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URBAN ECOLOGY OF DELHI: RELATIONSHIP BETWEEN BIRDS AND TREES IN URBAN GREEN SPACES AND THEIR MANAGEMENT

Minor Project Thesis

Submitted by

ARSH MARWAHA



For the partial fulfillment of the

**Degree of Master of Science in
ENVIRONMENTAL STUDIES AND RESOURCES
MANAGEMENT**

Submitted to
Department of Natural Resource
TERI University

August 2015

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DECLARATION

This is to certify that the work that forms the basis of this report “Urban Ecology of Delhi: Relationship between birds and trees in urban green spaces and their management is original and has been carried out by me at PSI Energy under Mr. Gaurav Shorey.

I certify that all sources of information and data are fully acknowledged in the project report.

Arsh Marwaha

M.Sc. Environmental Studies and Resource Management

1408 MNR

CERTIFICATE

This is to certify that the project work entitled “**Urban Ecology of Delhi: Relationship between Birds and Trees in Urban Green Spaces and their management**” has been submitted by Mr. **Arsh Marwaha** as a part of his Minor Project for the period of May-July 2015 under PSI Energy. It is an original work carried out by the student under my supervision and this work has not been used in any other publication.

SIGNATURE OF THE SUPERVIOR

Name: Mr. Gaurav Shorey

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I would like to extend my heartfelt gratitude to PSI Energy and Mr. Gaurav Shorey for showing the trust in me to carry out such a huge task in a short period of time, giving me the independence to completely mould it in a way I wanted to and for guiding me all throughout the study. I would also like to thank my professors, Dr. Joachim M. Schmerbeck for laying down the basis of the study with me and helping me get through the initial stages of planning the structure of the study and showing me the correct way to approach the results; and Dr. Sudipta Chatterjee for helping me to finalize the results, thus presenting them in a manner that would clearly answer the objectives. I would also like to thank the members of Delhi Bird Photographers for their constant support and information sharing that helped me to steer this study in a better direction.

Arsh Marwaha

ABSTRACT:

*Cities are generally depicted on the basis of their demographics, socio-economic status, political issues, pollution levels, traffic density, water quality and green cover. In the green cover lie areas of urban green spaces, which are generally parks, gardens or small woodlands. They could be privately or publically owned. A lot of development takes place by compromising on green spaces in and around cities, which affects not only the loss of just green cover, but also animal biodiversity. Many of them are not managed properly and have exotic species while some have invasive like *Prosopis juliflora* (Vilayati Kikar). With invasive like kikar, known to have negative correlation with birds and other exotic tree species growing, architects and landscape designers are now looking to manage these establishments such that they hold native vegetation, attract biodiversity, especially avian and can help in controlling the pollution levels. Albeit few and far between, the studies done correlate bird diversity to the tree diversity, but the basis of the correlation is not established. This study looks into 4 major urban green spaces in New Delhi and identifies the major native trees suitable for planting in large developments and in urban areas that relates to bird diversity and also evaluates the bird diversity and composition patterns showing relationship of individual trees with various bird species. Birds are important to the ecosystem due to their role as pollinators, plant and animal distributors and biological control agents. From the result we would conclude the right species of trees to be planted in urban infrastructures which would attract biodiversity. Smart cities mission launched in India aims to develop models such as walk to work and energy saving. Proper urban plantations can provide appropriate solutions for it.*

Key Words: Urban Ecology, Native tree species, bird diversity, bird-tree relationship, large developments, Smart cities

INTRODUCTION

Urban Ecology is an interdisciplinary subject that deals with the interactions among the natural and the anthropogenic systems and have roots in geography, urban planning, landscape architecture, climatology and ecology (Marzluff et al, 2003). In Urban Ecology, urban habitats and various environmental processes are analysed at various scales, be it local, regional or national by different fields of natural sciences, having a wide variety of disciplines (Herbet Sukopp, Berlin School of Ecology). Urban areas have dedicated green spaces that usually serve as a habitat for various plant and animal species, depending upon the size and various conditions like stress of noise, air pollution. The biodiversity of such green spaces increases as the size of the green space increases for the linkage is direct between the biological diversity, function of the ecosystem and sustainability of natural and managed ecosystems. Heterogeneity increases diversity (Karr, 1971) as homogenous plant diversity can trigger extinction. Human demographic expansion into the cities have taken over the much green cover and such spaces are rarely now left. New Delhi on the other hand has over 3000 green spaces (Khera N, 2009) but most of them are not managed properly. Some have really homogeneous populations of invasive Vilyati Kikar that grows extremely fast under which no other tree or shrub or grass can survive and is prone to browsing. The tree is now an invasive species and competes with the natural vegetation. Its root goes down deep in the soil and degrades it. Another tree common in urban environment in the eucalyptus tree. This tree draws a lot of water from the ground and threatens the ground water table.

Over the years a lot of developments have taken place in Delhi, with the highlights being the building of the Metro, T-3 terminal of the Indira Gandhi International Airport and the numerous expressways and highways. These developments were made on compromising the green cover. Approximately 33,000 Hectares of green cover was lost between 1999 and 2012 and NCR expanded to urban areas by 96,000 hectares and it was proposed that expressways were to be lined by 100m wide green buffer zones, while 60m and 30m green belts were proposed along national and state highways.¹ Such compensatory planting is done without keeping in mind the nature of the vegetation and whether it will attract any biodiversity or not. The Ministry of Environment and Forests states that compensatory afforestation is essential for forests now used for non-forest uses and shall be done on an equivalent area. It also proposes that for areas less than 1 hectare, no compensatory afforestation is required but the plantation of ten times the number of trees felled has to be carried out.² What is doesn't state is what kind of trees are to be planted and in what areas. Planting a homogenous forest wouldn't be good enough as it will not attract much biodiversity as the study Neeraj Khera did on urban spaces of Delhi states that the bird diversity increases with the increase in diversity of woody species of trees.

¹ The Times of India, Green cover equals to 23% of Delhi lost in 13 years, TNN Jul 4,2013

² Moefrolko.org/rule3.htm

Urban green areas are important because they not only add aesthetic value, but aids in environmental management like reducing air pollution and attract faunal diversity. Birds are an important part of this faunal diversity as their major role as agents of dispersal, biological control agents and as bio-indicators. As David Sibley rightly says “*Birds make any place a chance for discovery, they make garden seem wild, they are a little bit of wilderness coming into a city park and for a bird watcher every walk is filled with anticipation what feathered jewel might drop out of the sky next?*”³ In order to keep the common bird species common, one must keep the common tree species common as well. Furthermore birds are important to economies too as they act as huge businesses. As many as 46 million Americans are actively involved in bird watching and it has become a multi-million dollar business and provides over 19,000 jobs⁴. India too benefitted from birding as approximately USD 25million (INR 113crores) were contributed to the economy in the year 2009-10.⁵

Various green building consultancies led by architects and landscape ecologists are now expanding into the vegetation cover in and around the large developments. GRIHA- Green Rating for Integrated Habitat Assessment, a joint venture of TERI and Ministry of New and Renewable Energy is a national rating system for Green buildings in India is now focusing on the vegetation aspect of the urban settlements which would include the sprawl of native tree species such that they attract avian diversity which largely have been overlooked due to the prime importance given to the human habitation.

