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## EFFECT OF DEVELOPMENT AND HUMAN SETTLEMENT ON BIRD SPECIES RICHNESS, ABUNDANCE, DIVERSITY AND DISTRIBUTION: A CASE OF CHUKA UNIVERSITY AND SURROUNDING AREAS

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### ABSTRACT

Different land use practices affect birds differently and create micro-climates, which avail different resources to birds, thereby affecting distribution abundance, richness and diversity. This study determined how development and human settlement impact avifauna by comparing three habitat sites with differing land use practices (developed/settlement area, farmlands and forest) against diversity, distribution and abundance of birds therein. The study area was near the University and recently developed, while study sites were based on their uses. Data collection used line transects randomly laid on the ground, and opportunistic visual encounters. Species richness of 72 birds resulted, with 40 species in the forest, 34 in the farmlands and 33 in the settled and developed areas. Species diversity was highest in the forest ( $H'=3.45$ ) and was lowest in the settled areas ( $H'=2.91$ ). Species abundance was highest in the farmlands (432 species), followed by settled area (395 species) and forest (198 species). Development in settled area was a major threat to avian community due to habitat destruction and fragmentation, collisions with buildings which obstruct bird movement and road kills. Human settlement and development have a potential of contributing to extinction of native species through habitat fragmentation and loss. Engaging scientists, managers, environmentalists, community and developers will identify ways that development can better incorporate maintenance of ecological integrity and sustainable development.

**Key words:** *Birds, Developed areas, Habitat loss, Land use*

### INTRODUCTION

Biodiversity conservation has widely been viewed as an effort focused mostly on natural areas (Marzruff and Ronald, 2008). This has however been hampered by increase in human population and pursuit of land for agriculture and settlement (Brown et al., 2005). Development especially associated with human settlement has been found to be a major source of land use change throughout the world (Berry, 1990; United Nations Centre for Human Settlements, 1996; Cohens, 1997; Marzluff, 2001) with human settlement contributing to reduction in richness and abundance of birds (Fernández-Juricic, 2000; Mallord et al., 2007).

Land development, human settlement and urbanization poses a great challenge to biodiversity conservation efforts. Land use practices such as for development and conversion of natural habitats to built environments, have over time created micro-climates that offer different resources to birds than previously been the case. The diverse eco-climatic conditions so created produce different living conditions in terms of type, quantity and quality of resources for birds, thus affecting their distribution, abundance and diversity (Sala et al., 2000). Moreover, land use change is known to

be a key driver of biodiversity change (Sala et al., 2000), enabling some species to colonize new habitats and to increase their densities while making others to decline, move towards extinction or to go extinct in some areas (Donnelly and Marzluff, 2006). It has long been recognized that the structural complexity of vegetation influences the structure of bird communities, including the number and diversity of niches available, and therefore local bird abundance and guilds (Wiens, 1989; Díaz et al., 1998; Soi et al., 2012) but human activities have been found to profoundly modify these conditions and consequently affect the composition and abundance of bird species (Blondel & Aronson, 1999; Marzluff 2001; Heikkinen et al. 2004). Urbanization on the other hand is the largest threat to biodiversity worldwide (Ricketts & Imhoff, 2003) as it endangers more species than any other human activity and is one of the leading causes of species extinction (Czech, Krausman & Devers, 2000). When an area becomes urbanized, it's covered with buildings and pavements thus reducing the original vegetated area available to plants and animals, causing both fragmentation and habitat loss. For many taxa species richness decrease with decreasing vegetation cover (McKinney, 2002) and this is true for birds (Goldstein, Gross & DeGraaf, 1986).

Human settlement, land development and Urbanization are expected to grow substantially in coming years due to ever increasing human population and their needs. In developing countries like Kenya, land is valued for human settlement, agriculture and other economic developments, including building of infrastructure. The need for space for building settlement and agriculture has profoundly interfered with required bird habitats. Mt. Kenya East regions and areas surrounding the lower slopes of Mt. Kenya are rich agriculturally and had been intensely farmed. In addition, a section of this region such as areas around Chuka, has of recent times experienced influx of increased human population following the establishment of Chuka University, with the need of additional infrastructures such as settlement areas (housing) and roads. The emerging needs for land coupled with farming activities has greatly changed the bird habitat conditions availability in the area, hence the need to provide a documented effects of all these development activities on birds.

