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Full Length Research Paper

Mapping locations of nesting sites of the Indian house crow in Mombasa

Mwangome Muye Chongomwa

GEGIS Department, Jomo Kenyatta University of Agriculture and Technology, Kenya. E-mail: muye27@yahoo.com.

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The location of nesting sites of Indian house crows is related with the food availability within an area. Nesting sites are located close to food sources especially areas with poor sanitation. A Google image of the area was zoomed in to visually identify tree clusters and planning of residential areas. Ground observations of the tree clusters identified from the image for nesting and the conditions around them. In the 236 tree clusters identified in the Google image, 167 (71%) were nesting sites as per the ground observation. 69% of the nesting sites were found in areas with poor sanitation. These were areas in unplanned residential areas with poor road network hindering distribution of refuse handling services. The most preferred nesting tree was the mango tree with 1246 nests, observed in 464 trees. Some nests were observed in trees with small and open crowns e.g. pawpaw and Indian tree. House crows put more nests on trees with large crowns. The estimate number of nests in a nesting site may be given by $N=2T_L+T_S$. 76% of the model results were close to the actual nest count with a ±3 difference. The municipal council should improve on handling and monitoring of refuse disposal, plant trees that are less conducive for nesting, and regularly prune tall trees with large crowns.

Key words: Location, nesting sites, Indian house crow, model.

INTRODUCTION

The Indian house crow (*Corvus splnedens*) is a bird species that originated in India. It was first sighted in Mombasa Island in 1940s (Ali, 2008). As human settlements grew into the main land, Kisauni, Chngamwe and Likoni, the birds spread into these areas. In East Africa, the bird was introduced in Zanzibar in 1890s by British civil servants or by ships from India. By 1950s it had spread to Dar-es-salaam and other coastal towns (Cooper, 1996).

Development is uncontrolled in most parts of Mombasa with a few well planned and organized settlements majority owned by private developers and state corporations. Because of poor planning there are few access roads in most residential areas. Vegetation is now found in pockets surrounded by built up areas. Trees are found in clusters or single isolated trees in streets beautified with trees and flowers, undeveloped land, well planned organized residential areas, institutions, Municipal grave yards or non-designated grave yards and the protected mangrove forests.

The objectives were: to investigate the spatial location of nesting sites of the Indian house crows; develop a rapid method of locating nesting sites of the Indian house crows; and to produce a map showing the nesting sites of the Indian house crows.

Problem statement

The Indian house crow is abundant and associated with a myriad of problems ranging from nuisance, pest, disease transmission, and reduction of local biodiversity. Its population is increasing at a high rate.

Physical control measures such as destruction of eggs and nestlings have been applied with limited success as identification and locating nesting sites is a challenge.

There is need to discover the conditions affecting spatial location of nesting sites of Indian house crows. A rapid method of locating nesting sites needs to be developed to make the identification of these sites easy and quick.

A recent map of the nesting sites is lacking. If information on the nesting sites is available it will help in increasing the success of the destruction of eggs and nestlings which will reduce the population of the Indian house crow in the area greatly.

Literature review

Mombasa had a variety of bird species, but with the invasion by the Indian house crow, most birds have been displaced or their population reduced by the Indian house crows. The aggressive nature of the Indian house crow scares off other birds from feeding sites, hence, they moved out of the area to other places. The pied crow was a native bird and was displaced from the area in 1980 (Ali, 2008). The bird preys on nestlings and eggs of other bird species. It also preys on quite a number of small reptiles, insects and invertebrates, hence their populations are declining. Other problems caused by Indian house crows are; nuisance (noise, droppings, entering dwellings, electric power failure, destruction of TV aerial reception), disease transmission e.g. cholera and salmonella, pest (destroys crops e.g. ripe pawpaws and mangos, green maize and attacks poultry), and may cause air strikes due to the flocking nature (Cooper, 1996; Khan, 2002; Puttoo and Acher, 2003; eThekwini Online, 2009).

The population of the Indian house crow has reached plague proportions. Attempts to control the Indian house crow population in Mombasa began in 1984 (Ali, 2008). Population control measures applied include destruction of eggs, nests and nestlings; shooting and trapping; poisoning of birds with avicides; and covering and proper disposal of refuse (Daniels, 2004; Puttoo and Acher, 2003; eThekwini Online, 2009). Locating nesting sites is a challenge. The destruction of eggs and nestlings had limited success as there lacked a recent map showing nesting sites.