The purpose of this study is to find such native and naturalised trees that can be planted and grown in urban environment such that they attract a majority of birds. Birds depend on trees for food, nesting, and socialization or simply to perch. Relationships between birds and trees can be of mutual benefit or can be commensalism, amensalism, and even antagonism. With these native varieties of trees, one would understand their importance and moreover, aesthetic appeal can also be enhanced via using such trees, opposite to common belief that is based on the attractiveness of the exotics.

The smart city concept aimed by the Modi Government wants to create better cities that are well shaded with the help of avenue trees and so that people can enjoy walk to work and save on energy. A proper plantation strategy needs to be developed for this to happen. It would include a thorough study of the soil types of various part of Delhi at various places, the right vegetation to be used and the resources that the trees use. Coupled with their interrelationship with bird diversity, the smart city concept can really prosper.

³ <http://www.keepthemflying.org/why-birds-matter/> David Sibley, Author

⁴ <http://www.stateofthebirds.org>

⁵ <http://www.kolkatabirds.com>

AIM & OBJECTIVES:

Aim: Urban Ecology of Delhi: Relationship between Birds and trees in Urban Green Spaces and their management.

The study focuses on the establishing the basis of the correlation between certain trees species to the birds in urban green areas and finding the correct trees to be planted in urban environments, may it be parks, garden or in large developments that would help in increasing avian diversity.

Objectives of the study include:

1. To evaluate bird diversity, structure and composition patterns in local urban green spaces.
2. To establish relationship between various trees species with various bird species.
3. To propose proper Tree plantation strategy that helps in improving air quality and also attracts bird diversity.
4. To know about the general perception of people regarding urban green spaces using questionnaires.

METHODOLOGY:

1. Study Area: The national capital, with 6352 persons per sq. km, New Delhi is the second most populated city in India. The coordinates of Delhi are 28.6139° N, 77.2090° E and lies in the northern part of India bordering Haryana and Uttar Pradesh. At present there are more than 16 million individuals in Delhi (Census 2011 provisional report) which causes a lot of stress on the 1483 square kilometre of land it rests upon. River Yamuna passes through the city and Delhi is divided into various ridges that form part of the Aravalli range constituting the maximum green cover. Extreme weathers conditions are prominent as the climate is tropical steppe type. Summers can be as hot as 45 degree Celsius while winters can be as cold as 5 degree Celsius. Rains are erratic but the monsoon season usually starts from July and goes till September (Maps of India). There are some showers in the month of January and February as well.

The vegetation is mixed kind due to the fact that the ridge remains deficient of rainfall for most of the year and is overgrown by *Prosopis juliflora* (Vilyati kikar) while the areas near Yamuna show a rather mix type of vegetation ranging from herbs, shrubs to medium and large trees. Champion and Seth (1968) classified the ridge forest as Tropical Thorn Forest and more especially as Semi-arid Open Scrub. Apart from these remaining woodlands, Delhi holds almost 3000 urban green spaces (N. Khera, 2009) which include parks and gardens. Some of them are very rich in tree diversity and harbour a good diversity of animal species

especially avian and insects. Lutyens' Delhi is home to a wide range of avenue trees planted during the British raj and have some really old specimens of Jamun (*Syzigium cumini*), Neem (*Azadirachta indica*), Arjun (*Terminalia arjuna*), Peepal (*Ficus religiosa*) and Pilkhan (*Ficus virens*) as mentioned in Trees of Delhi by Pradip Krishen.

Out of the many urban green spaces, 4 locations were chosen namely- Lodhi Garden and District Parks of Hauz Khas, Janak Puri and Paschim Vihar. The parks were inspected for the general diversity of trees present and their interrelationship with birds was established. Apart from regular visits to these areas, other areas such as Arvavali Biodiversity Park, Okhla Bird Sanctuary, Sanjay Van, Deer Park, Kamla Nehru ridge and National Zoological Garden were also visited to have a better understanding of the relationships.