Chuka region, especially areas next to the Chuka University has gone through a series of development/urbanization which is attributed to the fact that Chuka University has seen an increase in population at an approximate rate of 20% annually owing to students' intake every academic year alongside increase of staff members. It is against the above background that the present study is trying to bring into fore the impacts of development ventures and various land use practices on bird species richness, abundance, distribution and diversity in Chuka University surrounding areas. The consequences that results from such human activities on ecological integrity of affected areas need to be understood and documented to assist managers, developers and decision makers on natural areas and environmental matters and to advice on maintenance of ecological integrity in the face of any development activities.

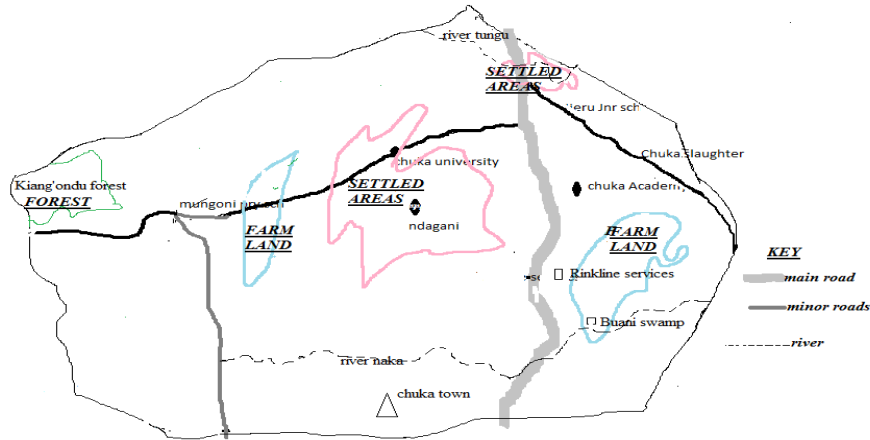
## **MATERIALS AND METHODS**

### **Study area**

This study was carried out in the month of January 2014 in Tharaka-Nithi County. The county is situated in former Eastern province bordering Meru County to the North and North east, Kitui County to the East and South East, and Embu County to the south and south west. Tharaka-Nithi County covers an area of 2638.8 km<sup>2</sup> and has a population of 365 330, with 48% males and 52% women (KNBS, 2009). The county has a population density of 138 people per km<sup>2</sup> and has three constituencies: Tharaka, Chuka-Igambang'ombe and Nithi.

Chuka University is located in Chuka-Igamba-Ng'ombe Constituency on the eastern slopes of Mt. Kenya in Meru south sub-county and has a population of about 13000 with an annual increase of about 15%. It is situated 186 km from Nairobi city along Nairobi-Meru highway at an altitude of 1,500 meters above sea level.

Chuka University is characterized by built and paved environment to greater extent and high population of people. Outside the University is surrounded by settlement consisting mainly of houses of different built and designs. The settlement near the university though interspersed with small farms, is now characterized by more concrete houses built as private student hostels and has seen increased human populations. Further from the university are farms dotted with homesteads with intensive small scale farming around the homes. There is also a section of Mt. Kenya forest (Kiang' Ondu forest) which is an extension of the lower parts of extensive Mt. Kenya forest which was used as a control in this study due to its more or less pristine nature as compared to other study sites.



sketch map of the study area: drawn not to scale

**Figure 1: Sketch map of the study area**

## Study design

### Selection of the study area

The study area was selected due to its proximity to the university, the witnessed development of the area of focus over the years and presence of other study sites that could enable comparison of data collected. This is an addition to the fact that no previous research has been conducted relating to birds in this area and how development could have impacted bird community, and the need to provide a basis for other related research in the coming years.

### Selection of the study sites

Chuka University, settlement around the university, farmlands and the forest was chosen as study sites to fulfill the need for assessment of how development impacts on bird communities. Chuka University at present is an institution that is experiencing development at an increasing rate. This is mainly manifested by the increased number of students and intensity of building structures within the university. Additionally, the growth of the university has seen the neighboring areas developed with more businesses and settlement structures being established. These have resulted to habitat fragmentation and land use changes thus creating a need for research to be done to help assess the impact of this development using bird communities as indicator.

### Selection and laying of transects

After selection of study sites, three transects were randomly placed at each site to enable collection of data. Considerations were made to ensure that all transects cover a kilometer length in each site with consideration of configuration and accessibility of the site. The first transect was laid aided by the compass where the direction of the magnetic north was followed at each site for 1 km. To ensure uniformity of all the transects a specific angle used in the first transect was applied for all other transects within that study site as used by Soi et al., (2012).