Animal habitats can be mapped by use of satellite imagery to delineate original key habitats. Ground observations are done to verify the identified areas as true habitats and mark their extents (William et al., 1992). Habitat maps are created based on locations of statutory protected areas defined by statutes as conservation areas (Bright et al., 2008). The animal habitat maps may be produced based on the areas where the animals have been spotted for a certain time period (ECO Specs, 2004; USGS, 2008). Literature sources e.g. scientific papers and thesis that describe the distribution and location of the animal habitats and breeding areas can be used the create habitat maps (Nyári et al., 2006; NABIS, 2004). Mapping animal habitats may be based on the territory the animal occupies (Kennedy et al., 1999). And ground surveys in known habitats or using existing land cover maps to establish the location of the habitats or breeding sites of animals to produce maps (Pearce-Higgins et al., 2008).

MATERIALS AND METHODS

Mombasa city is located 04°00'S, 039°36'E. The study area is in Kisauni area within Mombasa Municipality (Figure 1), east of the Mombasa Island. The area has a hot humid climate. It has an average annual temperature of 24°C. The annual rainfall received is between 1000 - 1600 mm annually. There are two rain seasons, the long rains (April to July) and the short rains (August to October). Humidity is very high throughout the year. The area experiences high evaporation rates.

Land gradient in the study area is generally flat. Some parts of the study area are seasonally flooded due to poor drainage. The soils that cover the study area are sand soils with the base rocks being the coral limestone. Sand beaches are found in the southern part of the study area.

Well planned residential areas are found in the south of the study area, Nyali and Mkomani. A few at Khadija estate located at the central part of the study area and around the New Nyali Bridge and Kengeleni. The rest of the study area is covered by unplanned residential areas.

An image from Google maps (2009) of the study area was zoomed in to be able to identify the location of tree clusters visually. Tree clusters were selected based on the closeness of the tree crowns to each other. Sketch maps of the locations of the tree clusters made to assist in coding of tree clusters during plotting on the map and gathering of data. Ground observation of the identified tree clusters for nests at around 4.00 to 6.00 pm. Nests were keenly observed if they were active by observing roosting at around 6.00 to 7.00 pm, nest construction activities and nest feeding. Data was collected in September and November 2009 which coincides with the breeding season.

Tree types having nests and nests were counted, and estimate crown diameter recorded. The conditions of the surroundings where nests were observed were recorded.

Housing conditions were analyzed from the Google image and grouped into planned residential estates and unplanned residential areas, then followed by ground observation. The road network was also analyzed for accessibility in all the residential areas. It was necessary in the analysis of the distribution of refuse handling services within the study area.

A map of the study area was digitized in ILWIS GIS software from a topographic map sheet number 201/1.

The tree clusters where nests were observed plotted on the map as points from the Google image. The codes for the points recorded from the sketch maps used in gathering data from the field used to code the points.

Tree density was analyzed within the study area. Tree density calculated by counting the number of trees within 6 sample blocks of 40000 m^2 (200 x 200 m); 3 in planned residential areas and the others in unplanned areas. The overall tree density determined from the average of all the 6 sample blocks.

RESULTS AND DISCUSSION

Tree clusters identified from the Google image

From the Google image, a total of 236 tree clusters were identified followed by ground observation for nests (Table 1). Tree clusters that had nests were 167 and those without nests were 69.

76.76% of the tree clusters identified from the Google image were nesting sites of the Indian house crows and 29.24% non-nesting sites.

Therefore, within an urban setup where Indian house crows are present 71% of the tree clusters are nesting sites of the Indian house crows. However, 7 tree clusters were identified on the ground as they were obscured by cloud cover; 5 were nesting sites and 2 non-nesting sites.