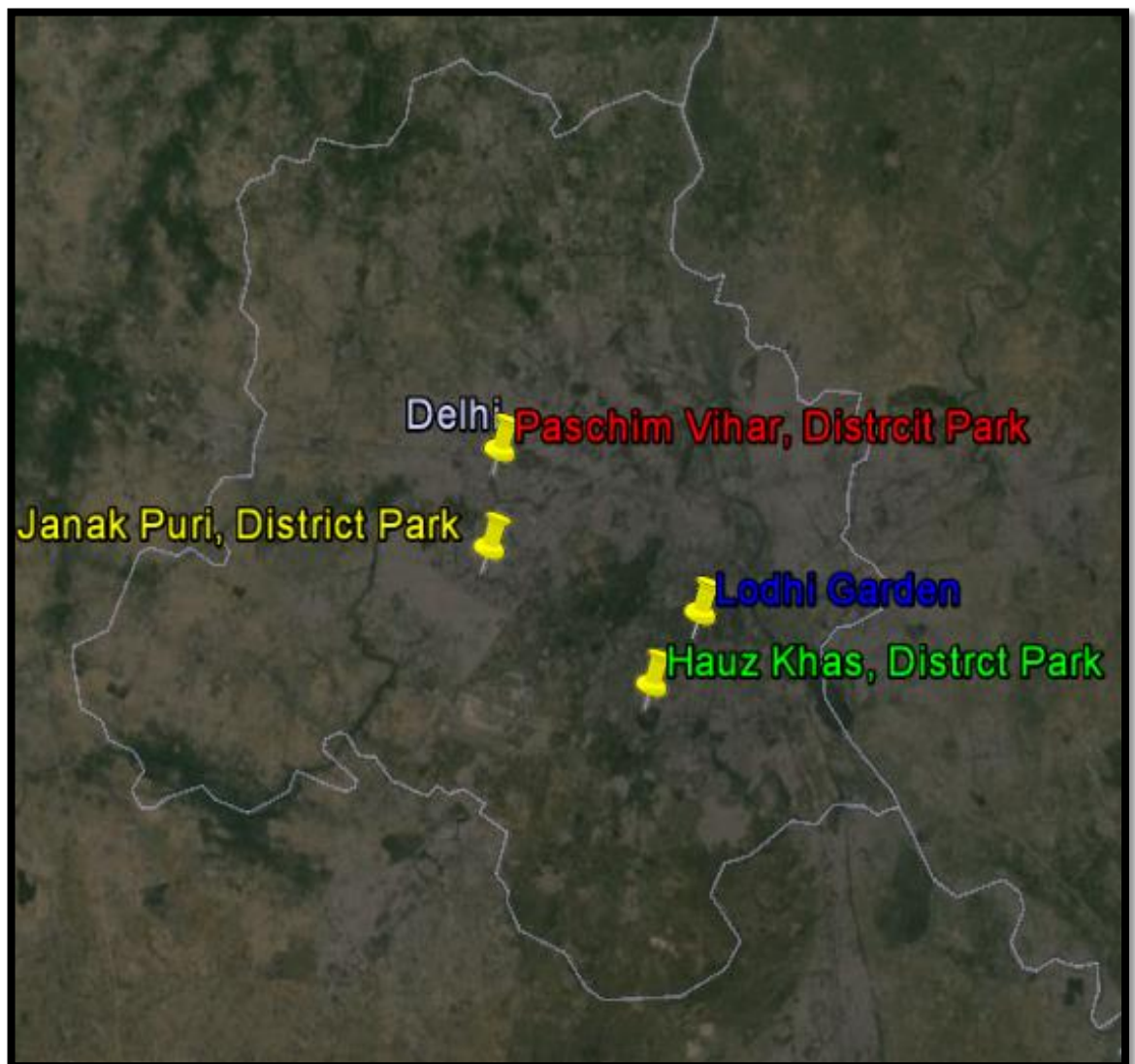


Image 1: A Google Earth image of Delhi showing the four main locations.

2. METHODS: Over the course of the study different trees were studied via visual observation and photographic capture techniques and behavioural studies were done of the birds that used to visit the trees. Bird behaviour included feeding, nesting, socialization and perching. From the observations a list of trees was made that were native or naturalised to the region of Delhi and attract maximum avian species. The study was conducted during May-July 2015 keeping in mind the average temperature of the day. Studies were not conducted during rainy days to maintain a coherency of data. The time of the study was 5am to 9am in the morning and 4pm to 7pm in the evening. Ideal trees were selected and observed with binoculars from a distance and photographs were captured. The tree studied was present on at least 3 locations out of the four selected and was observed. During observing an interaction or various interactions, the tree was focused as the main object and various birds coming to it and their activities were photographed and noted. A list of trees observed was also made as seen in Table 1 and the location of the trees selected, its features, shoot and root system were studied to determine the perfect location for plantation strategy.

Bird survey was made using Point count method (Swedish Environmental Protection Agency, 1978) at 5 random sampling points along a route. 3 such routes were established in Hauz Khas, Janak Puri and Paschim vihar district parks 5 were established in Lodhi Garden due to its larger area and more diverse vegetation. Only the species of the birds were recorded and not the number. Each bird seen or heard was observed for at least 5 minutes and birds that flew from above were not recorded. Many birds presented quite unique opportunities as it was breeding season for them hence breeding plumages of certain birds were seen and recorded.

To know about the general behaviour towards urban green spaces and the relationship that birds have with trees, four different kinds of surveys were carried out which included a group of students from school level to graduates, fellow birders, general public who visited the park and architects and landscape ecologists. Based on the questions asked about trees, birds and the urban environment the results were formulated.

Table 1: List of Trees observed in the four different locations.

S No.	Scientific Name of the Tree	Common Name of the Tree	LOCATIONS			
			LG	HK	JP	PV
1.	<i>Acacia nilotica</i>	Babool				
2.	<i>Albizia lebbek</i>	Siris				
3.	<i>Alstonia scholaris</i>	Saptarni				
4.	<i>Azadirachta indica</i>	Neem				
5.	<i>Bauhinia purpurea</i>	Kanar				
6.	<i>Bombax ceiba</i>	Semal				
7.	<i>Callistemon laceolatus</i>	Bottle Brush				
8.	<i>Caryota urens</i>	Fishtail Palm				
9.	<i>Cassia fistula</i>	Amaltas				
10.	<i>Casuarina equisetifolia</i>	Whistling pine				
11.	<i>Celis tetrandra</i>	Khirk				
12.	<i>Chorisa speciosa</i>	Floss-silk				
13.	<i>Dalbergia sissoo</i>	Shisham				
14.	<i>Delonix regia</i>	Gulmohar				
15.	<i>Drypetes roxburghii</i>	Puntranjiva				
16.	<i>Ehretia laevis</i>	Chamrod				
17.	<i>Eucalyptus camaldulensis</i>	Red river gum				
18.	<i>Eucalyptus tereticornis</i>	Forest red gum				
19.	<i>Ficus benghalensis</i>	Banyan				
20.	<i>Ficus palmata</i>	Anjeeri				
21.	<i>Ficus racemosa</i>	Goolar				
22.	<i>Ficus religiosa</i>	Peepal				
23.	<i>Ficus virens</i>	Pilkhan				
24.	<i>Grevillea robusta</i>	Silver Oak				
25.	<i>Holoptera integrifolia</i>	Chudail Papri				
26.	<i>Lagerstoemia speciosa</i>	Jarool				
27.	<i>Magnifera indica</i>	Mango				
28.	<i>Mitragyna pavifora</i>	Kaim				
29.	<i>Milleta pinnata</i>	Karanj				
30.	<i>Phoenix sylvestris</i>	Khajoor				
31.	<i>Pithecellobium dulce</i>	Jungle jalebi				
32.	<i>Plumeria rubra</i>	Frangipani				
33.	<i>Polythalia longifolia</i>	Ashoka				
34.	<i>Prosopis cinearia</i>	Jhaant				
35.	<i>Prosopis juliflora</i>	Vilyati Kikar				
36.	<i>Pterospermum acerofolium</i>	Kanak champa				
37.	<i>Pterygota alata</i>	Old coconut				
38.	<i>Roystonea regia</i>	Royal Palm				
39.	<i>Schleichera olesia</i>	Kusum				
40.	<i>Senna siamea</i>	Kassod				
41.	<i>Syzygium cuminii</i>	Jamun				
42.	<i>Tamindus indica</i>	Imli				
43.	<i>Thevetia peruviana</i>	Yellow oleander				
44.	<i>Terminalia arjuna</i>	Arjun				
45.	<i>Zizipus mauritiana</i>	Ber				
Key: LG: Lodhi Garden; HK: Hauz Khas; JK: Janak Puri; PV: Paschim Vihar				PRESENT		ABSENT

	Categories (in %)					
PLACE	Car	Fru	Gra	Ins	Nec	Omn
LG	20.5	8.8	8.8	12.5	2.9	35.2
JK	10.5	10.5	15.7	21	5	36.8
HK	16.1	9.6	9.6	22.5	3.2	38.7
PV	23.3	6.6	10	20	3.3	36.6

Key:
LG- Lodhi Garden **JK**- Janak Puri (District Park)
HK- Hauz Khas (District Park) **PV**- Paschim Vihar (District Park)

Car-Carnivore; **Fru**-Frugivore; **Gra**-Granivore
Ins-Insectivore; **Nec**- Necritivore; **Omn**-Omnivore