### Avifauna identification and categorization

Identification and categorization of birds followed the one in Birds of East Africa (Stevenson & Franshawe, 2011) and Birds of Kenya and Northern Tanzania (Zimmerman et al., 2001). Classification of bird species into forest-dependent categories shall follow that of Bennun et al. (1996). Birds were identified by use of visual traits and vocalization (song and call).

### Research instruments

An established data sheet was used to gather information about birds where visual survey and use of songs and calls to identify birds was conducted and the information so achieved recorded. Oral interviews with community members and area assistant chief was used to help in coming up with the history of the study area in terms of development and remarkable changes over the years since the establishment of the University. Instruments used

included: a bird guide book (Birds of East Africa by Birds of Kenya and Northern Tanzania by Dale A. Zimmerman et al., 1999) a binoculars (bushnell, 8\*25), a Bushnell range finder, a stop watch, data sheets and a pencil.

### **Data collection and methods**

Bird data were collected on Thursday mornings between January and February 2014. This was done during early mornings starting at 6.30 am and ending at 9.30 am. These times was chosen because the birds were very active and vocal, which allowed correct data recording of all bird contacts.

#### **Line transect**

Line transects was used as a primary data collection method and involved the observer continually walking and recording all bird contacts on either side of the transect (Bibby *et al.* 1998). A 2 km long transect was covered at each study site. On both sides of the transect, bird count was done within a width of 50 m were bird presence were noted and counted, bird species noted and a perpendicular distance to the birds were estimated using range finder. All birds seen or heard along these transects was recorded except the one on flight.

#### **Timed species count (TSC)**

In order to obtain a comprehensive bird species list of the study area, 6 TSC (Pomeroy & Dranzoa, 1997) was used to supplement the line transect method. Using this method, data was collected in a span of one hour and species received a cumulative score according to when they were first recorded on each count. This period was divided into ten minutes block and a score was allocated to each block as follows: the first minutes a score of 6 points, second ten minutes a score of 5 points, and the third ten minutes a score of 4 points all the way to the sixth ten minutes which was allocated a score of 1 point. A species that was recorded in the first ten minute was not recorded again in that hour. Counts were undertaken at different times of the day to cover species activity. In total, six counts was made in all study sites (two TSC count in each site and a mean figure for each was calculated). The above methods were also supplemented with opportunistic survey and basic counts. This helped in developing a comprehensive bird checklist within Chuka University and its environs.

#### **Observation and interview with local community members**

In addition, community members who involved local leaders were also engaged in informal interviews to shed more light on development and settlement history of the study sites and likely impacts of settlement on birds and bird community. Personal observation of the researcher was also used for the purpose of ground-truthing. Selection of these members was random. Only the area chief was purposively chosen to give history of the study area.

#### **Study assumptions**

This study was undertaken under the following assumptions that: there was an equal chance to sight a bird during the chosen time, biasness was reduced significantly when lying transects and timing of surveys, transect points were representatively placed, birds directly on each transect line and width or at each point were always detected and birds were always be detected at their initial location prior to their natural movement or movement in response to observer's presence.

#### **Data Analysis**

Species richness was measured by species number and diversity with Shannon-Weiner's index ( $H'$ ) (Shannon – Weiner 1949). It is estimated as  $H' = - \sum (P_i \ln P_i)$  where  $P_i$  is a proportion of the total number of birds belonging to species  $i$  and  $\ln (P_i)$  is the natural logarithm of that proportion, and summation is over all species. Bird abundance was defined as the number of individuals of a given species. Birds were also categorized by forest dependency (Bennun et al., 1996).

## **RESULTS**

### **Species richness**

The total bird species richness in all the study sites was 71. The forest had the highest number of species with 40 species followed by farmlands with 34 species while the settled/developed area had 33 species (Figure 3.1).

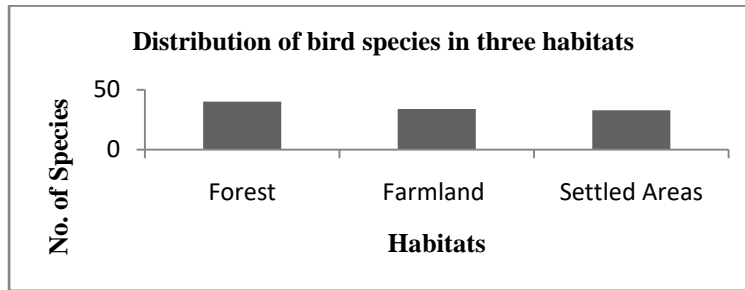


Figure 3.1. Distribution of bird species in the three Habitats

**Species diversity**

The highest recorded diversity was in the forest ( $H' = 3.45$ ) and the settled areas with the least diversity index ( $H' = 2.91$ ) (Figure 3.2).