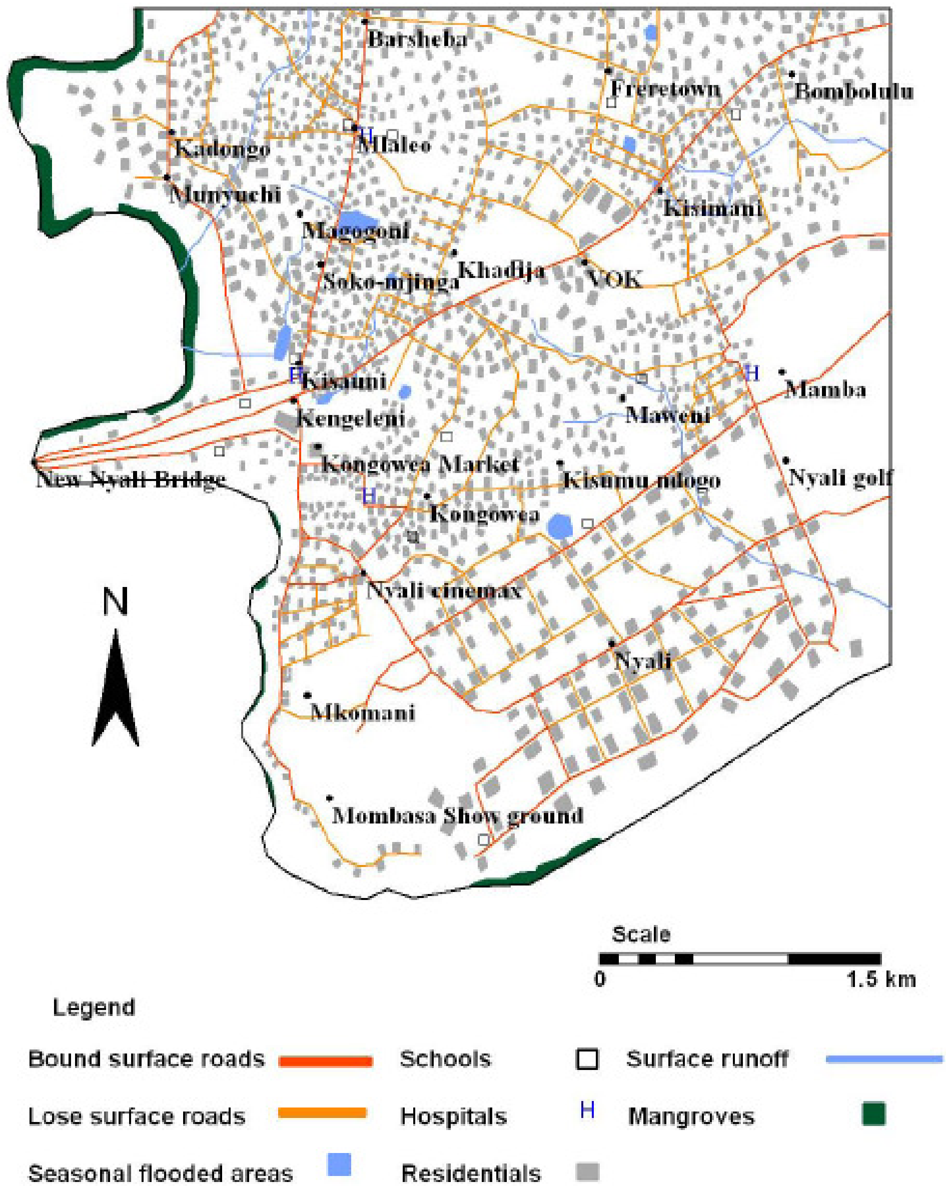

Figure 1. Study area map.

Location of nesting sites by Indian house crows

Nests and tree types with nests were counted in those tree clusters that were accessible on the ground. In 148 tree clusters nests and tree types were counted while in 19 tree clusters no count was done as the tree clusters were inaccessible. There were perimeter walls with entry points completely locked up, access denied by security personnel, houses were close together (about 3 m) and some access routes blocked. Alternative access routes had to be found or observe a few trees close to the walls for nests or roosting in the evening and use residents or security personnel whom were cooperative to collect data.

There were 51 nesting sites in planned residential areas and 116 nesting sites in unplanned residential areas (Table 2).

However, 48 tree clusters that had no nests were observed in planned residential areas and those found in unplanned residential were 21 (Table 3).

Nesting sites were located close to food sources; areas with poor sanitation (littering especially with kitchen refuse) had the highest number of nesting sites and highest number of nests per tree. Refuse was not covered; kitchen and bathroom waste water was directed outside the houses and not in septic tanks. The house fly larvae borne in the waste water became an extra food source for the house crows. Areas with highest number of

Table 1. Tree clusters identified from the image and observed for nests.

With nests	Without nests	Total
167	69	236

Table 2. Number of nesting sites as per the nature of residential areas.

Planned	Unplanned	Total
51	116	167

Table 3. Tree clusters without nests as per nature of residential area.

Planned residential area	Unplanned residential area	Total
48	21	69

nests per tree were Mlaleo, Kongowea, Kisimani, Bombolulu, Barsheba, Soko-mjinga, Magogoni, Khadija, Maweni, and Kadongo (Figure 2). Other nesting sites were located near refuse dumps (Appendix 1); there were 46 refuse dumps of which two were designated by the local authority for refuse collection. The refuse collection points were found in Mlaleo and VOK (Voice of Kenya) (Figure 3).

Refuse collection was done once per week, but at times it was delayed for two or three weeks. Areas with open air food kiosks or green groceries were found to be nesting sites. Indian house crows are aggressive and make efforts to snatch food from unsuspecting people (eThekwini Online, 2009) in open air food kiosks and green groceries. Also, nesting sites were in close proximity to the ocean.

Planning of residential areas contributes in the distribution and monitoring of refuse handling services. Accessibility of residential areas is hindered by poor road network especially in the unplanned residential areas (Appendix 2). This may be an attribute to poor sanitation as there is little or no monitoring by the local authority. Thus, a greater number of nest sites and number of nests were observed in unplanned residential areas (Table 4, Figure 4). The nesting sites in unplanned residential areas were 69.46% of the total nesting sites observed.