For Objective 2

Out of the 45 trees listed above in Table 1, 10 species stood out to be attracting most bird diversity. Moreover bibliographic research also uncovers the various other roles that the trees have. They help in maintaining the microclimate, act as fully functional ecosystems, provide sound filtration, act as wind break mechanisms and improve the quality of soil by the inflow of the nutrients from the roots of these trees to the soil. The 10 trees are:

1. *Azadirachta indica* (Neem)
2. *Bombax ceiba* (Semal)
3. *Ficus benghalensis* (Banyan)
4. *Ficus racemosa* (Goolar)
5. *Ficus religiosa* (Peepal)
6. *Ficus virens* (Pilkhan)
7. *Mangifera indica*
8. *Pithecellobium dulce* (Jungle Jalebi)
9. *Syzigium cumini* (Jamun)
10. *Terminalia arjuna* (Arjun)

Azadirachta indica (The Neem Tree)

Neem, an evergreen tree called arista in Sanskrit means perfect, complete and imperishable (K. Girish, 2008). Neem has been used in India for centuries for its medicinal properties referring it as one solution to thousand problems (Tomar L. et al, 2011). Apart from its use in medicines and cosmetic products, Neem is one of the most important tree species when it comes to ecosystem management. A Neem tree can itself act as a whole ecosystem and its fruits and flowers attract many birds. Some birds are also dependent on the Neem indirectly as it feeds on the insects living on it as in the case of Oriental Magpie Robin found out during the field study. It also filters noise and controls SPM concentration in air. Moreover the rate of photosynthesis is high in neem hence the amount of oxygen it gives out is much more than other trees. It also prevents desertification, soil erosion and temperatures under neem tree are found to be at least 10 degree less (I.P. Ogbuewn et al, 2011), hence it's a must in any urban green space.



Image 2: A rose ringed parakeet's nest on *Azadirachta indica*

***Bombax Ceiba* (Semal)**

It is a large deciduous tree that blooms in the month of February and last till march⁶. Semal is enjoyed in food items and also has medicinal qualities. (Natesh S., NII). The flowers especially the nectar in them and the fruit attract birds. Sunbirds are particularly attracted to these trees. Pollination is achieved also mainly through birds. Semal trees grow tall and have large spreading branches, which makes them ideal for bird nests and perching.⁷ A lot of activity can be seen and heard in a semal grove. Considered as a boon the environment it also helps in reducing pollution as they tend to have moderate sulphur dioxide efficacy (Farooq et al, 1988) and helps in maintaining the balance in the ecosystem.⁸ Moreover the tree can endure drier climate and doesn't utilize much of the resources. In an urban setting semal tree can be very useful as their dried leaves and flowers make excellent quality of vermicompost (Sannigrahi, 2009).



Picture 3 and 4: *Bombax ceiba*, a black drongo perching (Left) and a grey Hornbill's nest (Right)

***Ficus benghalensis* (Banyan Tree)**

The Indian National Tree declared by the Republic of India, *Ficus benghalensis* is probably one of the most useful trees as every part of it utilized in some way or the other. It is considered sacred (Simoons, 1998) in India and worshiped at many places. The Banyan Tree has been widely described in the Indian Mythology. Distinctive by its aerial roots, the Banyan has a very large trunk and crown. The immenseness of the tree itself attracts birds (Manna, 2010) for it acts as excellent tree for nesting and perching. The aerial roots are a particularly a favourite spot for birds to perch and eat as in case of Asian Koel and Hornbills. Juicy figs of the banyan are a part of diet of many and as many as 8 different species of birds were observed at a time on a single tree during the field visits. Its large crown is also an ideal spot for predator birds to perch and look out for prey. The Banyan tree also provides excellent shade and acts as a sound and wind barrier. The tree is also prone to dust and smoke. (CPWD- A Handbook of Landscape, 2013)

⁶ Trees of Delhi, Pradip Kishen page 212

⁷ Institute of Forestry, Pokhara

⁸ Pharmacology of *Bombax ceiba* Linn., Chapter 6 Ecological importance and Need for conservation, V. Jain and S.K. Verma, page 73



Picture 5: Sheer size of *Ficus benghalensis*

***Ficus Racemosa* (Goolar)**

Known as cluster Fig, *Ficus racemosa* is very distinct in nature as the figs of this ficus hang from the trunk of the tree. A large tree with a good crown, like *Ficus benghalensis*, Goolar provides several spaces of shade and nesting. Moreover, the figs are foraged upon by many birds (Cooper & Cooper, 1994). Besides that like other ficus, goolar has functions in medications and Ayurveda.

***Ficus Religiosa* (Peepal)**

The sacred fig is a large semi-evergreen tree that holds real importance in India. The tree is worshipped in many religions and is quite common in urban green spaces. They are very conducive to Delhi's environment and can grow in any soil type. Moreover like other ficus species, peepal has excellent medicinal value curing epilepsy, inflammations, infections, diabetes etc (Singh 2011). Not only *Ficus religiosa* presents itself as a great urban tree, it has many uses such as controlling environmental pollution and preventing soil erosion⁹. Furthermore it is drought resistant and is extremely tolerable to dust and smoke (CPWD- A Handbook of Landscape, 2013). Birds love to feed on figs and also help in seed dispersal (Starr, 2003). During breeding season of Asian Koel, many koels at one time can be seen perching on the peepal tree. Due to the juicy figs and a large crown, which means good places to perch and nest, *Ficus religiosa* is a must in every urban green space.

⁹Sustainable Building - Design Manual: sustainable building design practices

Ficus virens (Pilkhan)

A medium sized tree known as white fig is a common avenue tree seen in Delhi. Like the banyan it also has aerial roots but is not wide spreading. For this bird-dispersed ficus (Lambert1991), birds are extremely important and vice versa as in major parks of Delhi, pilkhan figs form a staple diet of many birds including hornbills, parakeets, barbets and mynas. Nesting of mynas and parakeets can also be seen. *Ficus virens* is ideal fig for boundaries as the crown is not large and the aerial root do not spread far apart hence, it cannot damage the building or fences. Ecological aspects of this tree include medicinal value and control of noise levels. Moreover the new leaves are red in colour and peak at least twice a year which gives a great aesthetic value.



Picture 6: Hornbills perching and socializing on *Ficus virens*

Mangifera indica (Mango)

It is a species of mango found in India and the fruit is the national fruit of India rejoiced by millions (Grin, 1997) thus being an important dietary part on many cuisines around the world. Tall trees, usually evergreen and provide shelter to a lot of birds and shade to humans. The fruit attract many species of birds, insects and bats (Bally, 2006). Birds rejoice the pulp of the mango hence many species of birds can be seen at once on mangifera indica especially parakeets, mynas, barbets, bulbuls and babblers. During breeding season it also acts as an excellent nesting tree due to its dense canopy. Apart from its relations with birds mango adds ornamental value to the urban green space, it is a good wind breaker and holds the soil firmly.