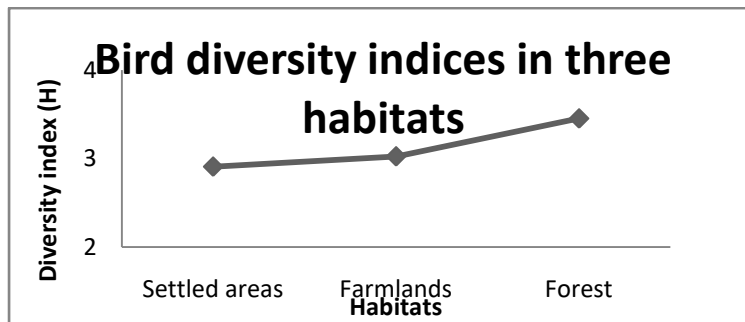


Figure 3.2. Shannon -weiner diversity index in the three study sites

**Bird species abundance**

The farmlands had the highest bird abundance with 432 individuals, settled area followed with 395 birds and forest lowest with 198 birds (Figure 4.3).

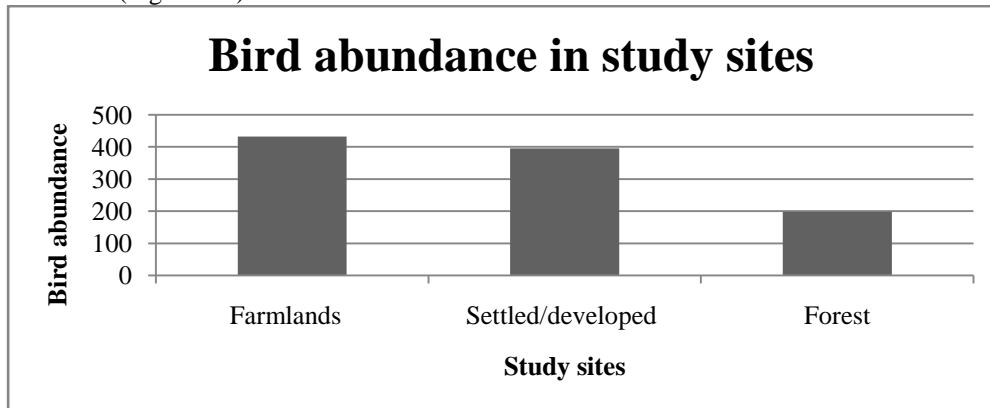


Figure 3.3. Bird abundance in each study site

**Bird distribution**

Passerine birds were mainly found within the settled/developed areas and a few of the group in the farmlands while majority of non passerines were mainly distributed in the forest habitat. Parrot billed sparrow (*Passer gongonensis*), speckled mouse bird (*Colius striatus*), ruppels starlings (*Lamprotornis purpuroptera*) and ring-necked dove (*Streptopelia capicola*) were sighted across all the habitats but with differing abundances. The barn swallows (*Hirundo rustica*) for example were only sighted in the settled areas while Hartlaub Turacos (*Tauraco hartlaubi*), Trumpeter hornbills (*Bycanistes bucinator*), Tambourine doves (*Turtur tympanistria*) and Northern brownbul (*Phyllastrephus strepitans*) were only sighted in the forest. Raptors and especially the black kite (*Milvus migrans*) were sighted across all the habitats. African pied crow (*corvus albus*), house sparrow (*Passer domesticus*) and speckled pigeon (*Columba guinea*) were commonly sighted within the human settlements and rarely seen in the other habitats.

### **Land use practices within the study areas**

Through personal observations and an in-depth interview with the area chief revealed that the area around Chuka University has undergone tremendous development ranging from building construction to infrastructural development. Intensity of roads for example, at the moment is higher above what was there eight years ago when Chuka University was in its initial stages of development. Much land use changes have been observed as land owners convert their lands to settlement areas, hostels and business centers. These have increased the need for road networks to connect one place to the other resulting to further fragmentation of the bird habitats.