The nesting sites in areas with good sanitation i.e. planned residential areas were 30.54% of the total nesting sites. The nest sites were found close to the open air food kiosks, green groceries or unplanned residential areas. Some nest site were close to the ocean where the house crows hunt for fish or steal fish when they are being sun dried, off loaded from boats or displayed for sale. Some fishermen used small net sizes at times mosquito nets which catch fingerlings and eggs which they did not return in water and became food for the house crows.

Considering the tree density, 29/40000m^2 in unplanned residential and 75/40000 m^2 in planned residential, more nest sites would be in the planned residential areas. But this is not the case as other factors apart from tall trees with large crowns are influential in locating nesting sites, the major factor being food availability. The house crow feed mainly on refuse which is abundant in unplanned residential areas due to lack of efficient refuse handling services and monitoring. The overall tree density was 52/40000 m^2.

Nesting trees

Mango trees (*Mangifera indica*) and neem trees (*Azandirachta indica*) were the common nesting trees; they are tall with large crowns (Table 5, Appendix 3b). The mango tree was the most preferred nesting tree (Figure 5). Other tree types were grouped together e.g. coco nut palm (*Cocos nucifera*), casuarinas (*Casuarina equisetifolia*), baobab (*Adansonia digitata*), Indian tree, tamarind (*Tamarindus indica*), *Thevethia peruviana*, half neem tree (*Maerua azandrach*), common bamboo, pawpaw and cashew nut tree.

Indian house crows prefer nesting in tall trees with large crowns to avoid human persecution and see food sources from fur (Dutta, 2007). The mango tree accounted for 59% of the nests counted and 42% of the total nesting trees. The mango trees are tall with large crowns suitable for nesting. Large crowns protect nests from rain as they are open upwards which may destroy eggs and nestlings, thus breeding is mostly in dry seasons. The large crowns are used by the house crows to hide nestlings from human persecution. Mango trees produce fruits twice a year if rains are good and act as source of food to the house crows when they are ripe. Other tree types accounted for 45% of the total nesting trees with 32% of the total nests. Neem trees had 9% of the nests and 13% of the total nesting trees. Some trees with nests had small and open crowns e.g. pawpaw (Appendix 3a), coco nut palm, Indian tree, and *Thevetia peruviana.* Some of these are used for beautification of streets and estates. This poses a great challenge to the Municipal council as it may be creating nesting sites for the Indian house crow. The mango trees in any nesting site had a mean of 3 nests per tree, the neem tree 1 and any other tree type 1. Any tree found in a nesting site had a mean of 2 nests.

Estimating the number of nests in a nesting site

Trees with large crowns, 5 to 10 m diameter or more, had the largest number of nests compared to those with small