Pithecellobium dulce (Jungle Jalebi)

An introduced species in India now has become naturalised over the years, this tree has settled in the weather of Delhi very well. A thorny tree acts excellent around the hedges. The ornamental value of this tree is high as not only the leaves of this tree look striking different; the flowers when in bloom are as sight to watch. Apart from its leaves and flowers, what mainly attracts biodiversity to it is the fruit. The pulp is sweet and attracts many birds and is one of the favourite fruit of the parakeet. The tree is well adapted to dry areas such as

Mexico where it originated hence it requires very less maintenance and resources. It is also reportedly useful in medicines curing for dysentery and tuberculosis (Hartwell, 1967–1971). It is nitrogen fixing (Brewbaker, 1992) therefore it helps in the soil maintenance and is heat and drought resistant. *P. dulce* is also used as shaped avenue tree in main countries (Streets, 1962).



Picture 7: Parakeet feeding on fruit of *Pithecellobium dulce*

***Syzigium cuminii* (Jamun)**

The jamun is common tree in Delhi, evergreen and slow growing. It is used as an avenue tree in Delhi and is common in urban green spaces. In some areas it is often planted along the boundaries and parking lots which sometimes pose a problem as the fruit droppings soil the area and cannot be naturally decomposed over roads or asphalt. It attracts a lot of bird diversity (Sinu, 2012) due to its larger size and fruit. Nesting places are equally good in this tree and bird vocalization can be heard greatly during early dawn hours. In urban greenspaces Jamun usually acts as a good shade tree and is considered sacred according to Hindu mythology. It also finds its usefulness in medicine¹⁰. The Jamun though slow growing is very well adapted to Delhi's climate and can sustain extreme heat and cold utilising minimum resources.

***Terminalia arjuna* (Arjun)**

Like the Jamun, the Arjun tree is also seen as an avenue tree in Delhi, especially in the Lutyen's Delhi and is also seen in parks and gardens. It is an excellent tree for noise reduction and is tolerant to dust and smoke (CPWD- A Handbook of Landscape, 2013). The tree has a dense canopy and hence is favoured for nesting. Mynas, hornbills, sparrows, crows, oriental magpie robins and babblers have been photographed nesting on *Terminalia arjuna*, moreover the flowers are foraged upon by many birds. Arjun is planted near wells or where ever there is underground storage as it helps in water purification. It is a very effective tree for erosion control, shade as well as for reclamation of saline, alkaline and other degraded soils. It is also used in treatment of cancer and dermatological issues¹¹.

¹⁰ The Hindu, TN "Is it good for diabetes" July 21, 2006

¹¹ http://www.worldagroforestry.org/Terminalia_arjuna

The 10 trees selected showed the maximum interrelationship with birds, hence they were chosen, but there were other trees as well that fit in to the category but ignored due to data and time insufficiency. Hence, apart from the above trees mentioned other trees that could be used in landscaping for better bird diversity are:

Albizia lebbbeck (Siris), *Butea monosperma* (Dhak), *Dalbergia sissoo* (Shisham), *Diospyros cordifolia* (Bistendu), *Ficus microcarpa* (Laurel Fig), *Ficus palmata* (Anjeeri), *Morus alba* (Toot) and *Plumeria obtusa* (White frangipani).



Pictures 8 and 9: Left- Spotted owlet nest on *Dalbergia sissoo*; Right- Parakeet feeding off from *Ficus palmata*

The *Ficus* species almost dominates the landscaping in urban green spaces, when it comes to this research but that doesn't mean that planting only *Ficus* will provide the solutions. A well maintained heterogeneous approach will have to be taken while landscaping and even keeping in the mind the locations of the trees to be planted.

The relationship that these trees have with different species of birds have been summarised in Table 4. Out of the 40 species of the birds recorded, a few were water birds like Spot-billed duck, farm goose, common moorhen and little cormorant. They didn't show any relationship with these trees hence have been left blank. Moreover birds like the peacock, Asian pied starling and the hoopoe were observed on the ground and no relationship was recorded.

In order to explain the relationship colour patterns have been used. 4 different colours indicate 4 different interrelationships. They have chosen specifically after watching the activity of birds during the field visits. They are:

	Feeding
	Nesting
	Socialization
	Perching

Table 4: Relationship of different birds with different trees

[illegible]

S No	Scientific Name of the Bird	Common Name of the Bird	Trees											
			Ai	Bc	Fb	Fra	Fre	Fv	Mi	Pd	Sc	Ta		
23.	<i>Necyarinia asiatica</i>	Purple Sunbird												
24.	<i>Ocyrceros birostris</i>	Indian Grey Hornbill												
25.	<i>Orthotomus sutorius</i>	Common Tailorbird												
26.	<i>Passer domesticus</i>	House Sparrow												
27.	<i>Pavo Cristatus</i> [@]	Indian Peafowl												
28.	<i>Phalacrocorax niger</i> *	Little Cormorant												
29.	<i>Psttiacula kreni</i>	Rose-ringed parakeet												
30.	<i>Pycnonotus jocosus</i>	Red-whiskered Bulbul												
31.	<i>Pycnonotus luteolus</i>	Red-vented Bulbul												
32.	<i>Streptopelia decaocto</i>	Eurasian collared Dove												
33.	<i>Streptopelia senegalensis</i>	Laughing Dove												
34.	<i>Sturnus contra</i> [@]	Asian Pied Starling												
35.	<i>Treron phoenicoptera</i>	Yellow footed Green Pigeon												
36.	<i>Turdoides caudatus</i>	Common Babbler												
37.	<i>Turdoides malcolmi</i>	Large Grey Babbler												
38.	<i>Turdoides striatus</i>	Jungle Babbler												
39.	<i>Upupa epops</i> [@]	Common Hoopoe												
40.	<i>Zosterops palpebrosus</i>	Oriental White Eye												

KEY:

Ai- Azadirachta indica **Bc**- Bombax ceiba **Fb**-Ficus benghalensis **Fra**-Ficus racemose **Fre**-Ficus religiosa
Fv-Ficus virens **Mi**-Mangifera indica **Pd**- Pithecellobium dulce **Sc**- Syzigium cumini
Ta- Terminalia arjuna

Birds: *- Water birds @- Ground birds

For Objective 3

PLANTATION STRATEGY IN URBAN GREEN SPACES:

Urban green spaces are significant for sustainable development. An interdisciplinary and integrative approach is used in which all aspects of economic, political, social, cultural, management and planning helps to enhance urban green spaces' facilities and services. While planting there are certain factors that are needed to be taken care of like:

- Plant material and characteristics
- Soil conditions
- Availability and quality of water
- Air quality
- Sunlight
- Functional aspects of design
- Soil conservation
- Maintenance