### **Impact of settlement and development on bird communities**

In this study, development was given an important consideration in accounting for variation in habitat use by birds. Bird species richness was lowest in the settled/developed areas. This habitat was marked by increased habitat fragmentation, high intensity of buildings and a large area of impervious surface resulting from roads and pavements that connected an area to another. This particular site had the highest human population size of the three study sites owing to the fact that majority of university students and staff members reside here. As such, the intensity of buildings, infrastructure and businesses was highest here. This was in contrast with the forest and farm habitats, where settlements, buildings and infrastructure were lowest.

### **Threats to bird communities**

According to observation made during the study period and information given by community members during data collection, according to them, major threat to birds within Chuka University and its environs is road kills and collisions with building structures

## **DISCUSSION**

Bird species richness decreased when an area becomes urbanized. This is evidenced by the fact that species richness increased as one moved from the settled/developed areas to forest area. This is in agreement with previous urban ecology studies done to evaluate the effect of larger human settlement on bird communities (Chace and Walsh, 2006; Evans *et al.*, 2009; MacGregor-Fors *et al.*, 2009). It agrees with a study done by Krohm (2000) who found a relationship to exist between bird species richness and woody plants where species richness was highest in habitats with a high percentage of woody plants, representing diverse niche for birds. The bird diversity also increased from the settled/developed areas to the forest areas. This can be attributed to the fact that forest still has a pristine environment providing a more or less ideal habitat for most diverse bird species. Low species richness in the settled/developed areas may be attributed to increased development, which has resulted to some form of urbanization, and therefore, increased impervious surface and reduced vegetation cover due to habitat loss and fragmentation. As a result of this also, birds that are urban avoiders will tend to disperse away while urban adapters will start colonizing the urbanized area. Since urban avoiders are mainly the majority in any given habitat, their dispersal from the given habitat results to reduction in species richness.

Tworek (2002) showed similar observation and pointed out that responses of birds to habitat changes differ depending on their life strategies and that some birds benefit from habitat change, while for others it is a principal threat. Urbanization therefore, tends to favour urban adapters for example house sparrows and African pied crows, while it's a threat to urban avoiders. These findings is further supported by a study done by Rottenborn (1999) who studied the relationship between development and the composition of bird communities at multiple sites and included measures of local habitat and the surrounding landscapes in the analysis. He found that bird species richness and overall density were lower at more urbanized sites as were the density of most individual species. James Miller *et. al.*, (2001) on the other hand in his research, "*effects of human settlement on low land areas of colarado*" also found that birds are likely to be affected not only by structural changes to riverine habitats but also by an increase in human population there in.

Species abundance was highest in the farmlands and lowest in the forest habitat even though the forest had the highest species diversity. This finding is comparable to the one by Tworek (2001) who pointed out that even though birds may occur in some non-forest habitats with densities markedly exceeding those in forests, this does not entail greater species diversity. He stated that high population density with low species diversity is attributed to great population numbers of one or two dominant species. Farmland in the current study area are probably attractive to many individual of birds of a given species owing to the presence of food such as seeds from crops or insects owing to suitability of these farms to insects which can attract large numbers of insectivorous birds.

Development in the settled areas was marked by an increased establishment of building structures and increased road networks. Roads are a threat to avifauna as they may turn source habitats into sinks by increasing mortality rates (Mumme *et al.*, 2000). This tends to agree with information gathered from the community members during the data collection where major threat was attributed to road kills and collisions with tall building structures. The presence of the main road and other major road networks in the university, which is frequently used by vehicles and human traffics, is believed to pose a major threat by causing noise thus moving birds further away from the road and by road kills. Noise has been reported to interfere with bird communication leading to their population declines (Reinjnen *et al.*, 1995; Forman *et al.*, 2002). Building structures cause obstruction to birds on flight and through collisions; some are injured to death while some avoid such premises by moving further away from the site consequently contributing to a decline of such species. Czech, Krausman & Devers, (2000) found that urbanization is a major factor that contribute to species extinction. This is because urban development produces some of the greatest local extinction rates and frequently eliminates the large majority of native species (Vale and Vale 1976, Luniak, 1994, Kowarik 1995, Marzluff, 2001). Urban-gradient studies showed that, for many taxa, for example, plants (Kowarik, 1995) and birds and butterflies (Blair and Launer 1997), the number of nonnative species increases toward centers of urbanization, while the number of native species decreases.