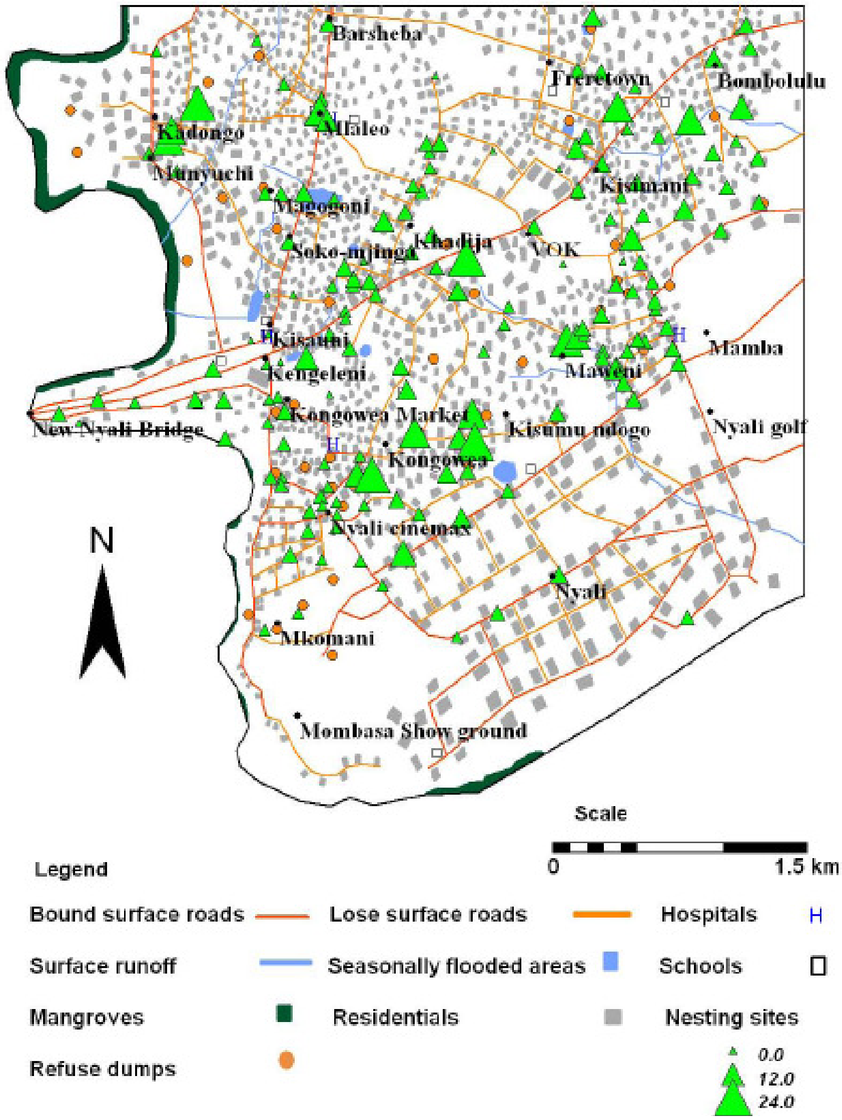

Figure 2. Map of nesting sites of Indian house crows.

crowns, up to 5 m diameter (Table 6).

The ratio between the nests of Indian house crows and the number of trees with large crowns is 1:2 and that with trees with small crowns is 1:1. The nests of house crows in trees with large crowns are 2 times greater than in trees with small crowns. It then follows that Indian house crows put more nests on trees with large crowns. When the number of trees and nests per nest site were plotted on a graph and a trend curve derived, the graph below was obtained (Figure 6). The estimate number of nests in a given nest site can be obtained if the number of trees with large and small crowns are known in a given nesting site of the Indian house crows. The number of nests in a nesting site can be estimated by the following formula.

$N=2T_L+T_S.$

Where N is the number of nests,
T_L is the number of trees with large crowns and
T_S is the number of trees with small crowns.

From the 148 tree clusters where the number of trees and nests per tree were counted, 76.35% of the model results were close to the actual nest count with a ±3 difference. Trees with large crowns should be planted and those existing not to be cut down to maintain diversity of plant species. Pruning can reduce the number of nests in a tree with a large crown by opening up the crown making it non-conducive for nesting. Regular pruning of trees with large crowns may offer a good opportunity in controlling the population of the Indian house crows. By reducing the number of nests, the number of eggs laid in a breeding season may be