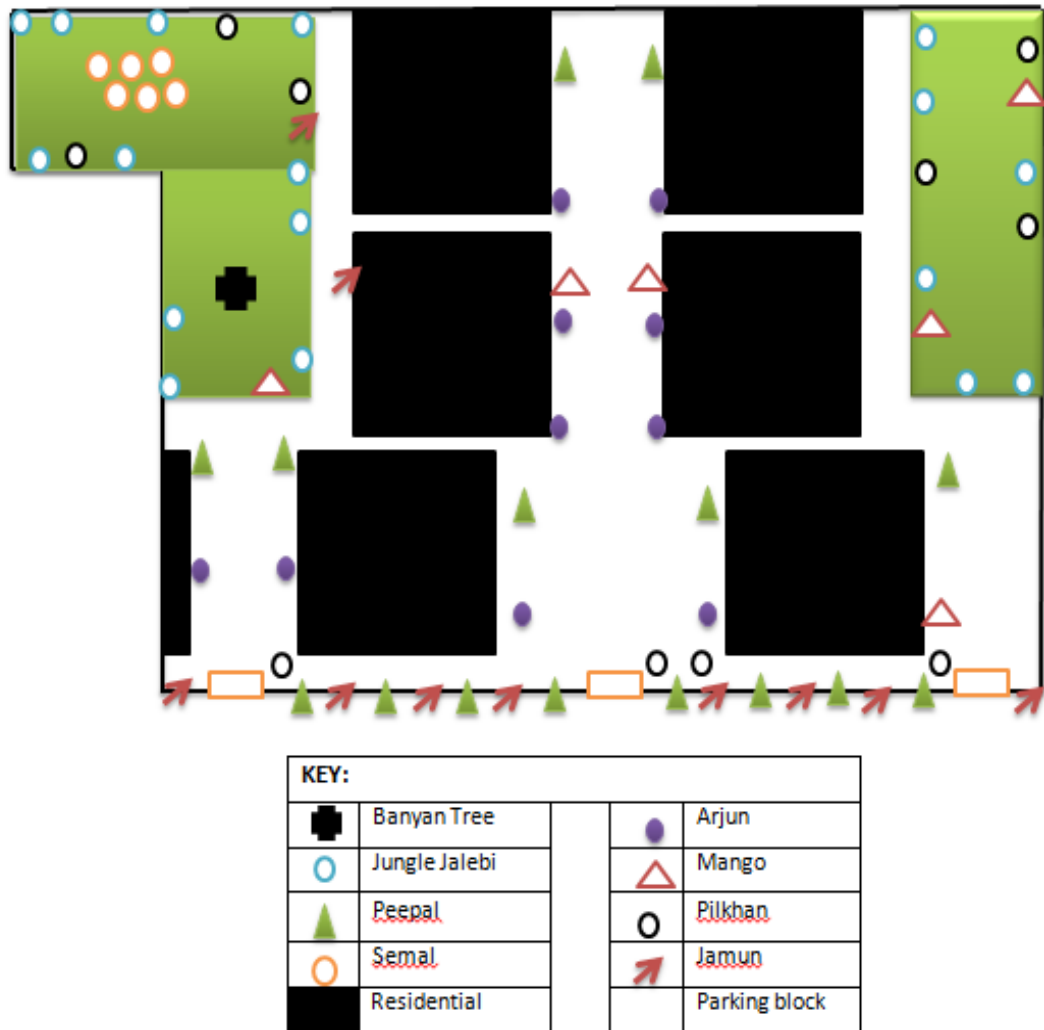
Plant characteristics include both its physical and chemical features such as growth rate, bark type, texture and foliage and even use in landscape design. Slow growing trees are generally recommended as a large development is aimed for future generations. Soil is also very important while deciding the type of vegetation as pH and texture of soil differ from place to place. Some trees require direct sunlight, while some require partial while other prefer shades areas. Apart from these basic requirements, a plantation strategy should also improve environmental conditions w.r.t to soil, drainage, air quality, micro-climate and attract biodiversity. Instead of looking from man-tree relationship, one can look for man-tree-bird relationships. (CPWD- A Handbook of Landscape, 2013)

Of the 10 trees shortlisted every tree has its own unique characteristics. The placement of the sapling is of essential importance as it determines the future of the tree. A huge tree like *Ficus benghalensis* (Banyan Tree) must be placed in an open area and not near to the boundary or any buildings as its aerial roots may damage them. A banyan tree can grow enormously large hence it is also advisable to get it trimmed from time to time contrary to the stigmas attached with the trimming. Other ficus like the *virens* (Pilkhan), *religiosa* (Peepal) and *palmata* (Anjeeri) can be grown on the boundaries as well as inside the complexes. *Azadirachta indica* (Neem) can be grown anywhere in the establishment provided it can be allowed to reach its appropriate height. They are tall trees hence planting them where there are cross-sections of wires going around is not suitable. *Bombax Ceiba* on the other hand should be grown in wide open spaces or on the edges and should be placed in a row or couples of rows together forming a matrix since these trees offer great perching and nesting points. Socialization of birds is at peak around semal during breeding seasons. the fruit of *Syzigium cumini* (Jamun) is foraged upon many birds. It's a part of the diet of myna, parakeets and barbets. This tree along with *Terminalia arjuna* (Arjun) proves to be a haven for birds as they both provide excellent

nesting sites and act in improving air quality and filter noise. *Pithecellobium dulce* (Jungle Jalebi) is excellent as a hedge tree.

A proper plan with right vegetation type has to be used before landscaping any large development. Following image of a part of a complex in New Delhi that shows the digitized version of the complex with the appropriate trees and proper location.

Picture: A residential complex showing appropriate trees at desired locations.



For Objective 4:

This objective included the questions asked to students, birders, general public, architects and landscape ecologists about their general perception about the urban green spaces, the vegetation that was found to be common and the birds that depend on them. Moreover they were asked about the relevance of such green spaces which was really the difficult part because for people, a urban green space clearly meant to be used for recreational purposes like a walk or play and they never seemed to understand from a biodiversity point of view. Although some answers were strikingly good, the average response of the

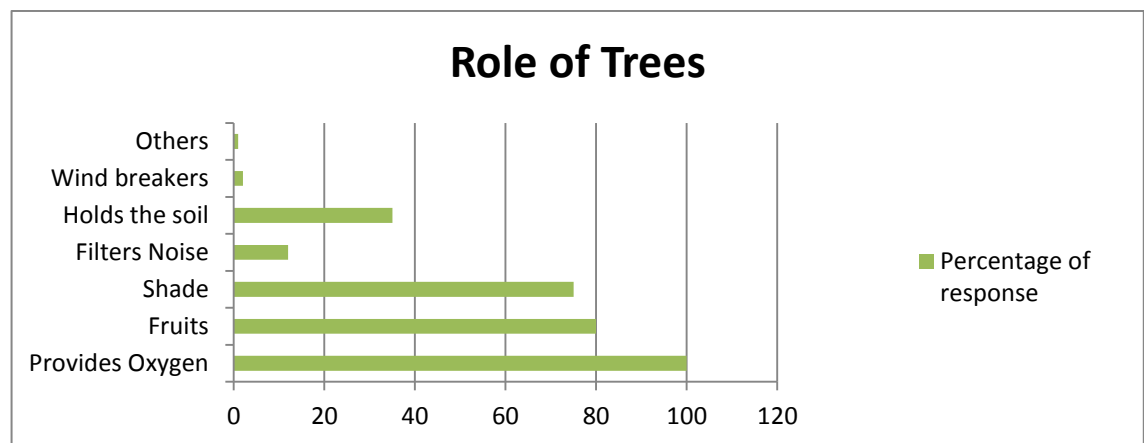
general public was mediocre. It was surprising to know that even architects face the similar situations as most of them were of the design background and never really thought about resourceful planning. Landscape ecologists however had some idea about it but not complete. Fellow birders were a real good source of information and their regular visits on green urban areas of Delhi provided insightful knowledge.

