot (*Castalius rosimon*)

Common Mormon (*Papilio polytes)*

Blue Tiger (*Tirumala limniace*)

Angled Castor (*Ariadne ariadne*)

Blue Pansy (*Junonia orithiya*)

Common Sailer (*Neptis hylas*)

Forget- me- not (*Catochrysops strabo*)

Common Rose (*Pachliopta aristolochiae*)

Crimson Rose (*Pachliopta hector*)

Plain Tiger (*Danaus chrysippus*)

Tricoloured pied flat (*Coladenia indrani*

PLATE III – MOTH SPECIES

Crimson-speckled moth (*Utetheisa pulchella*)

Indian Wasp Moth (*Euchromia spp*)

PLATE IV – DRAGONFLY SPECIES

Common Picture Wing (*Rhyothemis variegate*)

Black stream Glider (*Trithemis festiva*)

Ditch Jewel (*Brachythemis contamina*)

Scarlet Rock Glider (*Trithemis kirbyi)*

PLATE V – DAMSELFLY SPECIES

Coromandel Marsh Dart

(*Ceriagrion coromandelianum*)

Three striped Blue (*Pseudagrion decorum*)

PLATE VI – OTHER INSECTS

Blister Beetle

Jewel Bug

Red Cotton Stainer (*Dysdercus cingulatus)*

Orange Spider Wasp (*Cryptocheilus bicolor*)

Two Striped Jumper (*Telamonia dimidata*)

Antlion

PLATE VII – CRAB SPECIES

Hermit Crab

Fiddler Crab (*Uca annulipes*)

PLATE VIII – FISH SPECIES

Puffer Fish

Half beak fish

Mullet

Crescent Perch (*Terapon jarbua*)

Golden Trevally (*Gnathanodon speciosus*)

Starfish

PLATE IX – AMPHIBIAN SPECIES

Indian Tree frog (*Polypedates maculates*)

Asian Common Toad (*Duttaphrynus melanostictus*)

PLATE X – REPTILE SPECIES

Oriental Garden Lizard (*Calotes versicolor*)

Carcass of Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

Fan Throated Lizard (*Sitana ponticeriana*)

Beaked Sea Snake (*Enhydrina schistose*)

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