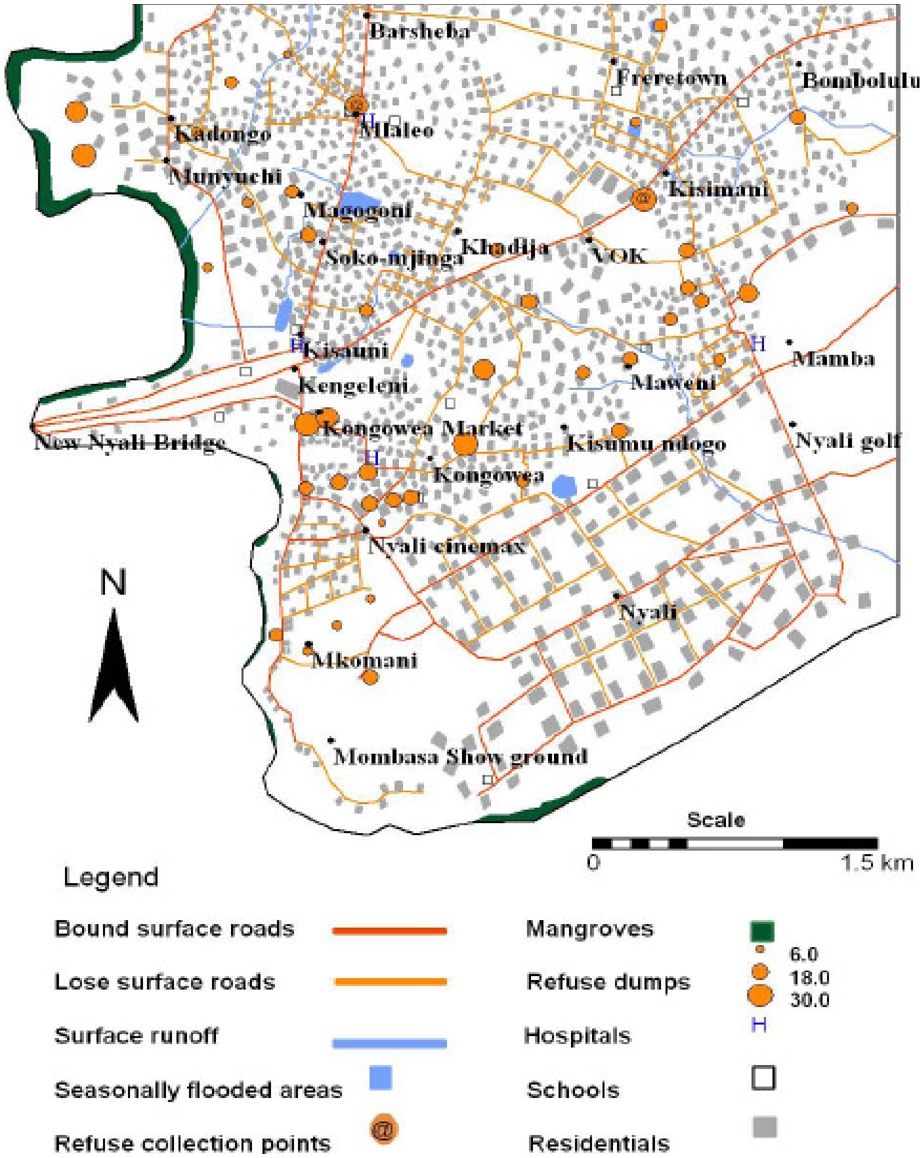

Figure 3. Non-designated refuse dumps

reduced. Considering other factors like egg loss and chances of nestling survival, the number of house crows can greatly be controlled.

Pied crow

Four pied crows (*Corvus albus*) were observed within the study area. Two were observed at Maweni perched on a GSM (Global System for Mobile Communication) transmission booster. The other two pied crows observed at Nyali constructing a nest on a casuarina tree. The pied crow was reported to have been displaced from Mombasa in 1980s (Ali, 2008). They are not aggressive as the Indian house crows. The study was focused on nesting sites of the Indian house crows, and thus, there is no discussion on pied crows.

Conclusions

The method is applicable in rapid identification of nesting sites as 70.76% of the tree clusters identified from the image and observed for nests were found to be nesting sites. The method considered Indian house crow nesting conditions within an urban setup and may not be directly applicable with rural or agricultural areas where the crows may be found.

Generally, Indian house crows locate their nesting sites close to food sources. This is in those places with poor sanitation especially in unplanned residential areas. Poor

Table 4. Tree types, number of trees and nests as per nature of residential.

Residential area		Planned			Unplanned	
Tree type	Mango	Neem	Others	Mango	Neem	Others
No. of trees	46	61	189	418	90	312
No. of nests	124	75	240	1122	119	432