Following are the results:

1. STUDENT SURVEY

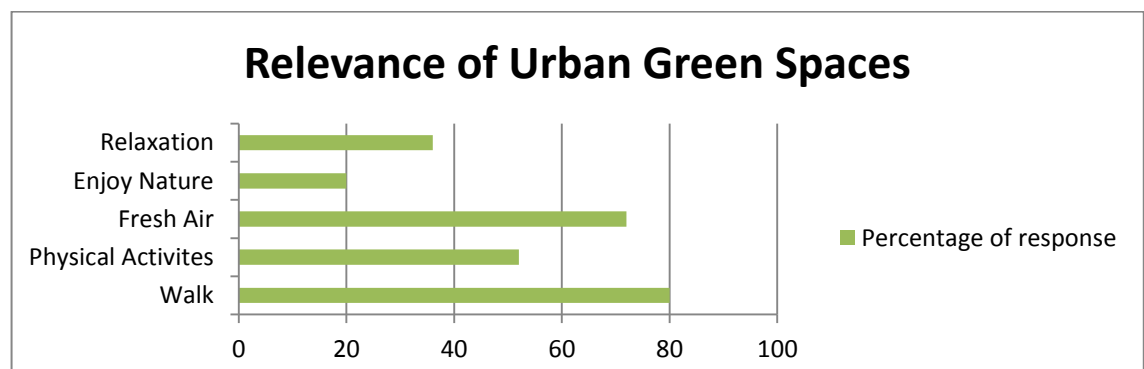
From the student survey of 25 students around Delhi, which included students from class 11th up till post-graduation, it was found that the average number of urban green spaces around a residential block within 1 km radius is **2**. The most common tree species included **Peepal** and **Neem** while the most common species of birds included The **Rock Pigeon**, **House Crow**, **Common Myna**, **Rose ringed Parakeet**, **Black Kite** and **Sparrows**. A few students also claimed to see Yellow-footed green pigeon and Asian Koel.

On being asked about the roles that tree played, the answers were:



The most favoured responses included providing oxygen and fruits followed by providing shade. Very little was known about the noise filtration and wind breaker ability of the trees. Other included i.e. approximately 1% of the response was that trees attract birds and insects and for other recreational activities. The relationships between Birds and trees were mostly answered in the form of **perching** and **nesting**.

On being asked about the relevance of urban green spaces, the answers were:



2. BIRDER SURVEY

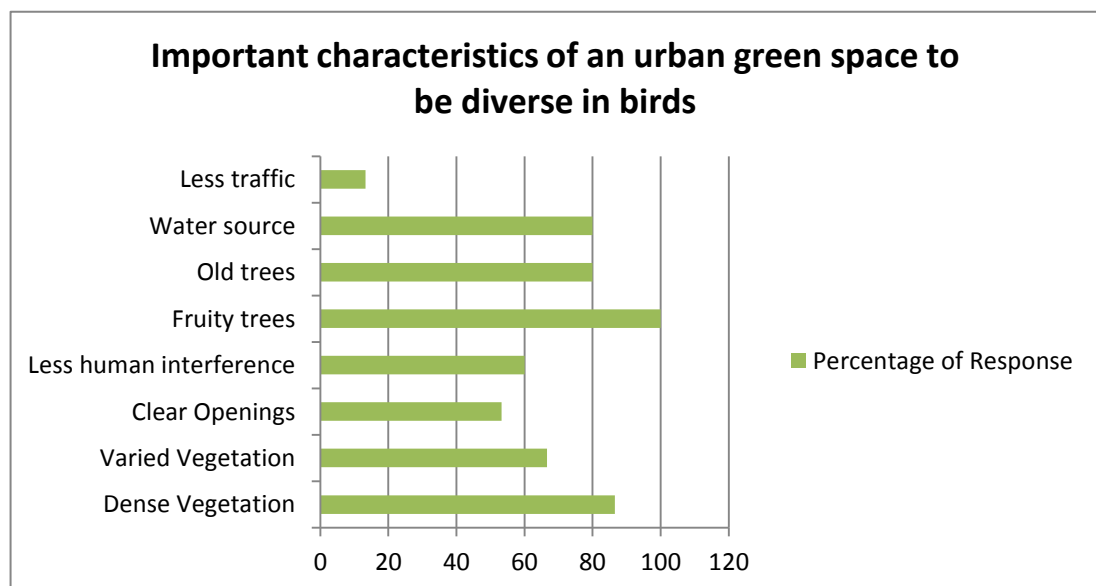
The birder survey was conducted with the help of 15 members of the Delhi Bird Photographers Society. Their knowledge proved to be extremely helpful during the course of study and they even shared excellent photos of interaction of birds with trees.

For birders the most favoured urban green spaces in Delhi for May to July were the **Basai Wetlands, Dhanauri, Najafgarh Jheel area, Sanjay Van** and **Aravalli Biodiversity Park**. Many of them visited the local nearby parks such as Deer Park and districts parks as well. Their experience in the field provided great in depth knowledge on the life of birds and their dependency on trees and vice versa.

The birds observed ranged from common birds like pigeons, mynas, crows to exotics like the greater flamingo and sarus crane. Oriental white eye were among the favourites to shoot due to its shy nature. Raptors like the black kite, Shikra and Spotted owl were also seen.

According to a birder's point of view the main relevance of urban green spaces included **habitat to biodiversity of animals** especially birds, insects and small mammals. They had understanding about the urban green spaces as an **ecosystem** thriving within the concrete jungle. A great number of trees were known but the banyan and the neem had special mentions due to the fact many birds like to perch upon them.

On being asked about important characteristics an urban green space should have to have more bird diversity, the answers were:



3. GENERAL PUBLIC SURVEY

From the four main locations, 15 people from each location were chosen at random to ask about their general perspective of the urban green space, its tree and bird diversity.

The visitors at Lodhi Garden and Hauz Khas District Park knew more about tree diversity generally because of presence of name tags. Moreover, people did observe the great diversity in tree species which they correlated with the diverse species of birds which on the contrary was not observed at districts park of Paschim Vihar and Janak Puri. Out of the two, Janak Puri even had a sadder story, as many people found it hard to find common tree species such as Peepal and Banyan and couldn't correlate with bird diversity as the diversity was naturally low.