The increasing development of the region has resulted to an increase in human population. This is evidenced from the progressive growth of the University resulting to increased number of students and staff members besides the community members who operate businesses. Increase in human population is a source of threat to avian community due to disturbance and persecution. This is similar to findings by Fernandez-Juricic (2000) and Mallord *et al.* (2007) who from their research on local and regional effects of pedestrians on forest birds in a fragmented landscape found human presence to reduce richness and abundance of birds due to human disturbance caused by their presence, their activity levels and domestic animals. Bird decline in urbanized habitat have been attributed to vulnerability of small birds to predation from large species in addition to the fact that small birds cannot compete with large birds for resources.

Land use changes over the years have resulted to land fragmentation as land owners subdivide their lands to cater for the growing need of settlements and establishment of businesses. According to McCallum & Dobson (2002), fragmentation of habitats affects the connectivity in the landscape thus affecting ecological processes such as migration and dispersal thus posing a threat to avian communities. In Chuka University and surrounding areas, land use change has been attributed to the fact that as the university grows, more building structures have been established either as lecture halls or offices. In addition, the community has been increasing their settlement structures to cater for the increasing number of students resulting to closure of dispersal corridors for birds, and therefore collisions with the building structures. Increase in road networks connecting one location to another especially within the settled areas and the busy meru-isiolo highway have resulted to avian disturbance and road kills. As a safeguard measure, much of the avian community tends to avoid the roads. Alternatively, infrastructural development is in its self a threat to avian composition as it tends to reduce the original vegetated area resulting to reduction of bird species. Besides disturbance, birds tend to avoid the roads and places with high human settlement due to noise.

In the farmlands, land cultivation and subdivisions pose a threat to avian communities. This was mainly due to loss of natural habitat and fragmentation. A few of the avian communities were reported to be persecuted by the community members since they preyed on their chicken while some grainivorous posed a nuisance to the community members by feeding on their grains in the farms. This had human persecution as a form of avian threat. Farmers had also increased their cultivation areas for purpose of increasing their yields. This results to loss of the natural habitat hence contributing loss of bird species agreeing to studies by Siriwardena *et al.* (1998) on the relationship of farmland birds and agriculture, who found modern day agricultural practices to cause decline in population of many farmland bird species. Raptors represented by goshawk had the lowest relative abundance in the farmland. This can be attributed to human persecution since raptors are considered a nuisance by farmers due to preying on their poultry. Due to their ability to explore resources across all the habitats, generalists' birds were present in all habitats for example, speckled mouse bird, while some species due to their specialized use of resources (such as Hartlaub turacos and Hornbills) could only be located on specific habitats and never recorded elsewhere.

The presence of resources across habitats resulted to an overlap of resource use in more than one habitat with the result of some birds being sighted across all the study sites. Raptors for example, have home ranges that extend beyond the urban boundary and therefore do not need to meet all their ecological requirements within urban areas

thus raptors were found across all the habitats under study. The black kites were common in the settled areas during the time of study but were also recorded in the farmland. Their presence in both habitats is attributed to its dietary requirements; in the settled area it can prey on chicken from homesteads and the same is possible in the farmlands.

In the settlement areas, urban exploiters are common due to their ability to colonize such a habitat in pursuit of food resources especially as seen in house sparrows and the African pied crows. In addition to their foraging behavior, human settlements have been shown to provide ideal conditions for invasive and exotic species due to high levels of disturbance which tends to favor non-native species at the expense of native species. The removal of native species and their replacement with non-native species drastically alters the composition of urban biological communities; the ecology of cities is therefore very different to the surrounding undeveloped areas (Hardman, 2011).

Overall, Bird diversity was Highest in the forested habitat and lowest in the settled areas. This is attributed to the complexity of forest habitat with differentiated niche hence ability to provide varied resources to varied species of birds. Bird species abundance was highest in the farmland and lowest in the forest as most bird species move in large groups which increase the abundance of any given species. Development results to tremendous changes in habitats and vegetation complexity which produces gradual decline of species richness and diversity. This is because development results to extinction of local native species while creating a conducive habitat for invasive bird species, urban invaders and exploiters to increase in numbers.

Scientists, managers and environmentalists in a university setting or any urbanized setting, need to work closely with home owners and developers to identify ways that urban development can better incorporate the maintenance of ecological value. This can be addressed in part by designing and managing landscapes in an ecologically sensitive fashion. Retention of open spaces and natural habitats for example in a university, will generally improve the ability of urbanizing areas to contribute to biodiversity conservation besides urging the communities to maintain native plant communities. Cluster developments help reduce road construction hence allow access and space for more natural areas.

The public should be well informed about conservation through mobilization programmes and community sensitization programmes as this is an important application of promoting effective conservation of native species.

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