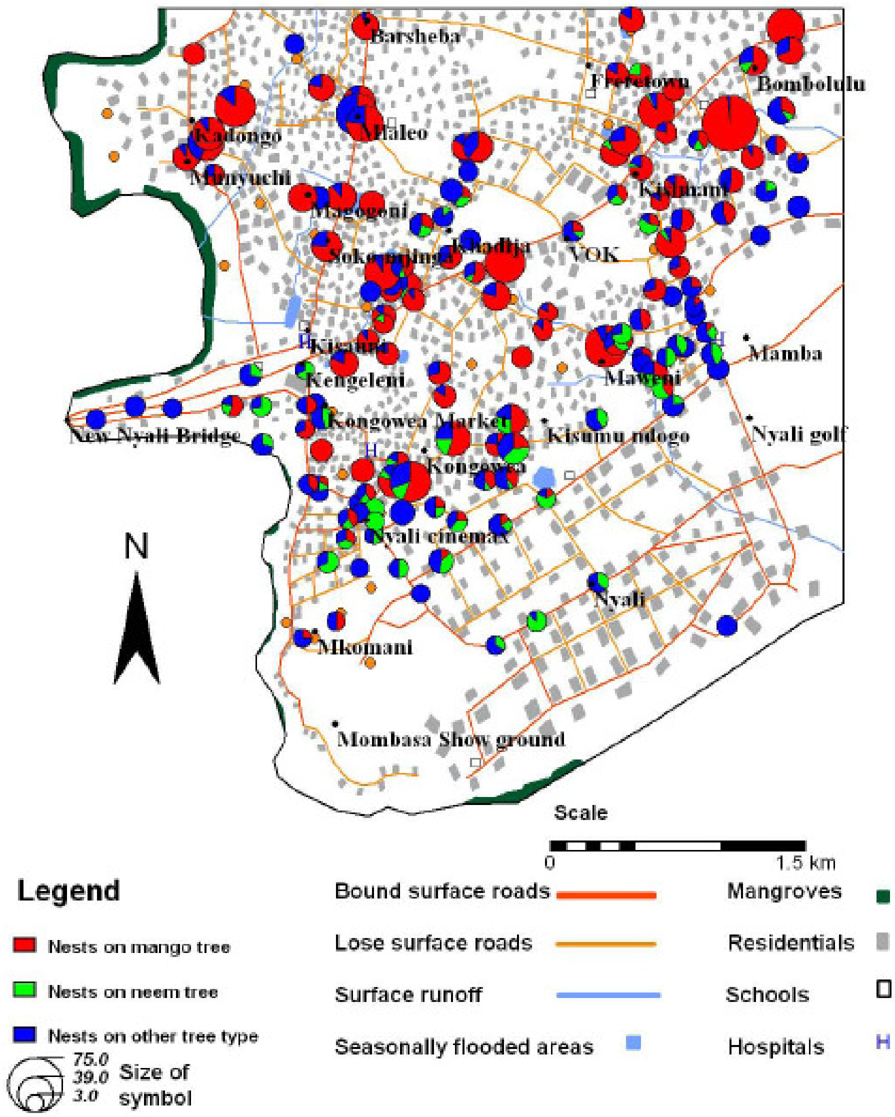

Figure 4. Distribution of nests on preferred nesting trees in the study area.

road network has a great impact on distribution of refuse handling services and monitoring of refuse disposal. The problem is complicated by the haphazard and uncontrolled development of residential areas. 69.46% of nesting sites were located in unplanned residential areas.

The Indian house crows are more adaptive and flexible and are now constructing nests in short/tall trees with small and open crowns especially those close together. Spacing of beautification trees needs to be considered to avoid creation of conducive conditions for nesting.

Indian house crows put more, 2 times, nests on trees with large crowns. If tree crowns are reduced by pruning then the number of nests reduces, hence reducing the number of eggs and nestlings per breeding season. The

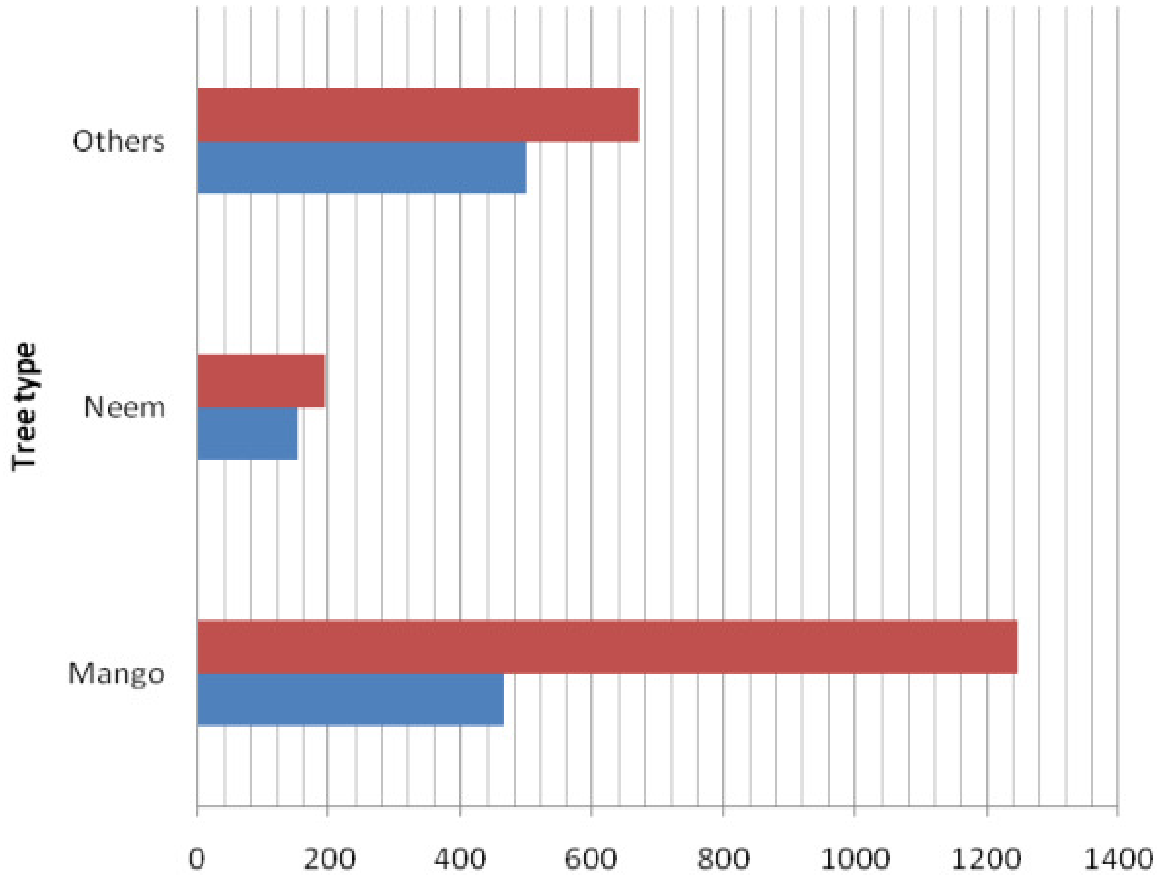

Figure 5. A graph showing tree types and the number of trees and nests.