The roles of trees mainly included providing shade, oxygen and also acting as sound barriers and air filters which included knowledge about carbon dioxide, SPM and Other harmful gases. Keeping soil erosion in check was also on the list.

Apart from the common birds like the pigeon, crow and myna observed in all 4 locations, the visitors at Lodhi Garden and Haus Khas District Park also have observed Grey Hornbills, Black Drongo, Jungle Babblers, Farm Goose and spot-billed duck. A few of them also observed these species at Paschim Vihar District Park along with the Green Bee-eater whereas it was hard to find birds at Janak Puri.

Interactions between birds and trees included nesting, socialization and feeding. The relevance of these urban spaces was cited as for walks, exercise, physical activities, socialization and to enjoy nature.

4. ARCHITECT/ LANDSCAPE ECOLOGIST SURVEY

Of the 10 architects and landscape ecologists consulted, most of them agreed on the point that not much consideration is given to biodiversity especially avian when it comes to landscaping. Those trees are generally planted that have high aesthetic value and should look exotic. Mainly flowering trees are considered for landscaping, which had led to yellow oleander becoming a very common tree in park, but it's fruit being poisonous and not much canopy to spread, birds generally are not attracted to that tree. Architects also look for good shade trees such as Peepal and Neem as well.

Trees that are common in urban areas and extensively used in landscaping include ***Cassia fistula*** (Amaltas), a beautiful tree with yellow flowers, however neither the fruit nor the flowers attract birds. Perching might be seen in a few cases but the tree is not suitable for nesting or foraging, hence birds avoid it. Another common tree that is usually used in landscaping is ***Polythalia longfolia***, popularly known as Ashok. It is a slender tree and does not branch much. Due to its compact shape, birds do not get space to perch hence, are not attracted towards it. ***Callistemon viminalis***, the weeping bottlebrush is often used due to its beautiful red flowers but fails to attract birds. Same is the case with ***Delonix regia***, the gulmohar. A beautiful tree with vibrant red flowers but fails to attract birds.

DISCUSSION:

Cities are known as urban jungles, but the truth is some part of the wild does exist in the city, only we tend to not see it. The study done managed to capture an important aspect that is usually ignored in our life because we take things for granted, the city birds and their interdependence with the tree diversity. The list of trees obtained might feel as very common to some but at the same time it is of great importance as it is not one tree that is being planted, it's about a group of trees being planted. As mentioned before heterogeneous vegetation increases diversity and this study is about the urban ecology of city the which includes not only the trees and birds but every other organisms that is in some way connected to the tree or the bird. When one comes up with the list, it doesn't mean only these 10 trees need to be planted only. There are other trees that do fit the profile and along with them presence of shrubs, herbs and grasses holds equal importance. Together they make a larger ecosystem than the tree itself.

From the first objective we concluded about the major species of birds living in the urban green spaces. Due to insufficient man power the bird count was limited to number of species only and not the number of birds each species had; hence various diversity and abundance indices couldn't be used.

The second objective established relationships between individual trees with individual bird species. This required a detail observation of the tree in morning and evening hours, due to which some other opportunity might have been missed about recording data that was happening at the same time.

The third objective looked into the appropriate planting strategy to be used while planting certain trees in large development or while developing architectural plans. 2 months is really less time to learn about all the planning techniques however they were used to their full potential.

The fourth objective gave us an insight of the mind-set people had w.r.t. the urban green spaces, their relevance and the part that is of most importance to them. Delhi is very diverse when it comes to its population; different people had different reasons to acknowledge the urban green space but lacked the ecological understanding of it. Moreover some of the visitors in the park had misleading information whose sources can't be relied upon. The architects seemed to disappoint in their survey as being planners of the city in this so environment friendly era, they lacked the basic knowledge about importance of using native trees in landscaping and adhered more to the customers demand.

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Books reviewed: Trees of Delhi by Pradip Kishen and Birds of Northern India by Richard Grimmett and Tim Inskipp

The photographs used in the report are taken by me using Canon EOS 550D with 55-250mm.

APPENDICES

ANNEXURES I

Surveys taken:

TERI UNIVERSITY
DEPARTMENT OF NATURAL RESOURCES

MINOR PROJECT

Urban Ecology of Delhi: Relationship between Birds and trees in Urban Green Spaces and their management

Date: _____

STUDENT SURVEY

1. Name of the person: _____

2. Age: _____

3. Level of Education: _____

4. Residential Address: _____

5. Number of urban green space near them (within 1 km radius): _____

6. Most frequently visited urban green space: _____

7. Tree species known (if any): _____

8. Role played by trees: _____

9. Bird species observed in the urban green space:

10. Interactions observed of birds with trees: _____

11. Relevance of the urban green space: _____

12. Improvements to be made in or around their residential place for trees and birds:

TERI UNIVERSITY
DEPARTMENT OF NATURAL RESOURCES

MINOR PROJECT

**Urban Ecology of Delhi: Relationship between Birds and trees in
Urban Green Spaces and their management**

Date: _____

BIRDER SURVEY

1. Name of the person: _____

2. Age: _____

3. Profession: _____

4. Gear used: _____

5. Number of urban green spaces visited: _____

6. Most frequently visited urban green space: _____

7. Tree species known (if any): _____

8. Common bird species observed in the urban green space:

9. Interactions observed of birds with trees:

11. Relevance of the urban green spaces: _____

12. Value characteristics for an urban green space to be diverse in bird species:

TERI UNIVERSITY
DEPARTMENT OF NATURAL RESOURCES

MINOR PROJECT

**Urban Ecology of Delhi: Relationship between Birds and trees in
Urban Green Spaces and their management**

Date: _____

GENERAL PUBLIC SURVEY

1. Name of the person: _____

2. Urban green space visited: _____

3. Age: _____

4. Profession: _____

5. Tree species known (if any): _____

6. Role played by trees: _____

7. Bird species observed in the urban green space:

8. Interactions observed of birds with trees: _____

10. Relevance of the urban green space: _____

11. Improvements to be made in or around the urban green space for trees and birds:

12. Any other comments: _____

TERI UNIVERSITY
DEPARTMENT OF NATURAL RESOURCES

MINOR PROJECT

**Urban Ecology of Delhi: Relationship between Birds and trees in
Urban Green Spaces and their management**

Date: _____

ARCHITECT/LANDSCAPE ECOLOGIST SURVEY

1. Name of the person: _____
2. Age: _____
3. Profession: Architect ____ / Landscape Ecologist ____
4. General views about landscaping: _____
5. Popular trees used in urban areas: _____
6. Criterion for choosing the above trees: _____
7. Important things kept in mind while planting trees:

8. Importance given to biodiversity while landscaping: _____
9. Views about smart city concept: _____
10. Can bird diversity be a contributing factor to landscaping:
