UTTAR PRADESH JOURNAL OF ZOOLOGY

42(17): 17-35, 2021
ISSN: 0256-971X (P)

URBAN GROWTH AND THE POPULATION OF HOUSE SPARROWS [*Passer domesticus* (LINNAEUS, 1758)] AND HOUSE CROWS [*Corvus splendens* (VIEILLOT, 1817)]: IS THE DYNAMICS OF URBAN ECOSYSTEM UNDERGOING A RADICAL CHANGE?

DEBRAJ BISWAL[1*]

[1]Department of Zoology, Government General Degree College at Mangalkote, Burdwan – 713132, West Bengal, India.

AUTHOR'S CONTRIBUTION

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

Editor(s):
(1) Dr. Pınar Oguzhan Yildiz, Ataturk University, Turkey.
Reviewers:
(1) Isaac Sarfo, Nanjing University of Information Science and Technology, China.
(2) Emelio Barjau González, Uniuversidad Autónoma de Baja California Sur, México.

Received: 05 June 2021
Accepted: 11 August 2021
Published: 17 August 2021

Original Research Article

ABSTRACT

Birds including house sparrows and house crows have always been considered as ecosystem indicators reflecting the health of the environment. Complete absence of a species (that was previously abundant) is not desirable from the ecologist's point of view. Anthropogenic activities like urbanization and deforestation have peaked in recent years resulting in the loss of biodiversity. This is not solely linked to the number of species but also the interactions among them that shapes up the ecosystem. The current study focuses on the sudden disappearance of house sparrows and house crows. The study area chosen was Chinsurah, West Bengal, India, as the place has undergone rapid urban growth in the last two decades with simultaneous erosion of the sparrow and crow populations. The urban sprawl of Chinsurah in the past few years was studied using satellite imagery data (from Google earth) and Landsat data (from GLCF) captured on a temporal scale. The study area was surveyed for documenting the preferable habitats of birds where they were found roosting. A comparative study of the architecture of the old and new/renovated buildings shows that buildings with modern designs lack suitable nesting sites. In addition, the loss of tree cover deprives the birds of their foraging grounds. Bird species like common myna, greater coucal, Indian treepie, black drongo and black kite have been observed living close to human settlements in the study area. They are known to exert predatory and/or competition pressures on house sparrows and house crows. Other factors affecting the sparrow and crow populations were also investigated. The declining bird species seems to affect the urban ecosystem by causing shifts in ecological balance. This can, however, be minimized by considering the ecological factors while planning urban

**Corresponding author: Email: debhraj@gmail.com;*

expansion. Therefore, future studies should not be aimed solely to conserve the biodiversity but also to preserve the ecosystem balance and prevent the loss of another species through sustainable urban growth.

Keywords: Biodiversity; Habitat loss; House Crow; House Sparrow; Urban ecosystem; Sustainable urban growth.

1. INTRODUCTION

The recent decade has witnessed serious negative impacts of anthropogenic activities on the environment resulting in devastating biodiversity loss throughout the world. Urbanization and pollution are the most damaging and rapid forms of anthropogenic pressures. Many rare species are reportedly affected by urbanization and pollution [1]. Widely distributed and common species like house sparrows (*Passer domesticus*) are also facing massive decline across several countries due to anthropogenic pressures [2,3]. Literature is replete with articles on the global decline of house sparrows in the last few years. It has decreased at an alarming rate in England with 47% decline in rural areas since the mid-1970s and about 60% decline in and around the urban areas [4,5]. Their population has almost been wiped off from urban areas [6,7]. It has also been eroded from many parts of India like Bangalore, Mumbai, and Hyderabad [8]. Studies show that the house sparrow population has declined by 80% in Andhra Pradesh and by 20% in Kerala, Gujarat, and Rajasthan [8]. Several authors have revealed the house sparrow was considered to be an endangered species, placed on the Red Data List in 2002 [9]. March 20th 2010 was declared as the 'World Sparrow Day' prior its adoption as the state bird of Delhi in 2012 [9]. Some current studies that report on the declining population of house sparrows in India include Sharma and Binner [3], Pandian and Natarajan [10] and Deepalakshmi and Salomi [11].

The story of house crows is however different. Surprisingly, despite several articles coming up in national newspapers expressing concerns over the dwindling population of house crows in urban areas there is a dearth of scientific research data on this species. It is worth to mention that like the house sparrows the house crows are also indicators of environmental health. Therefore, decline in their population indicates that something is seriously wrong with the environment. Expressing his concern over the status of house crows Dr. B.M. Arora, President of Association of Indian Zoos and Wildlife Veterinarians had remarked that their population was declining so fast from urban areas that in no time the species will become extinct [12]. Adding to this, he revealed the house crows have been neglected in comparison to the house sparrows [12]. House crows have been referred to as intelligent birds needing protection [13]. The intelligence of crows has also been highlighted by Prof. Paul Greenough who studied the declining population of house crows in India [14]. To explain the situation of scarcity of house crows he put forward the significance of crows in Hindu rituals, especially funerals, where wooden crows were acting as substitutes because of the non-availability of the real ones [14]. Many other articles published in newspapers highlighted the vanishing populations of house crows from towns and cities. Some research publications on house crows from India and abroad include the status and management of house crows in Mauritius [15], their feeding ecology in open agricultural fields in Jammu [16], status of population of house crows and their roosting places on Kharg Island in Persian Gulf [17] and the eco-biology of house crows [18]. Often the species has been dubbed invasive, with their control measures being described. Some of these include control of invasive house crows in Singapore [19]; the study about the prospect of house crows as invasive species in Ismailia, Egypt [20]; the nest success of invasive house crows in Dar es Salaam, Tanzania [21] and the house crows as a threat to New Zealand [22]. However, publications related to a systematic research on their declining population are not available. This may be partly linked to their characteristics of being invasive species affecting human health, agriculture, biodiversity, tourism, and transport [23]. Sadly, the ecological roles of house crows have largely been ignored.

Having reviewed existing literature and newspaper articles, several hypotheses regarding the decline of house sparrows and house crows have been explored. These hypotheses include loss of nesting sites, inter-species competition for food, cleaner streets with reduced foraging opportunities, disease transmission, pollution, and indiscriminate use of pesticides in parks and gardens [3,11,12,14,24-26]. Many studies have reported that house sparrows being small are preyed upon by larger bird species like kites and owls or mammals like cats and dogs [3]. Even snakes have been found preying on them [3]. This reason cannot be applied for crows because they have been reported to prey upon the sparrows. Lack of food for nestlings and rising incidence of diseases due to increased pollution have been cited as reasons influencing the population of house sparrows [24]. Though reports are not available, these may equally apply to the house crow population. It has also been suggested that

exposure to radiations for a long period of time may cause harm to the population of house sparrows [27,28]. Similar studies on house crows have not been done. Further studies in this field should be encouraged before the disappearance of other species.

Interestingly, most early studies explored dwelt on urbanization or urban growth. However, none suggested any appropriate technique to assess urban growth on a temporal scale. The current study employs a simple technique to estimate the urban sprawl in Chinsurah, situated in Hooghly district of West Bengal, India. Collection of geospatial data, of the study area, on a temporal scale helped to decipher the urban expansion during the study period. The data gave vivid visual proof of urban growth and the simultaneous reduction of tree cover. The town, Chinsurah, was chosen for the study because it has undergone rapid urbanization in the last two decades due to its ease of accessibility to the metropolitan city, Kolkata which is also the state's capital. Apart from roads and rails, the river Hooghly, on the banks of which the town is situated, provides an additional mode of easy conveyance to Kolkata. Moreover, no such studies have previously been carried out in Chinsurah. The aim of the current research is to provide a summary of the present status and discuss the effect of urban growth and habitat alteration on the population of house sparrows and house crows in Chinsurah. An attempt was also made to decipher the urban ecosystem changes over the years as the colonial Dutch town has gradually evolved into a concrete jungle with bustling streets.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out at Chinsurah with special reference to three areas: Gharir More (22^o 53'17.27" N, 88^o 23'58.04" E) [SA1], the area around Ramkrishna Road (22^o 53'39.20" N, 88^o 23'37.37" E) [SA2] and Chinsurah Railway Station (22^o 53'24.89" N, 88^o 22'11.45" E) [SA3]. These three study areas (SA1, SA2 and SA3) surrounding the heart of the Chinsurah town gives a clear picture of the changes in urban structure that the region has undergone over the last two decades.

2.2 Collection and Interpretation of Satellite Imagery Data [Flow Chart 1]

A. The satellite imagery data were collected from Google Earth and were analyzed in the following way:

1. The study areas were located first in Google Earth.
2. Each of the study area was then divided into certain polygons (preferably with human habitations as estimated from simple eye estimation) such that their boundaries were along some road(s) and/or their intersections.

Polygons for [SA1] 'Gharir More': A, B, C, D and E. [Fig 1 (a-f)]
Polygons for [SA2] 'Ramkrishna Road': A, B, C, D, E and F. [Fig 2 (a-f)]
Polygons for [SA3] 'Chinsurah Railway Station': A, B, C, D, E and F. [Fig 3 (a-f)]

3. The number of roofs of buildings (i.e. rooftops) were counted manually for each polygon of all the three study areas by zooming the imagery data obtained from Google Earth and recorded as percentage. The data were documented for the years 2003, 2005, 2007, 2009, 2011 and 2014. They were then plotted graphically [Fig 5 (I to III)].
4. The density of greenery in each of these polygons, in all the three study sites, for each year was observed by simple eye estimation [Figs 1 to 4].

B. The Landsat imagery data from GLCF were collected and composed into a true colour image by the software 'Geomatica version 9.1'. It was followed by producing its standard FCC (False colour composite). This was repeated for the images obtained on a temporal scale (1990, 2000 and 2011). The images were geo-referenced with the help of a scanned toposheet of Chinsurah (already geo-referenced using the QGIS software). The images were visually interpreted from the FCCs following the general colour patterns (greenish areas for human settlements and reddish areas for vegetation) and were comparatively studied on the time scale [Fig 4 (a to c)].

2.3 Surveying the Area to Locate Habitat Preference Sites of House Sparrows and House Crows [Flow Chart 2]

The survey works were carried out from January 2018 to January 2020. The following were done:

1. The study area was surveyed for the presence of old, new, and renovated buildings [Fig 6 (a to g)]. The number of natural/artificial water bodies and telephone towers were observed in SA1, SA2 and SA3. Simultaneously, the presence of sparrows and crows [Fig 7 (a, b)] in those areas were also recorded. The presence

of dead birds by the roadsides, if any, were noted as well.

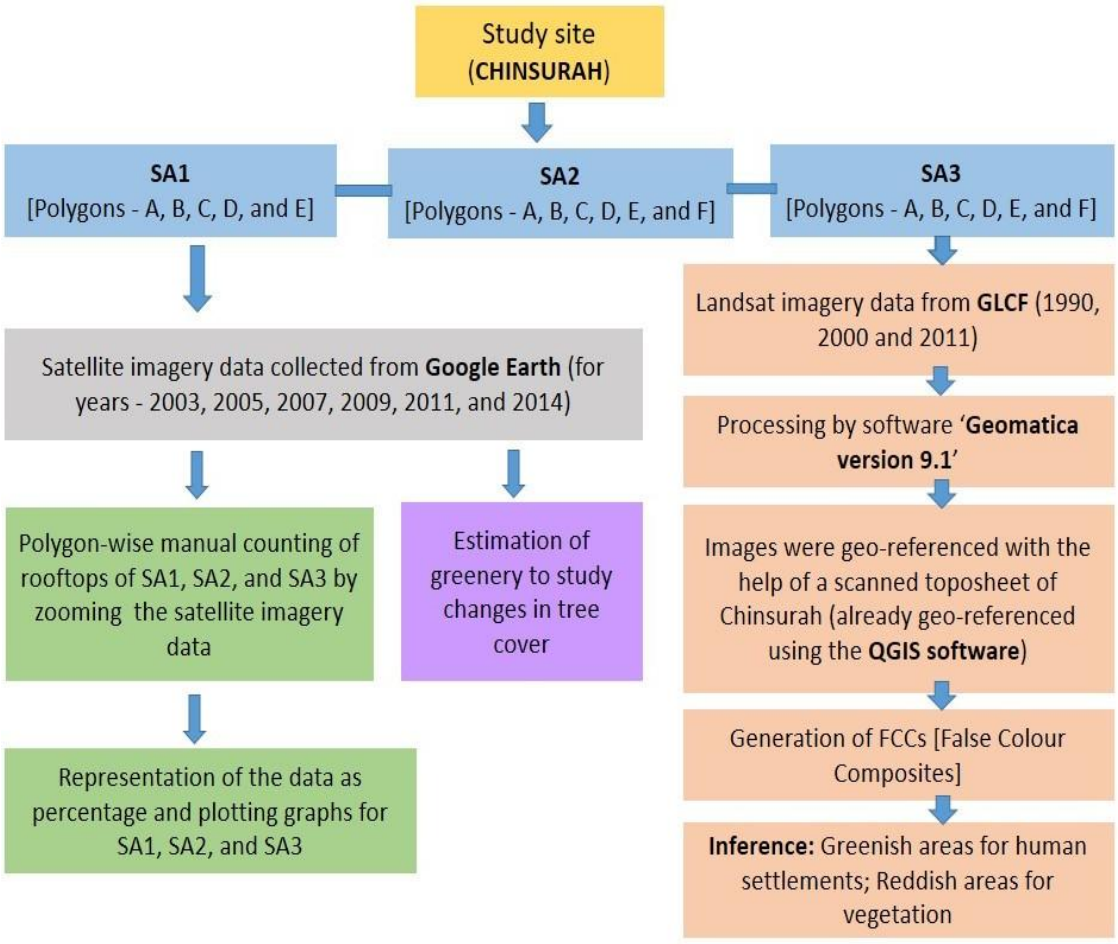
2. The architectural differences among the old, new and renovated buildings with respect to their habitability for birds were studied [Table 1] [Fig 6 (a to g)].

2.4 Surveying the Area for the Presence of Other Bird Species [Flow Chart 2]

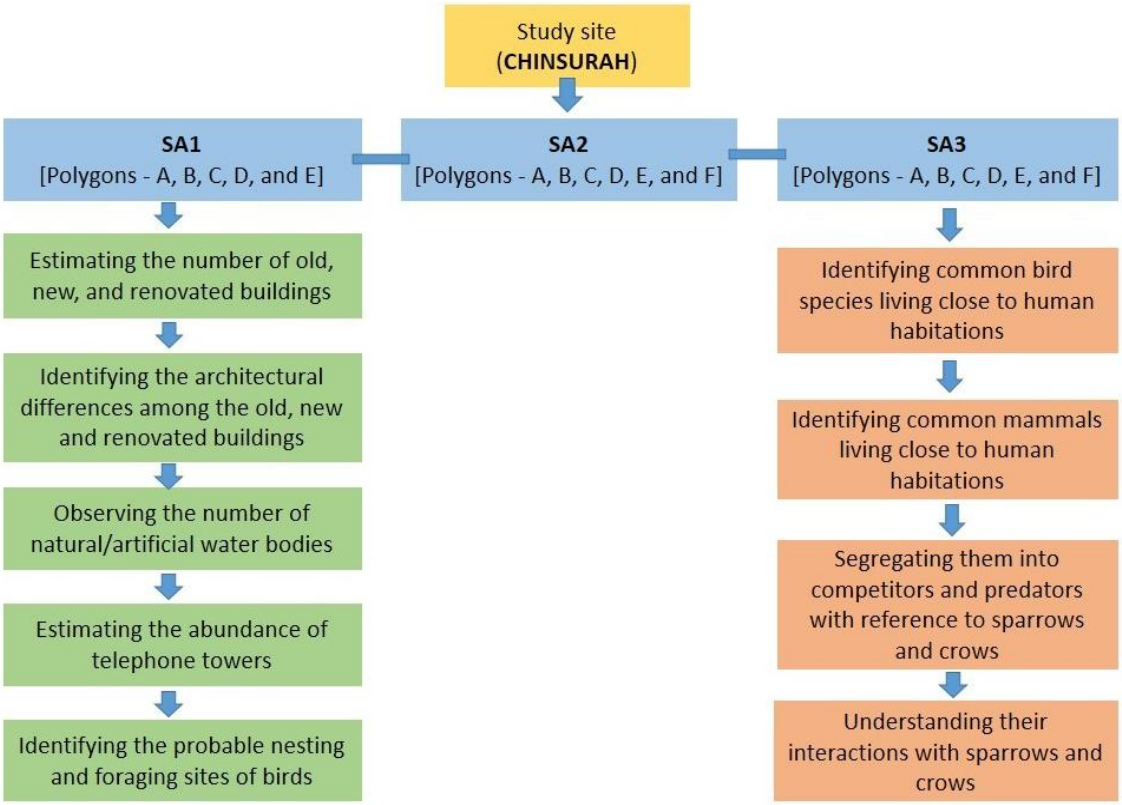
The study area was surveyed for other bird species living close to human habitations and were identified following Ali [29]. The survey was carried out from January 2018 to January 2020 such that it covered all the seasons. In this work only the common birds that could be spotted throughout the year have been considered [Table 2] [Fig. 7 (c to h)]. Though the survey was mostly focused on birds some common mammals (presumed to be predatory and/or competitors to sparrows and crows) in the study areas were also noted [Fig. 8 (a to d)].

3. RESULTS AND DISCUSSION

The study shows that there has been a rapid urban growth in Chinsurah in the last decade. As visible from the satellite imagery data the greenery has been much reduced and given away to concrete constructions [Figs. 1 to 5]. The town is no longer that green as it used to be [Figs. 1 to 3]. The Landsat data also clearly shows a depletion of vegetation areas in and around Hooghly-Chinsurah from 1990 to 2011 [Fig. 4 (a to c)]. This was evident from the increase in greenish areas in the FCCs indicating rapid development of human habitations in this area [Fig. 4 (a to c)]. The graphs [Fig. 5 (I to III)] also show how the number of buildings has shot up in Chinsurah within a small time span.



Flow Chart 1. Outline of the work plan for collection and analysis of geospatial data of the study areas; The final results gives an idea about the urban growth in Chinsurah (from 2003 to 2014)



Flow Chart 2. Outline of the work plan for survey of the study areas to identify the nesting and foraging sites of birds. This gives an idea about the suitability of the areas for habitation by birds; The second part involves identifying the common bird species and small mammals living close to human habitations in the study areas to understand their probable interactions with sparrows and crows; This gives an overview about the urban ecosystem dynamics

During the survey in the study areas (SA1, SA2 and SA3) a few observations drew my attention. Many ponds in SA1 and SA2 were not being maintained and would soon disappear. SA1 with over 100 old buildings was the most habitable area for birds followed by SA2 with over 75 old buildings and SA3 came the last with the count of old buildings being below 30. This indicates that SA3 is a newly urbanized area. Some buildings displayed the typical old architectures like beamed ceilings, porch, giant windows with windowsills, gardens and backyards that are preferred by birds for roosting and nesting [Fig 6 (a to d)]. The old buildings in SA1 were more varied because there are several government schools, colleges and offices including the official residence of the District Magistrate with age old heritage structures preferred by birds. SA1 also hosts several open parks of sizeable area lined by trees along with a promenade by the Hooghly River. The promenade is well decorated by gardens and trees. SA1 is the commercial centre of the town with many newly emerging shopping malls and restaurants as well. The places of worships in these areas were not considered in this study. The architectural differences between the old and new/renovated buildings have been summarized in Table 1. Sparrows [Fig. 7a] could be spotted in only in SA1 and SA3 nearby the old buildings. They were more common in SA1. Sparrows could not be spotted in SA2 despite there being considerable number of old buildings. It was quite surprising. The population of crow [Fig. 7b] was found to be highly scattered and visible in all the three areas but were not so common. Their cawing could rarely be heard. They were least common in SA3. Their visibility in SA1 and SA2 were similar. The largest number of telephone towers were spotted in SA2 and the least in SA3.

The observations may be summarized as follows:

a. All the three study areas have undergone rapid urbanization in the past years and have witnessed uprising multi-storey buildings of modern designs to serve the purpose of

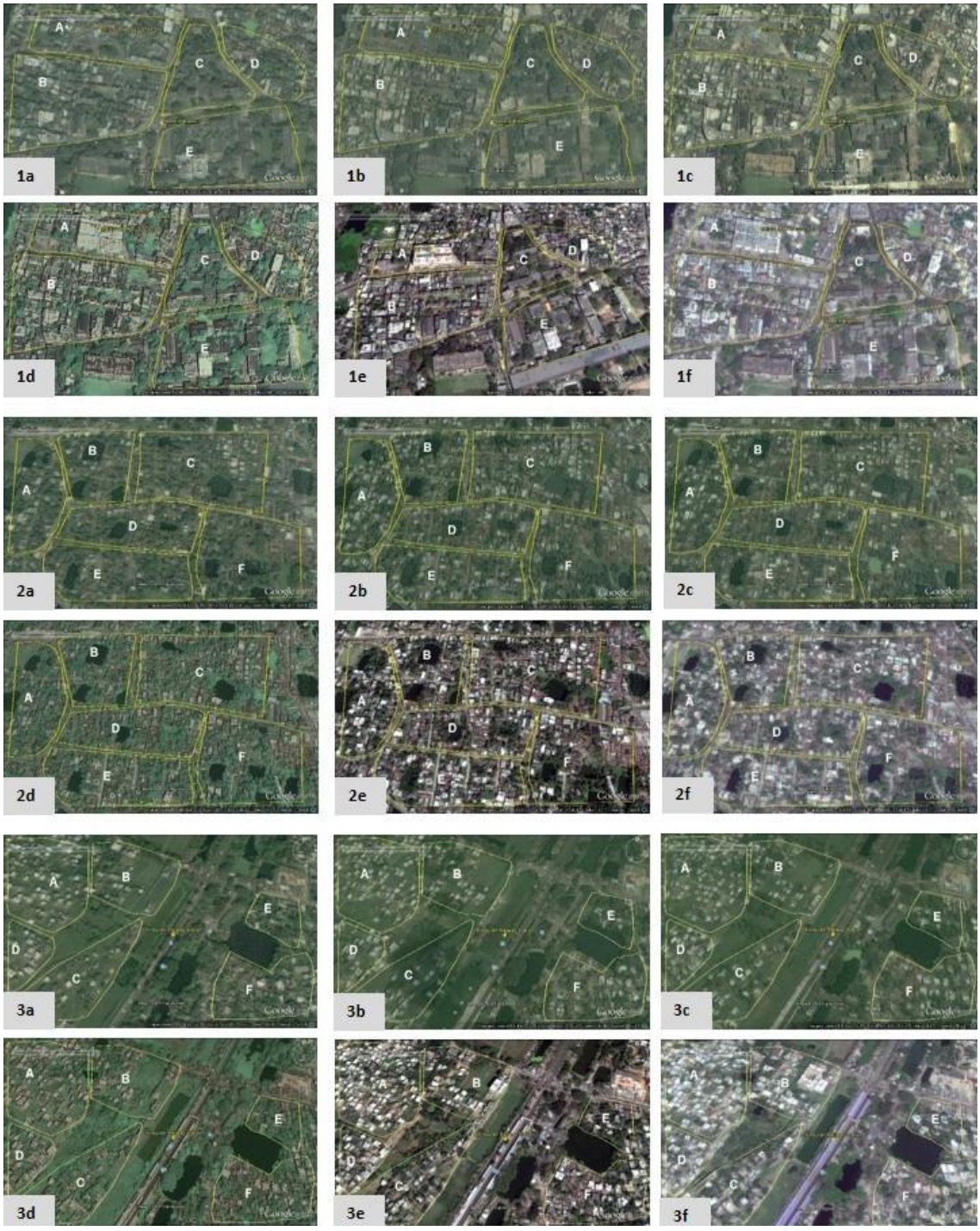
residence, commerce as well as offices. But there is a difference in history. While in SA1 and SA2 many old buildings have been demolished to build newer structures SA3 has faced lesser demolition of older structures simply because there were not too many of them. The buildings in SA3 were constructed not many years ago and therefore most of them are of modern designs.

b. All the three areas have faced reduction of tree cover with SA3, probably, facing the highest loss because vegetation was cleared for construction [Fig. 3 (a to f), Fig. 5 (I to III)].

c. Of all the areas, SA1 seems to be the most habitable area for birds because of the variability in the building architectures ranging from pre-independence, post-independence and modern designs with ample nesting and roosting sites. The open parks lined with trees and the proximity to the Hooghly River seems to be an added advantage. Though SA3 lacks enough old buildings sparrows could be spotted in the area probably because of the proximity of the rice farm and fewer number of telephone towers. Crows could also be spotted but they were not abundant. From this point of view SA3 seems to be the second preference for birds. Despite enough old buildings with sufficient nesting sites sparrows could not be spotted in SA2. The telephone towers may be held responsible though other reasons could also have exerted their effects. A few crows, however, could be spotted along with other birds. If only sparrows and crows are considered, then SA2 seems to be the least habitable.

Hooghly district has its own heritage that began with the arrival of Vasco da Gama, a Portuguese sailor, in Bandel. Subsequently a port was set up and a Portuguese colony was established there. They were followed by the French, Dutch and the Danish who established their colonies in Chandernagore, Chinsurah and Serampore respectively. The interest of the European colonies in these towns grew because of the proximity to the Hooghly River and ports were established in each of these places with the aim of trading. For a while, Hooghly reigned as the commercial capital of Bengal with Chinsurah as its headquarters before being shifted to Calcutta by the British. The architecture of buildings in Chinsurah had colonial influence which unfortunately have not withstood the ravages of time. Very little remains from the past till date that could be spoken of. A handful of buildings that managed to survive, exhibit the age-old architectural designs. They were characterized by high ceilings with parallel iron or wooden beams as support, large wooden doors and windows, windowsills with flowerpots, ventilators, balconies, front gardens with fountains and artificial water bodies, spacious backyards, and some of them with a porch [Fig. 6 (a to d); Table 1]. Sadly, however, many of these buildings have been sold off to the promoters or are waiting negotiation and eventually be torn down [Fig. 6g] to construct residential areas or standalone flats characterized by lower ceilings without any supporting beams, windows with iron or aluminum frames and glass panels mostly lacking the broad windowsills, narrow balconies (surrounded in most cases to create additional room) and without gardens and backyards [Fig. 6 (e to g); Table 1]. The clay and terracotta roof-tiles that were used to form shades on the balconies [Fig. 6c] have been replaced by metallic roofing or concrete [Fig. 6e] mainly because the replacement of the tiles incurred a recurring cost and due to their poor availability nowadays, especially of matching designs. These shades with tiles resting on bamboo poles or wooden beams [Fig. 6c] are the preferred nesting sites of small birds like house sparrows which live close to human habitations. The metallic roofing gets heated up quickly during the summers which probably does not make it suitable for nesting. Old buildings with backyards offer good nesting sites for sparrows [30]. Therefore, their demolition can be considered to have exerted negative impact on their population. Reportedly, the newly emerging shopping malls with large windowpanes also do not provide much space for placing the nests [30]. Several new/renovated buildings with glass windows could be spotted in the study areas. The windows in modern constructions also lack the broad windowsills where the birds used to roost and chirp and take shelter in the rain. This observation was similar to that of Bokotey and Gorban [31] who suggested that construction of buildings without suitable roosting places or nesting sites are responsible for the declining population of house sparrows. Studies conducted by Pandian and Natarajan [10] in some villages of Tamil Nadu reported that power-looms were fast replacing the traditional handlooms in as many as 20 of them which were dominated by weaver community. They had observed that the alteration of the building design to accommodate the power-looms had rendered them unsuitable for nesting. The continuous sound being generated from them was an additional factor that chased away the birds [10]. Studies carried out in ten different villages of Tamil Nadu showed extremely poor population of house sparrows in urban areas. They opined that deprivation of suitable breeding sites for the bird due to urbanization was responsible for this observation [11]. According to Sharma and Binner [3] the design of the modern and renovated old buildings leaves no sites for nesting for many birds.

Thus, the current finding supports the hypothesis that increase in the number of modern buildings does have a role in the reduction of the number of sparrows. Though there are no such detailed studies on house crows, from the available information [32] it may be said that modern building designs do not provide favourable nesting sites for crows as well.



Figs. 1 to 3. Satellite images of study areas with polygons (SA1, SA2 AND SA3) from Google Earth in the years - a- 2003, b- 2005, c- 2007, d- 2009, e- 2011, f- 2014. SA1 [1(a to f)], SA2 [2(a to f)] and SA3 [3(a to f)]

Fig. 4 (a to c). Landsat images of Hooghly-Chinsurah (Standard FCC, greenish areas show human settlement, reddish areas show vegetation) [a-1990, b-2000, c-2011]

Not only the architecture but also the surroundings of the houses and buildings are important factors that influence the habitat preference of birds. Choudhary et al. [33] studied the habitat preferences of house sparrows in Delhi and concluded that they choose their nesting sites such that they are close to foraging grounds. Their foraging grounds mainly consist of the gardens and backyards of old buildings [Fig. 6a]. They could roost on the porch or the broad windowsills or the balcony and search for food from these gardens because they are a good source for tiny arthropods that these birds need to nourish their young ones [34]. The sparrows prefer bushy shrubs comprising of *Ziziphus mauritiana*, *Combretum indicum*, *Prosopis* spp., *Lawsonia inermis* and *Bougainvillea glabra* for roosting and foraging [33]. They are also used as escape cover [35]. Presence of these bushes close to buildings attract birds. Apart from food, the source of water is also an important factor. Proximity of natural aquatic bodies like ponds and pools or artificial water bodies like fountains in the gardens make them preferable habitats. The presence of open drainage system may also act as a determining factor [33]. They may act as source of water for thirsty birds. Survey of the modern constructions show that they do not have enough space for gardens and even if they have, people prefer cleaner gardens [34]. Extensive use of insecticides, pesticides and herbicides in the gardens have resulted in the reduction of the available small arthropods [34]. A clean and a tidy garden thereby affects the ecological balance that humans are not aware of or are becoming aware more recently. Due to shortage of space the construction of artificial water bodies seems to be a distant dream. In fact, some natural water bodies have dried up due to lack of maintenance while a few have been filled up and converted into residential properties. The development of sanitation habits in humans has led to the construction of closed drainage system that further reduces the source of water to the birds. The open areas around new/renovated buildings are plastered nowadays. The current study shows that most of the residential complexes and housing estates have ornate walkways covered with tiles or stones. These complexes simply have narrow strips of gardens surrounded by low concrete or iron railed boundaries, sometimes with elegant designs for beautification and cleanliness. The reason for plastering open spaces is not just for beautification but also to prevent waterlogging during the monsoons that would otherwise turn the place muddy. Another reason is the fear of snakes entering houses during the rainy season. For all these causes the bushes are cleared and the open soil is covered. This, however, restricts the availability of soil arthropods and other arthropods from the bushes that form an important food source for the birds. Additionally, the soil worms, annelids, rodents, lizards, and small snakes are also not available on plastered surfaces. They form an important part of diet of house crows who are thereby deprived of adequate food. Open garbage bins are rarely found nowadays [33] in the residential areas or complexes and people prefer to dispose the leftover food wrapped in plastics to keep their surroundings clean [12]. It becomes very difficult for the house crow to collect food from these plastic bags further reducing their food source. This point regarding the availability of food for house crows has been highlighted in many news articles [12,25,26]. One such article states that the scarcity of food forces the crows to feed on grains and worms from agricultural fields contaminated with toxic pesticides. This change in food habit could cause their untimely death [12]. The shortage of food is further heightened by the absence of small eateries and groceries in the vicinity of the new residential areas [33]. The current study supports earlier findings. The house sparrows and house crows were mainly found in those parts of the study areas where there were old buildings with foraging grounds. The proximity of SA3 to the rice farm suggests that the crows could be poisoned due to consumption of grains or rodents contaminated by pesticides. However, the absence of sparrows in SA2 despite the presence of old buildings seems to be a matter of concern.

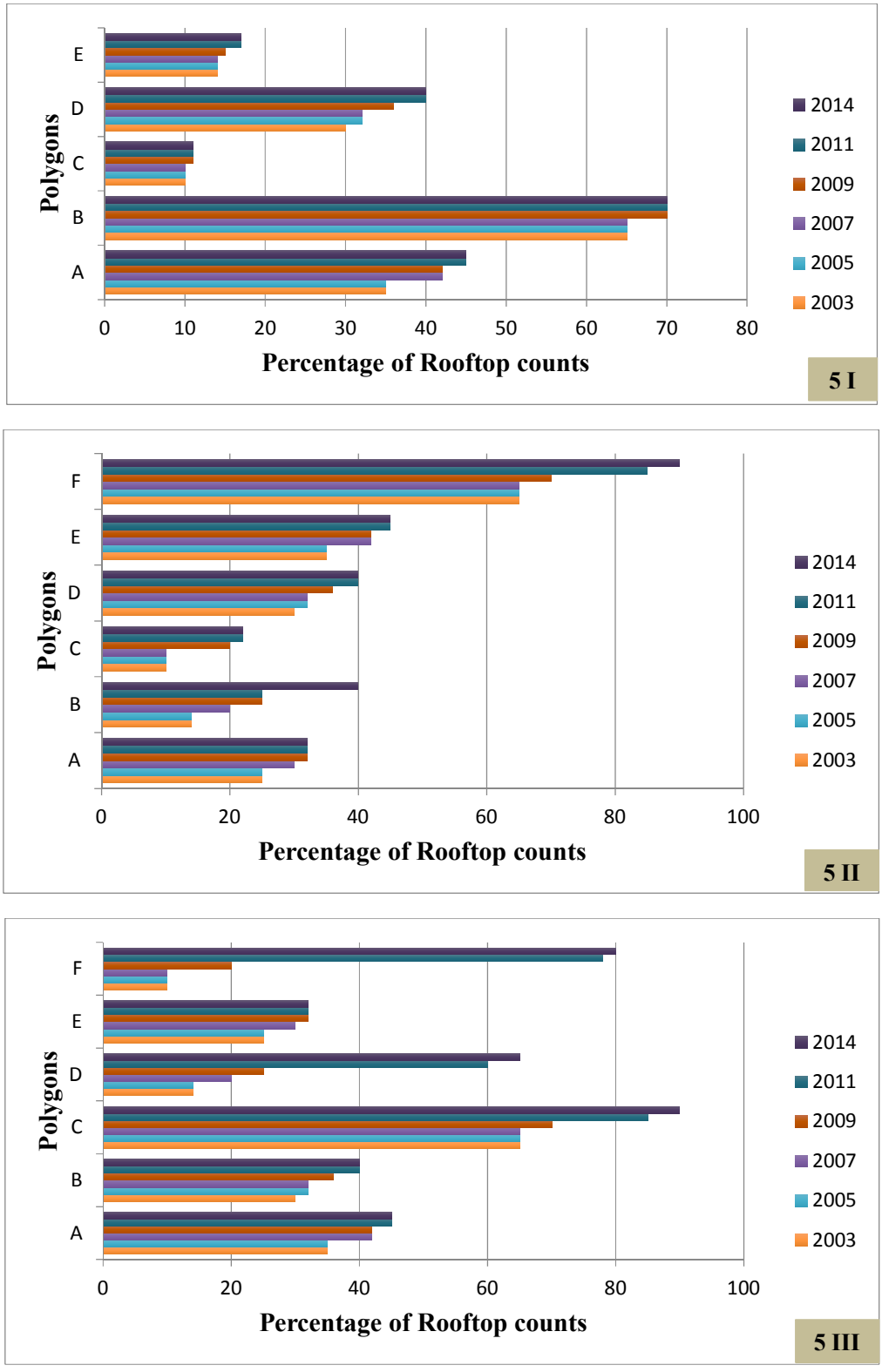


Fig. 5 (I to III). Graphical representation of urban growth in Chinsurah in the last decade (represented as percentage of rooftop counts): I. SA1, II. SA2, III. SA3

Fig. 6. Variations in the architecture of the buildings in the study areas (SA1, SA2 and SA3)
a to c – Very old buildings with preferable roosting and nesting sites labelled,
d – Moderately old building with preferable roosting and nesting sites labelled,
e and f – Modern buildings [OEL- overhead electric lines, BWTS – balcony without tiled shade, W – window without windowsill, B – balcony covered with glass for additional room]
g – An old building being demolished for new construction [D – demolition site]

The lack of food is not just restricted to the adults alone. It has much deeper effects. Nestling diet is one of such aspects. Studies show that insufficient nestling diet may be a major cause for low productivity, hence, a decline in urbanized sparrows [2,36]. Schwagmeyer and Mock [37] showed that suburban nestlings receive lower quality as well as quantity of diet as compared to those in rural areas. Thus, differential availability of large arthropods in urbanized habitats may be cited as one of the reasons for reduction in the population of house sparrows. The availability of certain taxa over others also affects the nutritional quality of nestling diets as some taxa are rich in certain nutrients, like spiders are rich in taurine [37]. Reduced abundance and diversity of beetles, caterpillars, flies, spiders and aphids under the pressures of urbanization also reduces the quality of diet for sparrow nestlings [38,39]. Arthropods that are positively affected by urbanization are typically smaller in size (like the aphids) or unavailable for

sparrows (like the gall-forming taxa) [39]. The size of individual arthropods within the taxa is also reportedly reduced in urbanized and polluted environments [40], which may further decrease the availability of nestling food. It has also been reported that the urban sparrows have smaller body size and mass due to non-availability of adequate food during the nestling stages [41]. This makes them more vulnerable to early death and reduced growth thereby augmenting their mortality rates in urbanized habitats. Though all these studies have been conducted for house sparrows the house crows may also fail to provide enough food to their offspring which may not only reduce their survivability, but may also grow up into malnourished birds who may either be infertile or may not live up to their reproductive age. The cause of poor availability of nestling diet is rooted to loss of tree cover to make space for concrete constructions. The current study shows that rise of urbanization causes a simultaneous loss of greenery [Figs. 1 to 4]. Therefore, these reasons hold good and might have caused a decline in the population of house sparrows and house crows.

Table 1. Architectural differences between old buildings and modern/renovated buildings/residential complexes encountered in the study areas

Sl. No.	Characteristic features	Old buildings	Modern/Renovated Buildings/Residential Complexes
1	Ventilators	Present.	Absent.
2	Porch	Present.	Absent.
3	Ceiling	High, often with iron or wooden beams as support.	Low without iron or wooden beams.
4	Balcony	Present, usually broad and open.	Present, usually narrow and covered by sliding glass panels. Sometimes absent.
5	Windows	Wooden, usually louvers with inner glass panes fitted in wooden frames.	Mostly iron or aluminum frames with windowpanes.
6	Windowsill	Present, wide, both interior and exterior.	Present, broad on the inner sides and extremely narrow on the outside.
7	Cracks and crevices	Mostly present.	Absent.
8	Building ledges	Present mostly.	Absent.
9	Nooks and crannies	Present in most cases.	Absent.
10	Trees growing on walls	Mostly present.	Absent.
11	Shades of balconies	In most cases consist of mud/terracotta tiles or asbestos sheets laid on bamboo or wooden structures.	Usually, concrete designed to look like terracotta tiles or made of metal sheets on structures made of iron.
12	Lawns	Mostly present with indigenous shrubs, hedges, and even wild climbers in some. Trees like wild figs, mango, jackfruit, guava or common flowering trees also present in the more spacious ones. Soil is mostly exposed with narrow strips of cemented tracks meant for walking.	Usually, absent. When present, it's mostly cemented with narrow strips of exposed soil bearing some exotic plants meant for beautification of the garden. Indigenous plants or fruit trees lacking.
13	Backyard	Mostly present with trees and bushes and sometimes ill-maintained with wildflowers and vines. Soil remains exposed.	If present, usually concrete floor covering the soil.
14	Garbage Bins	Open type mostly present in the backyard.	Usually, absent. Covered when present. Garbage mostly disposed in polythene bags.
15	Drainage system	Open type.	Closed type made of pipes or covered with tiles or blocks.

Increased predation of house sparrows by sparrow hawks (*Accipiter nisus*), the tawny owl (*Strix aluco*) and the domestic or feral cat (*Felix catus*) in urbanized habitats may also be a contributing factor for the declining population of house sparrows [42]. Absence of garden hedges in the newly designed urban areas may increase the predation of the nesting birds [43] because they provided sites for the birds to hide from predators. Inter-species and intra-species competition have been cited to be a detrimental factor for the declining population of house sparrow [42]. A survey of the study areas showed the presence of many birds of other species [Fig. 7 (c to h)] [Table 2] that live close to human habitation and have similar foraging habits exerting additional competitive pressures on the house sparrows. These augment the shortage of food supply and nesting sites. Of these species, common myna [Fig. 7f] is reportedly an invasive species [29] and the house sparrows must be facing a strict competition from them. The house crow [Fig. 7b] is known to bully smaller birds [29]. The greater coucal, house crow, black drongo and Indian treepie [Table 2] [Fig. 7 (b to h)] are known to feed on eggs and nestlings of other birds [29]. These birds thus exert predatory pressures on other smaller birds like house sparrow [Fig. 7a] and counts among the limiting factors. Black Kites have also been spotted around Chinsurah which may prey upon smaller birds like house sparrow [Table 2]. Presence of domestic cats [Fig 8 (c to d)] everywhere also indicates predation pressures on sparrow eggs or their nestlings. The house sparrows have also been reported to be preyed upon by snakes, dogs, raccoons and shikra [3]. They can be spotted in Chinsurah, and may contribute to the declining bird population. The presence of Indian mongoose (*Herpestes* sp.) [Fig 8 (a, b)] has also been spotted in and around the selected study-areas. These mammals also prey on small birds (like house sparrows) and their eggs. House crows, on the other hand, are quite robust and prey on smaller species like sparrows. However, they face competition from dogs, cats and other animals who depend on wastes or leftover food discarded by humans. They must also compete with kites and shikras because they prey on small mammals as the crows do. Moreover, the cuckoos often dislodge one or more crow eggs to lay their own in a crow's nest, further reducing their survival rates [25]. Kites and koels have been spotted in the study area [Table 2]. Thus, predation and competition pressures are deemed critical or important factors.

Table 2. List of some common birds found around human habitations and gardens in Chinsurah (other than house sparrow) (birds have been identified following Ali [29])

Sl. No.	Common Name	Scientific Name
1.	Red-Vented Bulbul	*Pycnonotus cafer*
2.	Red Whiskered Bulbul	*Pycnonotus jocosus*
3.	Oriental Magpie Robin	*Copsychus saularis*
4.	Common Myna**	*Acridotheres tristis*
5.	Jungle Myna	*Acridotheres fuscus*
6.	Bank Myna	*Acridotheres ginginianus*
7.	Asian Pied Starling	*Sturnus contra*
8.	Jungle Babbler	*Turdoides striatus*
9.	Greater Coucal*	*Centropus sinensis*
10.	House Swift	*Apus affinis*
11.	Domestic Pigeon	*Columba livia domestica*
12.	Spotted Dove	*Streptopelia chinensis*
13.	Asian Koel	*Eudynamys scolopacea*
14.	House Crow*, **	*Corvus splendens*
15.	Black Drongo*	*Dicrurus macrocercus*
16.	Black Kite*	*Milvus migrans*
17.	Common Tailor Bird	*Orthotomus sutorius*
18.	Indian Treepie*	*Dendrocitta vagabunda*
19.	Asian palm swift	*Cypsiurus balasiensis*
20	Spotted owlet*	*Athene brama*
21.	Shikra*	*Accipiter badius*

** Indicates predatory species on small birds [29]*
*** Indicates invasive species/species that bully small birds [29]*

Fig. 7. Some bird species spotted in the study areas
7a. House sparrow, 7b. House crow, 7c. Red-vented bulbul, 7d. Indian treepie, 7e. Greater coucal, 7f. Common myna, 7g. Black drongo, 7h. Asian pied starling

Fig. 8. Some common mammals spotted in the study areas that are presumed to be predatory on house sparrows
8 (a, b). Indian mongoose
8 (c, d). Kittens (of domestic cats)

The harmful effects of exposure to radiation for a considerable time period have been observed on house sparrows. They have been found to have negative impacts not only on their abundance but also on their behaviour [28]. Balmori and Hallberg [27] have reported a 75% decline in house sparrow population in London since 1994 which may be correlated to the advent of the cellphone. Electromagnetic radiation alone or in combination with several other factors were cited as the reason behind the fall in house sparrow population in Europe [44]. Experiments carried out in Spain revealed that the microwaves released from telephone towers were indeed harmful to the house sparrows and caused their population to decline [28]. The microwaves were also found to cause reproductive and co-ordination problems in house sparrows [45]. Reports from India also indicated the population of house sparrow is on a fast decline in areas like Bhopal, Nagpur, Jabalpur, Ujjain, Gwalior, Chhindwara, Indore and Betul with high concentration of electromagnetic waves due to increased use of mobile phones [46]. The damaging effects of electromagnetic radiations on the eggs, and the embryos, of house sparrows were reported by Kumar [47]. There are no reports on the effects of such radiations on house crows. However, a newspaper article reported that electromagnetic waves from mobile towers can cause death among the house crow population [14]. In Chinsurah, the number of telephone towers and the use of mobile phones have increased along with the increasing rates of urban growth in the last decade. This may be negatively correlated with the the number of crows and sparrows as proposed by Kumar [47]. The probable reason for the absence of sparrows from SA2 might be because of the significant number of telephone towers in the area. However, this needs further research.

Increased urbanization has led to increased traffic and overhead electric lines dangling between electric poles [Fig. 6e]. These overhead lines are one of the favourite perching sites for urban birds [Fig. 7 (a to h)]. Sadly, many birds are accidentally electrocuted by these wires and as a result die. Limited number of dead birds (crows, pigeons, doves, and mynas) were spotted during the survey. They had probably been electrocuted. The rise in the number of overhead wires [Fig. 6e] can therefore be considered as one of the reasons for the decline of house sparrows and house crows. Accident with vehicles can also be accounted for death of the bird species under study. A newspaper article had reported traffic accidents to be the cause of death of a considerable number of house crow species [14].

More so, some studies opine that superstitions may also affect the population of birds in a particular region. The study of Pandian and Natarajan [10] showed that sparrows were being killed for superstitious beliefs in some villages of Vellore

district in Tamil Nadu. Though the existence of similar rituals in Chinsurah was not investigated the findings are quite surprising simply due to the fact that they exist till date. As far as crows are concerned, accounts of superstitious killing of the species have not been encountered. However, they are considered to be ominous and found to be of importance only during the completion of Hindu funeral. Since they are regarded inauspicious, humans avoid feeding them or drawing them nearer [26] and prefer to nurture birds like doves associated with fortune. Prof. Paul Greenough observed the use of wooden crows as substitutes for the Hindu funeral ceremony because of non-availability of the real ones [14]. This preferential treatment received by house crows further deprive them from their food. Thus, superstitious beliefs may be an important factor that shapes up the species diversity of urban birds.

Death of sparrows due to disease infestation cannot be overlooked as a contributing factor for their decline [42]. However, the exact reason for such increase in diseased conditions of house sparrows fails to be identified. Newton [48] advocated that the reasons may be either direct increase in parasitic infections or indirect i.e., reduced ability of the house sparrows to overcome the diseased condition due to shortage of food supply and/or detrimental environmental factors. No available published reports claim that the house crow population has declined considerably due to any disease. However, it may well be considered to be an important cause. The diseased condition may either be correlated with the unavailability of sufficient food (both in quantity and quality) leading to poor levels of immunity or due to increased levels of pollution making the birds more vulnerable to infections. There is yet another reason that may cause untimely death of these birds. House crows often consume discarded rodents and cockroaches killed in domestic premises using rodenticides and insecticides [26]. The toxic substances present in them could cause their death [26]. Use of such insecticides and rodenticides are quite popular in any urban region including the study areas and therefore adds to the list of reasons for the vanishing species of birds under investigation.

4. PROJECTIONS FOR FUTURE STUDY

The urban ecosystem is complicated in its own way consisting of closely knitted food chains forming food webs and being acted upon by abiotic factors. Both the birds, house crows and house sparrows, occupy important positions in such food webs. Removal of any one of them or both is unwanted from an ecologist's point of view because it creates an imbalance. The next question that arises is how the ecosystem pays for such shifts in balance. Or maybe the imbalance persists and becomes the new balance. Though the ecosystem is ever adjusting and makes up for small disturbances what remains unanswered is whether these disturbances are small enough to be ignored! The questions gain gravity in the present conditions when the world is witnessing sudden eruptions of infectious diseases every now and then. Some birds and animals have been reported to act as reservoirs for many of these parasites and pathogens. Thus, the question is not restricted to the conservation of biodiversity alone. It should also be aimed at preserving the balance of the ecosystem to prevent further loss of another species. This field deserves more attention than it is currently getting.

The ecological role of the birds in question and the interactions between them is also very intriguing. The sparrows are known to control insects, disperse seeds and form food for the larger predatory bird species or other animals who prey upon them [49]. On the other hand, the discussion on the ecological role of house crows has always been limited to their scavenging activity that keeps the nature clean. This activity may be compared with a natural process of recycling. Apart from this they are invasive, preying upon smaller species of birds and spreading diseases among humans [22]. If that is so, then their absence should have encouraged house sparrow populations which surprisingly does not materialize under natural conditions. Then what is it the disappearing bird species are supporting? Or is it a process of wiping out of a species (or some species) suddenly? Whatever may be the process cannot be termed as natural because the situation has arisen as a result of anthropogenic interventions. These tiny links in the food web are however very crucial in the maintenance of ecosystem health. They need to be studied in detail so that appropriate measures could be taken to preserve its components.

As far as the methodology of such studies related to bird population are concerned, they are mainly based on the study of secondary factors like sources of food and tree cover [26]. The present paper also utilizes the same clues using simple methods to collect satellite images of the study area. The method discussed here may be developed to collect additional and meaningful data to be used in town planning. The workers in this field can either take training for these or collaborate their works with someone who knows how to handle these methods.

In the current investigation it was found that a few natural aquatic bodies have dried up or have simply disappeared without any trace. They are not only source of water for many aerial birds but also form the food source and habitat for many aquatic birds. Their

presence is therefore important in shaping up the ecosystem and its constituent species. The next in line are probably the aquatic birds who are going to be affected by this. A detailed study also needs to be done on this aspect to urge the authorities for preservation of such water bodies.

An article published in a leading daily news outlet back in 2014 highlighted lack of official monitoring programs and mechanisms for birds in India, like what is observed in developed countries, urge the workers to mainly rely on "impressions" and "intuitions" for drawing conclusions [26]. Contemporarily, studies carried out in most areas focus on endangered species. Common species are still being ignored. The Goa State Biodiversity Board has taken an encouraging initiative to keep records of crows in the state in addition to rodents. Biodiversity in the area are generally being documented by the People's Biodiversity Register under it [50]. This initiative step was taken following reports on the declining population of house crows in Bengaluru [50]. It is worthy to note that some birds also act as pollinators and help in the natural dispersal of seeds. This is extremely important from the productivity point of view. The current work proposes many more similar studies to keep a temporal record of as many species as possible.

5. CONCLUSION

The study shows that Chinsurah has witnessed rapid urban growth in the last decade. Simultaneously, the population of house sparrows and house crows have declined alarmingly in recent years. The cause, however, cannot be attributed to urbanization alone. The changing lifestyles of inhabitants remain a key contributory factor. From the foregoing discussion, the reasons for their decline may be summarized as (i) decline of tree cover, (ii) architecture of modern buildings, (iii) poor maintenance of natural aquatic bodies, (iv) sanitation habits, (v) excessive use of insecticides and rodenticides, (vi) lack of sufficient food supply for the birds, (vii) radiation from telephone towers, (viii) accidents due to increased traffic, (ix) pollution, (x) electrocution due to increased density of overhead lines, (xi) competition and predation pressures, (xii) preferential treatments driven by superstitious beliefs, and (xiii) death due to disease infestation. The study gives an insight into an evolving urban ecosystem. The advantages and disadvantages of such changes need to be deciphered. The study also brings into focus many important issues regarding an urban ecosystem which has mainly arisen due to unplanned growth of towns and cities without taking into consideration their ecological impacts in the long run. Proper redressal of these issues needs rigorous research in this field.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Mcdonald RI, Kareiva P, Forman RTT. The implications of current and future urbanization for global protected areas and biodiversity conservation. Biological Conservation. 2008;141(6):1695-1703. Available:https://dx.doi.org/10.1016/j.biocon.2008.04.025
2. Balaji S, Baskaran S, Pandiarajan J. Impact of urbanization on house sparrow population in Virudhunagar district, Tamil Nadu, India. Journal of Entomology and Zoology Studies. 2017;5(4):493-497. Available:https://www.entomoljournal.com/archives/2017/vol5issue4/PartG/5-3-349-185.pdf
3. Sharma P, Binner M. The decline of population of house sparrow in India. International Journal of Agricultural Science. 2020;5:1-4. Available:https://www.iaras.org/iaras/filedownloads/ijas/2020/014-0001(2020).pdf
4. Robinson RA, Siriwardena GM, Crick HQP. Size and trends of the House Sparrow, Passer domesticus population in Great Britain. Ibis. 2005;147:552–562. Available:https://doi.org/10.1111/j.1474-919x.2005.00427.x
5. Vincent KE. Investigating the causes of decline of the urban House Sparrow, Passer domesticus population in Britain. Ph.D. Thesis. De Montfort University. 2005;303. Available:http://katevincent.org/thesis/HouseSparrows%20(final%20version).pdf
6. Raven MJ, Noble DG, Baillie SR. The breeding bird survey. BTO Research Report 334. Thetford: British Trust for Ornithology; 2002,2003. Available:https://www.bto.org/sites/default/files/u16/downloads/reports/bbsreport02.pdf
7. Daniels RJR. Can we save the sparrow? Current Science. 2008;95(11):1527-1528.
8. Dandapat A, Banerjee D, Chakraborty D. The case of the disappearing House Sparrow (Passer domesticus indicus). Veterinary World. 2010;3(2):97-100. Available:http://veterinaryworld.org/Vol.3/February/The%20case%20of%20the%20Disappearing%20House%20Sparrow.pdf
9. Raj PJS. Where have the sparrows gone? The Hindu, September 14th; 2014.

Available:http://www.thehindu.com/opinion/open-page/where-have-the-sparrows-gone/article6408162.ece

10. Pandian M, Natarajan S. Probable reasons for declining populations of House Sparrow, Passer domesticus (Linnaeus) (Passeriformes: Passeridae) in rural Vellore district, Tamil Nadu, India. International Journal of Advanced Research. 2018;6(7):621-628.
Available:http://dx.doi.org/10.21474/IJAR01/7406
11. Deepalakshmi S, Salomi AA. Impact of urbanization on House sparrow (Passer domesticus) diversity from Erode and Namakkal districts, Tamilnadu, India. International Journal of Advanced Research in Biological Sciences. 2019.6(11):22-27.
Available:https://ijarbs.com/pdfcopy/2019/nov2019/ijarbs4.pdf
12. The Times News Network. Disappearance of house crows causes problems for performing shradh. The Times of India; 2018.
Available:https://timesofindia.indiatimes.com/city/bareilly/disappearance-of-house-crows-causes-problems-for-performing-shradh/articleshow/65940723.cms
13. Gandhi M. Disappearing crows, a wake up-caw: Intelligent birds just like humans, action needed before numbers further dwindle. Firstpost; 2019.
Available:://www.firstpost.com/india/disappearing-crows-a-wake-up-caw-intelligent-birds-just-like-humans-action-needed-before-numbers-further-dwindle-7270181.html
14. DiGiacomo J. Urban crows disappearing in India, throwing off ecosystem. The Daily Iowan; 2017.
Available:https://dailyiowan.com/2017/12/15/urban-crows-disappearing-in-india-throwing-off-ecosystem/
15. Feare CJ, Mungroo Y. Notes on the House Crow (*Corvus splendens*) in Mauritius. Bulletin of the British Ornithologists'Club. 1989;109: 199–201.
16. Koul S, Sahi DN. Feeding ecology of house crow (*Corvus splendens*) in open agricultural fields in Jammu (J&K), India. International Research Journal of Environment Sciences. 2013;2(6):85-87.
Available:http://www.isca.in/IJENS/Archive/v2/i6/13.ISCA-IRJEvS-2013-110.pdf
17. Behrouzi-Rad B. Status of Population and Roosting Places of Indian House Crow *Corvus Splendens* on Kharg Island in Persian Gulf. Journal of Environmental Conservation Research. 2013;1(1):1-8.
18. Ramakrishna S, Alexander R, Deepak P, Jayashankar M. Review on Eco-Biology of the House Crow, Corvus Splendens (Vieillot, 1816), (Corvidae: Passeriformes). International Journal of Scientific Research. 2014;3(6):488–490.
Available:http://dx.doi.org/10.15373/22778179/June2014/165
19. Brook BW, Sodhi NS, Soh MCK, Lim H. Abundance and projected control of invasive house crows in Singapore. Journal of Wildlife Management. 2003;67(4):808–817.
Available:https://doi.org/10.2307/3802688
20. Kamel AM. Potential impacts of invasive House Crows (*Corvus Splendens*) bird species in Ismailia Governorate, Egypt: Ecology, Control and Risk Management. Journal of Life Sciences and Technologies. 2014;2(2):86-89.
Available:https://doi.org/10.12720/jolst.2.2.86-89
21. Shimba MJ, Jonah FE. Nest success of the Indian House Crow *Corvus splendens*: An urban invasive bird species in Dar es Salaam, Tanzania**.** Ostrich. 2016;88(1):27–31.
Available:https://doi.org/10.2989/00306525.2016.1223766
22. Fraser DL, Aguilar G, Nagle W, Galbraith M, Ryall C. The House Crow (*Corvus splendens*): A Threat to New Zealand? ISPRS International Journal of Geo-Information. 2015;4(2):725-740.
Available:https://doi.org/10.3390/ijgi4020725
23. Ryall C. Predation and harassment of native bird species by the Indian house crow *Corvus splendens*, in Mombasa, Kenya. Scopus. 1992;16:1–8.
24. Peach W, Vincent K. Environmental causes of the decline of urban House Sparrows: a review of the evidence. Journal of Ornithology. 2006; 147:19.
25. Khanna B. Vanishing crows, a wake-up caw. Deccan Herald; 2014.
Available:https://www.deccanherald.com/content/434027/vanishing-crows-wake-up-caw.html
26. Bhanutej N. The Indian House Crow slowly disappearing from Bengaluru. The Economic Times; 2014.
Available:https://economictimes.indiatimes.com/news/politics-and-nation/the-indian-house-crow-slowly-disappearing-from-bengaluru/articleshow/45655231.cms
27. Balmori A, Hallberg Ö. The urban decline of the house sparrow (*Passer domesticus*): A possible link with electromagnetic radiation. Electromagnetic Biology and Medicine. 2007;26(2):141–151.

Available:https://doi.org/10.1080/15368370701410558

28. Everaert J, Bauwens D. A possible effect of electromagnetic radiation from mobile phone base stations on the number of breeding house sparrows (*Passer domesticus*). Electromagnetic Biology and Medicine. 2007;26(1):63–72. Available:http://dx.doi.org/10.1080/15368370701205693
29. Ali S. The Book of Indian Birds (Thirteenth Edition). Oxford University Press: Bombay Natural History Society; 2002.
30. Wotton S, Field R, Langston RHW, Gibbons DW. Homes for Birds: The use of houses for nesting by birds in the UK. British Birds. 2002;95:586-592. Available:https://britishbirds.co.uk/wp-content/uploads/article_files/V95/V95_N11/V95_N11_P586_592_A003.pdf
31. Bokotey AA, Gorban IM. In: J. Pinowski et al. (Eds.) International Studies on Sparrows, Numbers, distribution and ecology of the House Sparrow in Lvov, Ukraine. Institute of Biotechnology & Environmental Protection, University of Zielona Góra. 2005;30:7-22. Available:http://wnb.uz.zgora.pl/files/prints/iss/iss_vol30.pdf
32. Khan LA. Professor concerned over disappearance of crows. The Hindu; 2017. Available:https://www.thehindu.com/news/national/karnataka/professor-concerned-over-disappearance-of-crows/article18196117.ece
33. Choudhary S, Chauhan NS, Kalsi R. Seasonal habitat selection by house sparrows across the urbanization matrix in Delhi, India. Journal of Wildlife and Biodiversity. 2019;3:57-65. Available:https://doi.org/10.22120/jwb.2019.113270.1084
34. Balaji S, Baskaran S, Rajan MK, Pavaraj M. Effect of habitat alteration and fragmentation on the population of House Sparrow (Passer domesticus) in different vicinity of Virudhunagar District, Tamil Nadu, Southern India. British Journal of Poultry Sciences, 2014;3(3):62-67. Available:https://idosi.org/bjps/3(3)14/2.pdf
35. Dhanya R, Azeez PA. The House Sparrow (*Passer domesticus*) population of Arakku township, Andhra Pradesh, India. Indian Birds. 2010;5(6):180–181. Available:https://indianbirds.in/pdfs/IB_5.6.180-181.pdf
36. Chamberlain DE, Toms MP, Cleary-McHarg R, Banks AN. House sparrow (*Passer domesticus*) habitat use in urbanized landscapes. Journal of Ornithology. 2007;148: 453–462. Available:https://doi.org/10.1007/s10336-007-0165-x
37. Schwagmeyer PL, Mock DW. Parental provisioning and offspring fitness: Size matters. Animal Behaviour. 2008;75:291–298. Available:https://doi.org/10.1016/j.anbehav.2007.05.023
38. Anderson TR. Biology of the ubiquitous House Sparrow: From Genes to Population. Oxford University Press, New York; 2006. Available:https://doi.org/10.1093/acprof:oso/9780195304114.001.0001
39. Raupp MJ, Shrewsbury PM, Herms DA. Ecology of herbivorous arthropods in urban landscapes. Annual Review of Entomology. 2010;55:19–38. Available:https://doi.org/10.1146/annurev-ento-112408-085351
40. Zvereva EL, Kozlov MV. Responses of terrestrial arthropods to air pollution: A meta-analysis. Environmental Science and Pollution Research. 2010;17(2):297–311. Available:https://doi.org/10.1007/s11356-009-0138-0
41. Bókony V, Seress G, Nagy S, Lendvai AZ, Liker A. Multiple indices of body condition reveal no negative effect of urbanization in adult house sparrows. Landscape Urban Planning. 2012;104:75–84. Available:https://doi.org/10.1016/j.landurbplan.2011.10.006
42. Ghosh S, Kim K, Bhattacharya R. A survey on house sparrow population decline at Bandel, West Bengal, India. Journal of Korean Earth Science Society. 2010;31(5):448−453. Available:https://doi.org/10.5467/JKESS.2010.31.5.448
43. Shirodkar S. 10 reasons why the sparrow is fast disappearing from Mumbai. DNA; 2016. Available:http://www.dnaindia.com/mumbai/report-10-reasons-why-the-sparrow-is-fast-disappearing-from-mumbai-2190510
44. Balmori A. Electromagnetic pollution from phone masts. Effects on wildlife. Pathophysiology. 2009;16:191–199. Available:https://doi.org/10.1016/j.pathophys.2009.01.007
45. Balmori A. Possible effects of electromagnetic fields from phone masts on a population of White Stork (*Ciconia ciconia*). Electromagnetic Biology and Medicine. 2005; 24:109-119. Available:https://doi.org/10.1080/15368370500205472

46. Dongre SD, Verma RG. Effect of cell phone radiation on Gauriya Sparrow, Passer domesticus. Shodh, Samiksha aur Mulyankan-International Research Journal. 2009;2(7):51-52.
Available:http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.398.1596&rep=rep1&type=pdf
47. Kumar G. Report on cell tower radiation. DOT, Delhi; 2010.
Available:https://www.ee.iitb.ac.in/~mwave/GK-cell-tower-rad-report-DOT-Dec2010.pdf
48. Newton I. Population limitation in Birds (1st Edition). USA: Academic Press Limited; 1998.
49. Daniel VP. When was the last time you noticed a sparrow in your window? Why are sparrows endangered in India? Rediff.com News; 2013.
Available:https://www.rediff.com/news/report/slide-show-1-saving-the-sparrow/20130225.htm
50. Malkarnekar G. Concerned over dwindling numbers, Goa sets out to count its crows. The Times of India; 2019.
Available:https://timesofindia.indiatimes.com/city/goa/concerned-over-dwindling-numbers-state-sets-out-to-count-its-crows/articleshow/67731842.cms