Table 5. Tree types and number of trees and nests.

Tree type	Num. of trees	Num. of nests
Mango	464	1246
Neem	151	194
Others	501	672
Total	1116	2112

model gives an estimate of the number of nests in a given nesting site, with 76% close to the actual nest count with a ±3 difference.

RECOMMENDATIONS

Residential areas need to be well planned to improve on the monitoring of refuse disposal and distribution of refuse handling services. This is because 69.46% of nest sites were observed in unplanned residential areas.

The environmental cleanliness needs to be improved through public campaigns to control the population of the crows

The local authority should design standard food kiosks and green groceries that do not allow entry of house crows and discourage open air food kiosks.

The public parks and gardens within Mombasa city already provide good nesting sites. With the ongoing beautification programme, more nesting sites are being created by planting flower plants especially trees. Spacing of trees needs to be considered as those close together encourage nesting. The local authority should plant trees unsuitable for nesting and regularly prune tall trees with large crowns and especially during the breeding seasons.

More research can be done into the modeling of the nest counts estimates in a given nest site to improve on the accuracy of the results obtained from the model. There is more room for research to improve the model results as 76% of the model results are close to the actual nest count in a given nest site.

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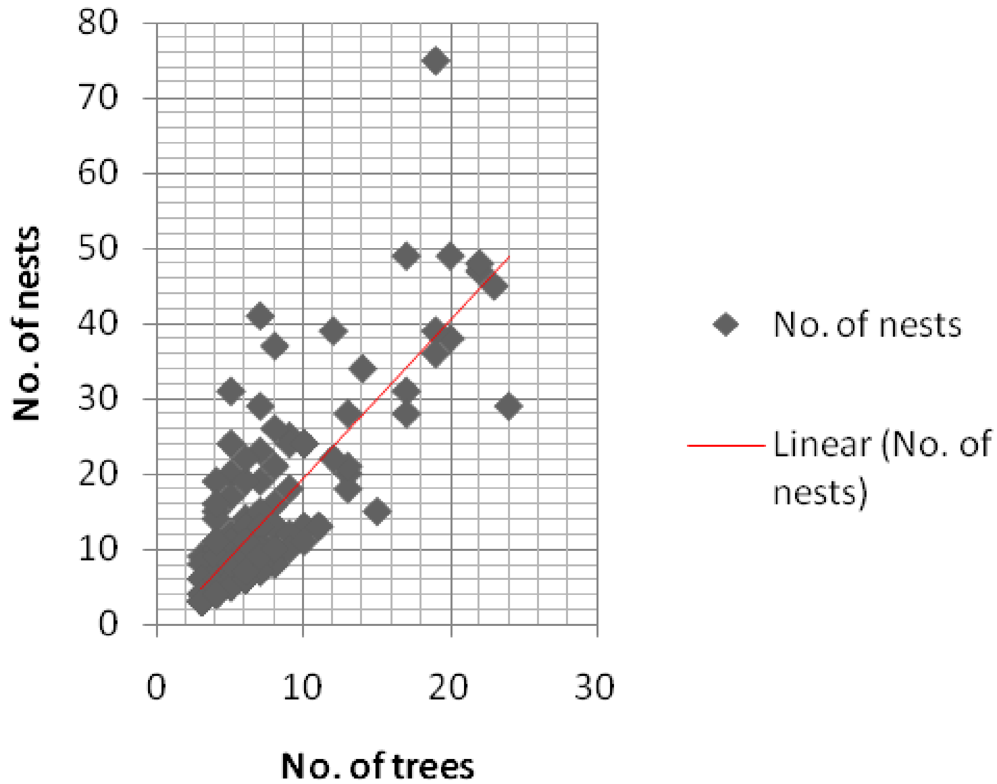

Figure 6. A graph showing the number of trees and nests per nest site

Table 6. Trees with large and small crowns with nests.

Trees with	Number of trees	Number of nests
Large crowns	695	1683
Small crowns	421	429
Total	1116	2112

accomplishing this work, I also thank my supervisor Dr. David Ndegwa Kuria for the academic guidance.

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Appendix 1. A refuse dump at Kongowea (not designated by the Municipal council). Source: Google maps 2009.

Appendix 2. Unplanned residential areas on the left and planned residential area on the right. Source: Google maps

(a) A nest on a pawpaw plant (b) Neem tree with large crown

Scale 5m 10m crown diameter

Appendix 3. Nest on pawpaw tree and neem tree with large crown.