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# Spatial distribution of nests and nesting trees of colonial birds at Telineelapuram pelicanry using geospatial tools in Andhra Pradesh, India

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**Abstract**
Telineelapuram pelicanry (IBA-IN-229) is located in the village scenery with an area spread of about 244 ha at Tekkali mandal in the Srikakulam district. The present study was carried out from 2009 to 2015. An attempt was made to record spatial distribution of nests of Spot-billed Pelican or Grey Pelican (*Pelecanus philippensis*) and Painted Stork (*Mycteria leucocephala*) over a wider canopy with a ground cover of 11.04ha. A handheld Global Positioning System (GPS) unit was used to mark the canopy ground cover and Open-source GIS tool, QGIS Wein 2.1.8 was used to visualize the in-situ conditions by integrating the ground data and analyze temporal variations with spatial scenario. During the study period, there was an increase in spatial distribution of nests over the available trees, and reduction of canopy area utilized for nesting. The increase in the population of two bird species during the study period indicates the potential of available resources for the expansion of its nesting area.

**Keywords:** Canopy cover, nesting canopy, nesting preference, near threatened birds, free and open-source GIS tools

## Introduction
Nature offers a living habitat for all the species with enough amenities. All the organisms depend/exploit on resources within their natural habitat for their existence and survival (Block *et al*., 2009) [5]. Historically, certain locations in the state of Andhra Pradesh, India have been a safe haven for many colonial nesting birds and been attracting the birds such as Spot-billed Pelican (*Pelecanus philippensis*) and the Painted Stork (*Mycteria leucocephala*) on regular basis (Del Hoyo *et al*., 1992; BirdLife International, 2008a, b) [1, 2-3]. Spot-billed Pelican and Painted Stork, fish as their prime diet, are therefore associated with water bodies (Neelakantan, 1949; Nagulu, 1983; Grimmett *et al*., 1998; Gokula, 2011; Kannan, 2013) [6-10]. These birds reproduce by nesting on large tree canopies; the choice of selecting the nest sites varies with their physical strengths (Nelson, 2006; Schreiber, 2009) [11-12]. In this region, these two birds are known to nest on the tree canopy from August to May on *Azadirachta indica*, *Barringtonia acutangula*, *Borassus flabellifer*, *Ficus religiosa*, *Ficus benghalensis*, *Pongamia pinnata*, *Tamarindus indica*, and *Prosopis juliflora.* From these trees, birds used to build their nests using fresh and dry twigs and leaves from various other plants in its vicinity. Spot-billed Pelican have strong and short legs and with heavy weight, choose to nest at the top and open canopies with strong and network of tree branches whereas, Painted Storks with long and thin legs and relatively lesser weight choose to nest on peripherals of the same canopy when they have to share the same tree. With the onset of north-east monsoon, the exceptional locations that hosts these bird species for nesting along the coastal regions of Andhra Pradesh are at Telineelapuram, Kolleru, Uppalapadu and Nelapattu.
The present study was an attempt to study the spatial distribution pattern of these nests over a wider canopy at Telineelapuram village, Srikakulam district from 2009 to 2015. The art of science and technology offered by GPS, and open-source geospatial tools like QGIS software was utilized to locate as well as visualize the above bird nesting area. This approach of integrating the ground truthing data with temporal variations and spatial data offers a platform to analyze the *in-situ* conditions (Spurr, 2003) [13].

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Very recent evolution of integrating remote sensing, GIS and spatial technology to study biodiversity in relation to understand the community structure of a landscape; species distribution, gradience of disturbances and help in designing the conservation measures accordingly (Anitha, 2010; Valle, 2018) [14, 15], also supporting the conservationists and researchers in analyzing the interactions among species in communities using various species distribution models (Ovaskainen *et al*., 2016 & 2017) [16-17]. Huang *et al*, (2020) [18] infer, spatial temporal connectivity may provide less biased and more realistic estimates of habitat connectivity. Ornithological studies integrated with GIS tools were extrapolated for spatial configuration of suitable habitat and framing the effective conservation measures (Gibson *et al*., 2004; Gottschalk *et al*., 2005) [19-20]. The present study is an attempt made to find the available nesting habitats and resources utilization pattern using GIS and RS tools.

## Material and Methods

### Study area

Telineelapuram village (18.5733°N and 84.2644°E) is in Tekkali mandal, Srikakulam district, Andhra Pradesh, India (Figure 1& 2). It is located 57 km from Srikakulam district headquarters on Chennai–Kolkata National Highway 16 (NH16).

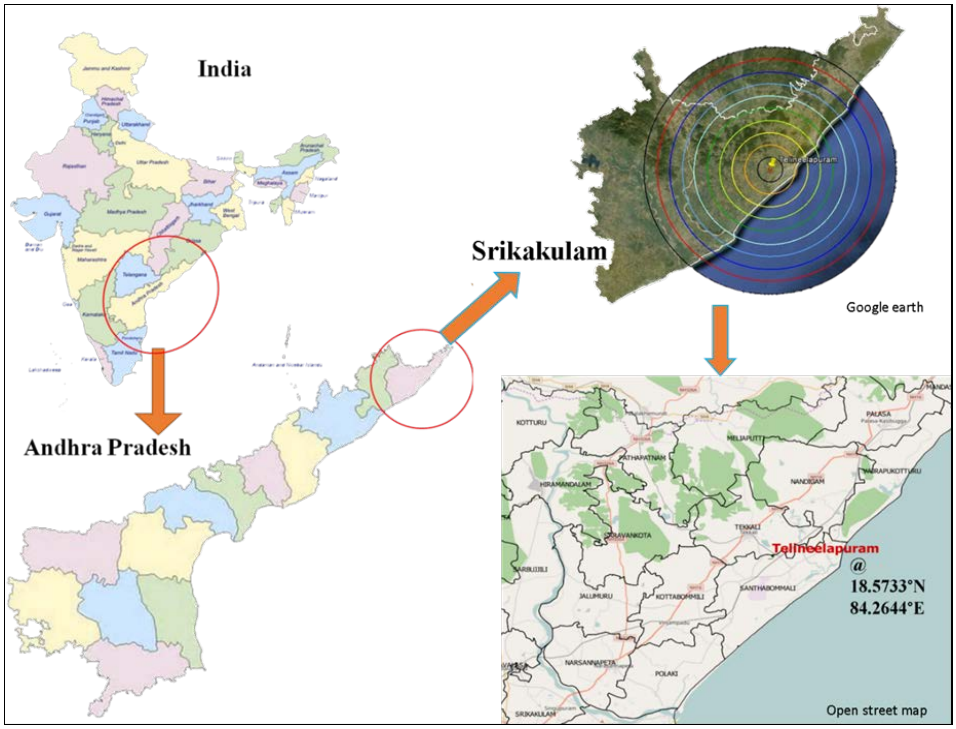


**Fig 1:** Map to depict the location of the study area


**Fig 2:** Telineelapuram village (a) Canopy cover in the village premises before the arrival of birds, (b) Nesting colony of Spot-billed Pelicans and Painted storks.

Telineelapuram village is spread in an area of 244 ha. Shuttle Radar Topography Mission (SRTM) 2009 values for two km radius around the village show the terrain has an altitude ranging from 0-25m MSL with a slope extending from SE to NW. The village is 8 km aerial distance from the Bay of Bengal on SE direction. As per the secondary information provided by villagers of Telineelapuram, the village was hosting the Painted Storks from the very past days of the village formation, and it is only in 1970's the Spot-billed Pelicans started to nest along with the Painted Storks. This coincides with the period of abandonment of famous Kolleru pelicanary (Neelakanthan, 1949; Nagulu & Rao, 1981, 1983; Nagulu & Rao, 1983; Rao, 1986; Subrahmanya, 2006) [6, 21, 22, 23, 26].

Studies were conducted during 2009-2013 and monitored from 2013-2015. It was to know the pattern of resources being utilized by the colonial nesting birds for breeding at Telineelapuram village. The village hosts the two near threatened species the Spot-billed Pelican and the Painted Stork for nesting. The village was recognized as an Important Bird Area, IBA-IN-229 **(**Rahmani *et al*., 2016) [24] because of the nesting of these two Near Threatened bird species. Various GIS layers were generated using QGIS Wein 2.1.8 versions. The data was used to analyze and visualize the *in-situ* conditions of the nesting grounds. The procedure adopted for data collection was depicted through an image **(**Figure 3).

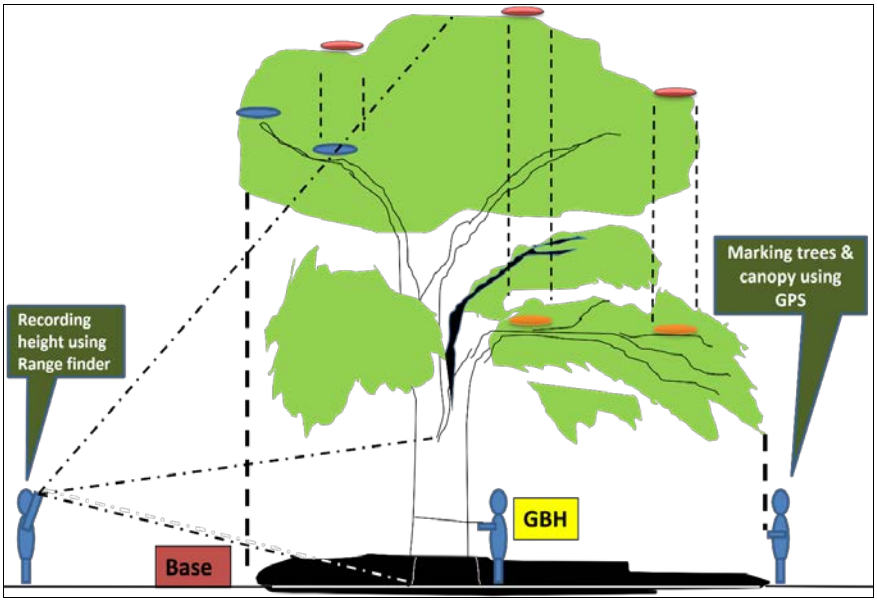


**Fig 3:** A model that depicts the method followed to calculate the canopy and to mark nest positions.

Data compilation: Field studies were initiated from November 2009 with simultaneous recording of GPS locations of each nesting tree at Telineelapuram village. The study area/nesting colony is in the village backdrop. The nesting trees were located within the village premises and the possible number of tree bases which can be accessible were geo-referenced. The co-ordinates of the inaccessible remaining trees were procured from Google earth. As the birds' choice of selecting the trees to construct nests differed every year and as not all the trees were utilized for nesting in the same year, the nesting trees observed within the colony were numbered with codes to represent the landmark.

Generation of nesting trees layer: Every year the nesting trees were recorded and correlated each tree point to their associated tree identification number and species name and nesting information (Spurr, 2003) [13]. Similarly, the new nesting trees were also geo-tagged. Garmin Oregon 550, a handheld GPS unit (at an accuracy of 1-3 meters), was used for geotagging the position of each tree. Geo-locations of trees which were utilized for nesting, and the trees which have fallen or uprooted or axed during the study period were also included in records for representing the past nesting tree count and the number of nests constructed on them. This helped in studying the impact despite the loss of some nesting trees during the study.

Nesting zone: An imaginary center point for the study area was generated from the polygon drawn by joining the geo-referenced nesting trees in the fringes, and the point was maintained constant throughout the study period. Using the center point, a circle was drawn encompassing all the nesting trees. It generated the nesting zone.

Canopy: The total canopy spread over the village was recorded by using a handheld GPS unit and corresponding canopy layers were generated by walking at the edges of the tree canopy. The canopy of the nesting trees was delineated from the total canopy to denote the extent of nesting canopy.

## Results and Discussion

The dense tree canopy across the village has a ground cover of 11.04 ha. A total of 83 trees belonging to 11 species were marked as preferred nesting and roosting trees in the village vicinity during the study period (Figure 4).

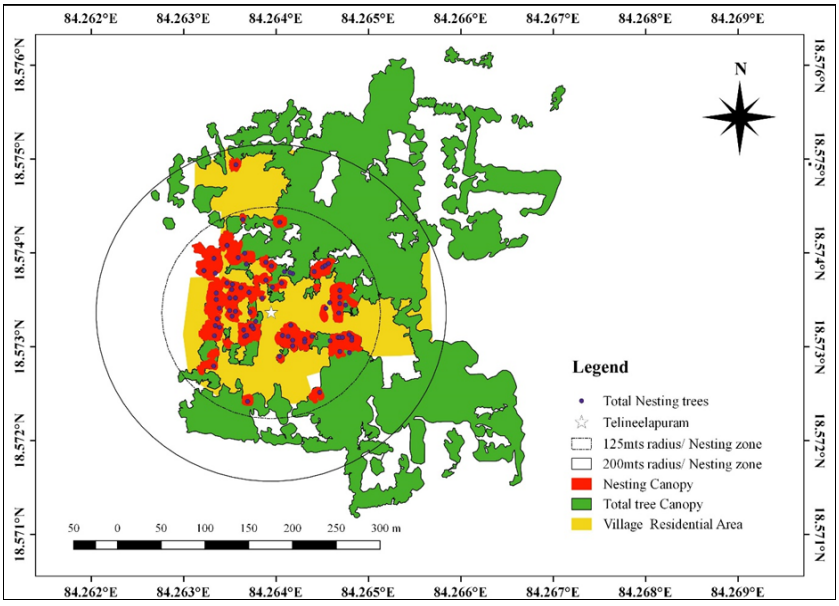


**Fig 4:** Extent of total canopy, spatial distribution of nesting trees, and extent of nesting zone in the village backdrop.

During the period of study, yearly, the number of trees and the area of canopy cover utilized for nesting varied. A minimum of 36 trees were recorded for nesting in the year 2009–2010 and a maximum of 62 trees were utilized by nesting birds in the year 2012–2013 and in 2014–2015. A total of 83 individual trees of 11 species were recorded for being utilized by the birds for nesting, of which the tree composition or the individual tree number of remained changing, so the canopy cover. Of the 83 trees recorded the maximum number of trees were contributed by *Tamarindus indica* (30 individual) and *Prosopis juliflora* (30) followed by *Bamboosa* sp (9), *Ficus mollis* (4), *Samanea saman* (3), *Morinda pubescens* (2) and one individual each of *Ficus benghalensis*, *Pongamia pinnata*, *Sapindus emarginatus*, *Ziziphus jujuba*, *Azadirachta indica*. Neelakanthan (1949) [6] observed the Spot-billed Pelicans at Kolleru (Sarepalle and Aredu) and noted the birds were not making use of the entire canopy at once. Furthermore, a location that is heavily populated one season may only have a few or no nests in another, while a location that is completely uninhabited one year was seen crowded with birds the next year. The details of yearly chosen nesting trees and their extent of canopy cover are provided in table 1,

**Table 1:** Plant species and number of trees utilized for nesting by colonial birds at Telineelapuram.

| Tree species | 2009-10 | 2010-11 | 2011-12 | 2012-13 | 2013-14 | 2014-15 | Total Trees |
|---|---|---|---|---|---|---|---|
| *Tamarindus indica* | 16 | 24 | 25 | 26 | 23 | 26 | 30 |
| *Bambusa* sp. | 4 | 4 | 6 | 7 | 5 | 9 | 9 |
| *Ficus benghalensis* | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| *Ficus mollis* | 1 | 0 | 1 | 0 | 0 | 0 | 4 |
| *Morinda pubescens* | 0 | 2 | 1 | 2 | 2 | 1 | 2 |
| *Pongamia pinnata* | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| *Prosopis juliflora* | 12 | 25 | 19 | 22 | 18 | 24 | 30 |
| *Samanea saman* | 1 | 2 | 3 | 2 | 1 | 0 | 3 |
| *Sapindus emarginatus* | 0 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Ziziphus jujuba* | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Azadirachta indica* | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| Total no. of nesting trees | 36 | 60 | 58 | 62 | 50 | 62 | 83 |
| Nesting Canopy area (ha) | 0.65 | 0.97 | 0.56 | 0.52 | 0.60 | 0.52 | |
| Total Canopy area (ha) | 11.04 | | | | | | |

The Grey Pelican population was observed to be increasing from 350 individuals and 116 number of nests in the year 2009-2010 to 711 individuals and 192 nests in the year 2014-2015. The Painted Stork population has increased from 600 individuals with 156 nests to 872 individuals with 385 nests. The number of trees being utilized has also increased from 36 trees in the year 2009-2010 to 62 trees in the year 2014-2015. A comparison was made with that of the number of birds arrived and number of nests constructed to that of the total extent of canopy utilized for nesting; varied with the number of nesting birds and their preferred trees in respective years (Table 2),

**Table 2:** The number of trees utilized by the nesting birds and the ground cover provided by the nesting tree canopy.

| Year | Number of nests / populations | | No. of nesting trees | Area of nesting canopy (ha) |
|---|---|---|---|---|
| | Spot-billed Pelican | Painted Stork | | |
| 2009-2010 | 116/350 | 156/600 | 36 | 0.65 |
| 2010-2011 | 117/269 | 348/760 | 60 | 0.97 |
| 2011-2012 | 149/298 | 426/897 | 58 | 0.56 |
| 2012-2013 | 185/532 | 336/760 | 62 | 0.52 |
| 2013-2014 | 147/490 | 218/652 | 50 | 0.60 |
| 2014-2015 | 192/711 | 385/872 | 62 | 0.52 |

The trees preferred for nesting by birds were identified to be distributed within a radius of 125m in 2009–2010 and 200m during 2011-2012 (Figure 5), within the village premises. The canopy area or the ground cover utilized by the nesting birds was observed to be instable, it was 0.65 ha (1.6 ac) in 2009-2010, in the following by year the canopy utilized had increased to 0.97 ha (2.4 ac) in 2010-2011 and decreased to 0.56 ha (1.4 ac) in 2011-2012 further decreased to 0.52 ha (1.3 ac) in 2012-2013, 0.60 ha (1.48 ac) in 2013-2014 and 0.52 ha (1.28 ac) 2014-2015.

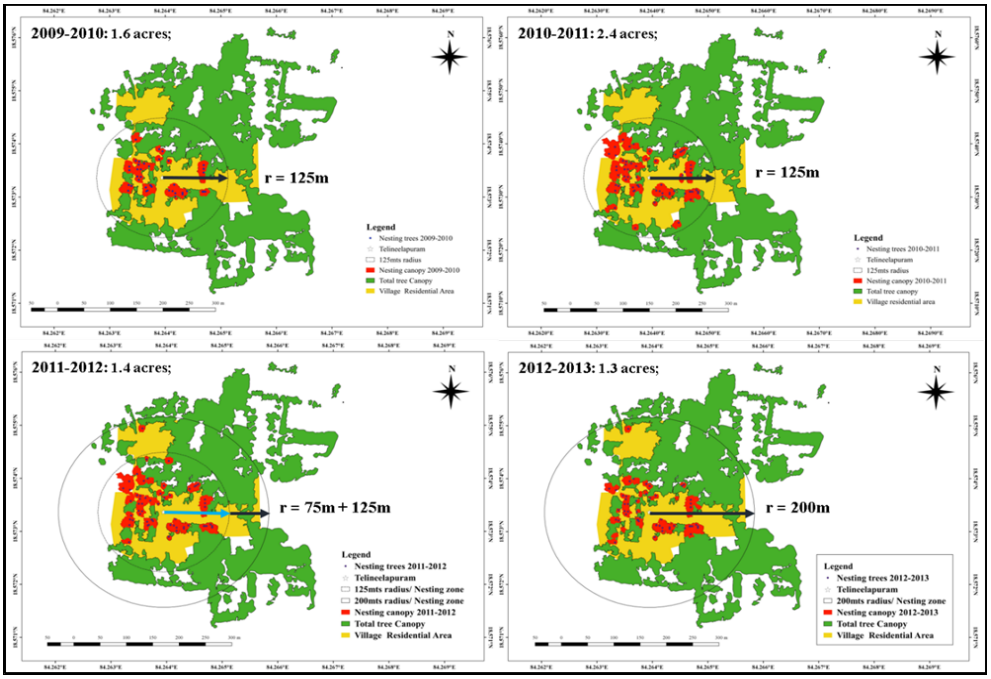


**Fig 5:** Maps showing the pattern of drift in the extent of canopy utilized for nesting during the study period, and the increase in the nesting zone.

It was observed there was an increase in the number of nests constructed which was proportional to the number of birds arriving. Apparently, a few new trees were also added to the list for being used by the birds for nesting. The change in using the canopy for nesting was shown in Figure 5. Despite the decrease in the nesting canopy recorded with the loss of nesting trees in the nesting zone, the number of nests built had increased on the existing trees. It implies, the location of preferred trees was more suitable for nesting but would also describe the scenario of overcrowding at the locations. And the other trees which were used in earlier years were deserted in the consecutive years due to the disturbances experienced at those trees. Hence there is a need to provide nesting spaces with protection from predators or to secure the existing trees.

Nesting resources: Field survey of the locality revealed the presence of wooded country predominantly with the tree species *Azadirachta indica*, *Bamboosa sp*, *Bombaxi ceiba*, *Borassus flabellifer*, *Eucalyptus globulosa*, *Phoenix sylvestris*, *Prosopis juliflora*, *Terminalia arjuna*, *Tamarindus indica* and Mango orchards. Collectively, the village has a ground cover of 11.04 ha. In the early stage of nest construction, the birds were observed to collect nest material from the nesting tree and their adjacent trees. They were observed to make intensive visits for the collection of nest material. Such locations were delineated and measure an area of 2.12 ha distributed in the Northeast to southeast of the nesting location, which has to be necessarily conserved for the provision of abundant nest material (Figure 6 &7).

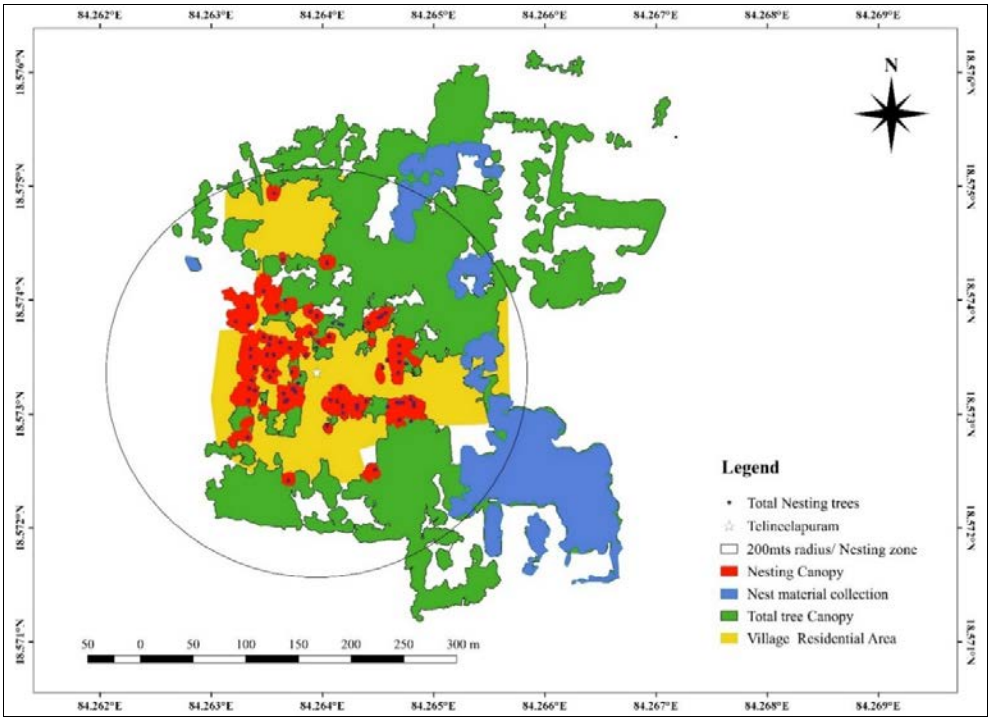


**Fig 6:** Predominantly utilized canopy for collecting nest material from the study area.

**Fig 7:** Intensive location to collect nest material.

Shift in nesting canopy: The shift in nesting canopy was recorded because of the disturbance caused by the Rhesus macaque (*Macaca mulatta*) passing through the nesting area (Figure 10). During the two consecutive years 2011- 2012 and in 2012 -2013, due to the Rhesus macaque intervened into the nesting area. It was observed that Spot-billed Pelicans had abandoned the nests and moved to the other nesting trees. It was also observed that the Spot-billed Pelicans from the nests of other trees were collecting nest material from these abandoned nests while constructing new nests, Figure 8 presents the visualization of the change in the respective canopy cover of the nesting trees. In the year 2012 – 2013, the reappearance of Rhesus macaque and recurrence of disturbance had caused complete abandonment of the few nesting trees along with the partial abandonment i.e., on certain trees, few nests were completely abandoned, and few nests were re-occupied by the birds and lasted till the end of the season, which are shown in the map (Figure 9) as disturbed canopy.

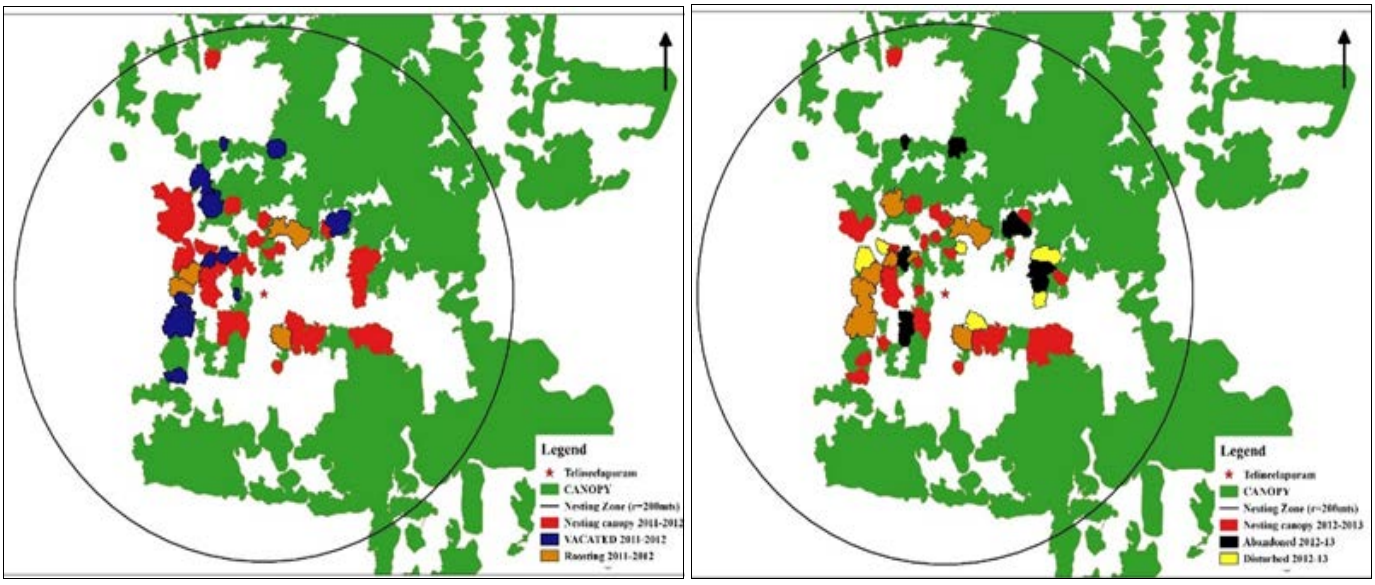


**Fig 8:** 2011-12; Figure 9: 2012-13, occurrence of disturbance, abandonment and relocation of nesting spaces during the period.

During the two consecutive years, the disturbance had shown similar effects, the abandoned nests were noticed to have incubating nests, the eggs under incubation in the abandoned nests were observed to be fed upon by and lifted away by House crows.

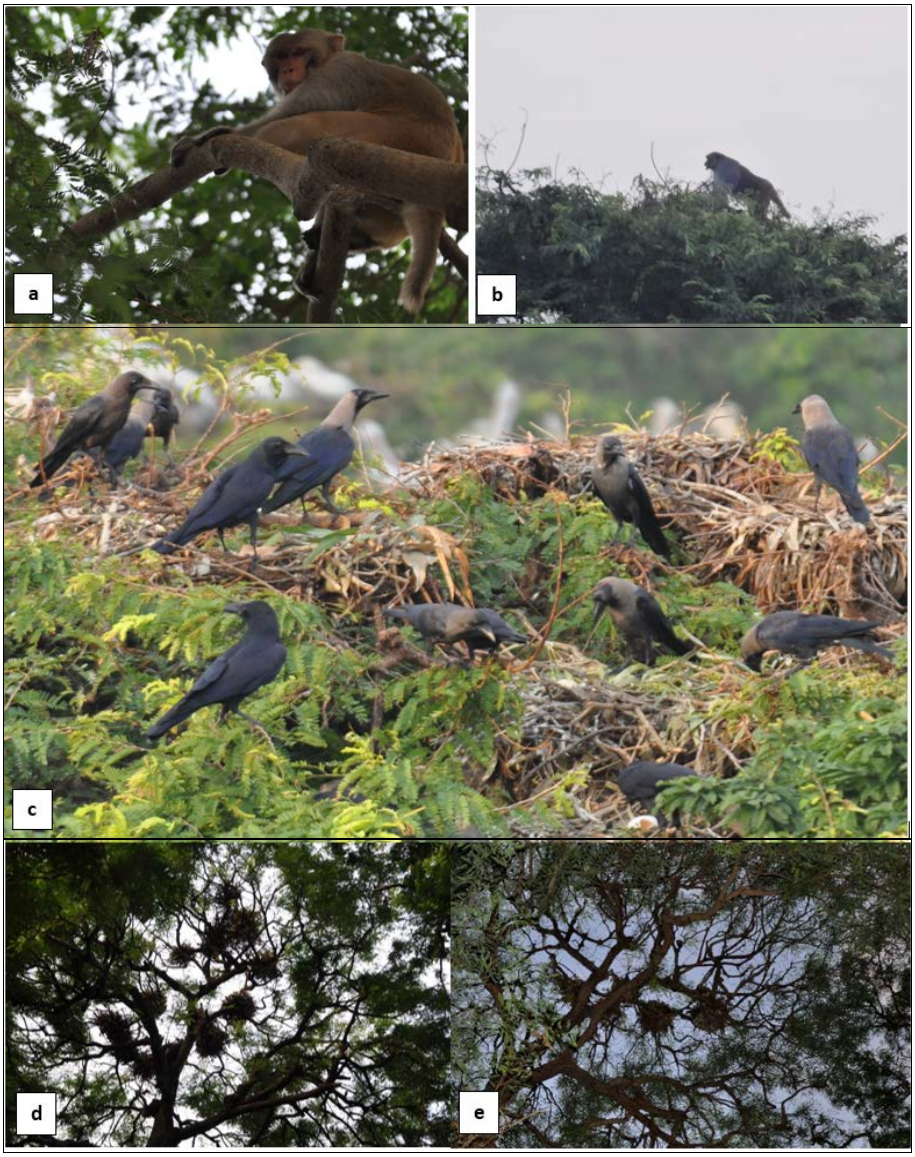


**Fig 10:** (a, b) Intrusion of Rhesus macaque (*Macaca mulatta*) on to the nesting trees, (c) Abandoned nests with eggs are predated upon by House Crows and Jungle Crows. (d) Number of nests present on the tree before and (e) Decrease in number of nests after the Rhesus macaque intrusion (as birds dismantled and collected the nest material).

**Roosting Canopy:** Variation in utilization pattern of canopy from nesting to roosting purpose was observed during the year 2011-12 & 2012-13; post disturbance by Rhesus macaque intrusion in the nesting area, it was observed that the certain population of breeding birds had shifted to nest on the other trees with existing nesting population. Certain trees were recorded for being utilized by Spot-billed pelicans only for roosting (Figure 11).

**Fig 11:** Canopy utilized by the roosting birds.

## Conclusion

Spot-billed Pelican owing to the improved protection measures the conservation status was brought back from Vulnerable (VU) 1994-2006 to Near Threatened (NT) from 2007 (BirdLife International, 2017) [4]. The species experienced a decline phase and key threats were the loss of breeding and feeding locations (Subramanya, 2006) [26].

In the present study, table 2 denotes about the increasing trend of population and nest count at Telineelapuram pelicanry. Spot-billed Pelican and Painted Storks are known for their adaptability to different habitats and are known for their adaptability to artificial structures for nesting. The present study emphasizes ecological values of trees and habitat sharing among two different bird species. The resource utilization by the two birds studied in this area gave a baseline knowledge among researchers, conservators, and forest officials. Since developmental activities are going at every stretch at global level, there is an urgent need to conserve the migratory birds and their habitats. The study reveals that the trees in bird habitats will play a key role in conservation of bird nesting areas. More such type of studies for various habitats and nesting sites of the species under conservation priority by implementing the technology updates is the need

of hour. The study suggests for the propagation of more trees with good canopy spread in terms of providing the nesting space/ platform. Long-term preservation of the ecosystem is necessary to provide nesting spaces for the breeding birds. Soberon, (2007), articulates Species' ecological niches, and their distributions and responses to global changes, are determined by several factors acting at various spatial scales.
The integrated studies of GIS with Ornithology would help in monitoring the present-day status of the nesting community and would help to build a framework and to implement conservation measures. It is suggested that routine adaptation of these tools is quite essential and much needed for conservation of the species under protected category and monitoring the status of the resources in habitats.

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