Ecological corridors in urban areas: a case study for integrating ecological engineering in Mumbai region.

Sagarika Damle[1], Shruti Barve[2], Pallavi Latkar[3] and Nishith Dharaiya[4]

1. K.C. College, Mumbai. Email:sagarikadamle@hotmail.com
2. N.M. University, Mumbai. Email:shrutiutpal@gmail.com
3. Rachana Sansad Institute for Urban and Regional Planning Mumbai. Email:pallavilatkar@gmail.com
4. HNG University, Patan, Gujarat, Email: nadharaiya@gmail.com

Abstract.

Biodiversity conservation is becoming a large concern with the rapid pace of urbanization in developing countries. Currently biodiversity conservation is limited to conservation of existing natural green areas, like National Park, and Sanctuaries. This research undertaken by the authors and funded by the Mumbai Metropolitan Region Environment Improvement Trust, proposes to map association within and amongst communities to study, evaluate and make maximum use of such floral-floral and floral – faunal associations to develop and sustain the ecological balance of urban areas through natural processes. The research proposes ways of integrating this with urban landscaping to make the urban areas more rich in biodiversity.

Keywords: Ecology, biodiversity, urban green corridors, landscape design, integrated urban planning, cluster plantations

Introduction

Biodiversity in a forest ecosystem has been studied in many different aspects since long. There are number of checklists of species, stray notes and inventories available for almost all the Sanctuaries and National Parks of India. However, very little study has been carried out in Indian ecosystems that how different species in a community and different communities in an ecosystem are integrated and associated. It is also very essential and interesting to know that how these different floral-floral and floral –faunal associations are playing a role in sustaining the ecological balance. The growth trend towards rapid urbanization has been extremely detrimental to the biodiversity in and around the urban centers. Mumbai region boasts of varied biodiversity owing to its unique geographical location .The entire Mumbai metropolitan region spanning over 4,300sqkilometres is bestowed with large areas of land under reserved forests and marsh lands. These areas rich in biodiversity are fast depleting due to the growth of dense urban centers along the infrastructure routes leading to fragmentation of the rich bio-reserves.

It is interesting to study plant communities as a "working mechanism" as much as it is interesting to study the plant communities for classification. There is very little information regarding native plant communities and their associations in terms of their relative proportions, spatial and temporal relations, compatibility and interdependency.

It is well established that nature is full of mutually beneficial arrangement between organisms. Geographic trends in characteristics of species making up communities interests ecologists because they may suggest factors underlying the organization of communities and the characteristics of their species. Similar climates and soil tend to produce groupings of organisms with similarities at both individual organism and community level.

These groupings of organisms with similarities are produced by natural selection and through the bio-geographic setting of previously adapted species.

Today it is extremely essential to have an acceptable qualitative idea of nature of relationships between components of the communities. The information pertaining to individual sites and soil fauna groups, their direct/ indirect catalytic role or contribution to ecosystem metabolism is significant.

Significance of green areas to biodiversity and the environment

Nature as created by man is often considered to be inferior to nature that evolves without human intervention. In support of this, it is often asserted, e.g. that the number of species is often greater in untouched nature. Green areas play a significant role in the environment.

Trees intercept particulate matter and absorb such as gaseous pollutants as ozone, sulphur dioxide and nitrogen dioxide, thus removing them from the atmosphere. Trees also emit various volatile organic compounds that can contribute to ozone formation in cities. By transpiring water and shading surfaces, trees lower local air temperatures (Nowak, 1995). Because trees lower air temperatures, shade buildings in the summer, and block winter winds, they can reduce the consumption of building energy and consequently reduce the emission of pollutants from power-generating facilities (Mc Pehrson & Rowntree, 1993; Nowak, 1995).

Currently biodiversity conservation is limited to conservation of existing natural green areas, like Sanjay Gandhi National Park, Karnala Bird Sanctuary etc. Along with this developmental strategies / tools are needed to make urban greens more and richer in biodiversity. The existing plantation practices in Mumbai and MMR region tend to be superficial beautification exercises. Such efforts are not sustainable as they are high on maintenance and water demand. The current need is to move

away from the wholesale reliance on traditional horticultural based plantings composed primarily of exotic species and cultivars.
Therefore, even if urban nature perhaps cannot compare to “natural” nature, it is still of great importance. The nature that exists in the landscape is the source we should use for disseminating wild plants and animals into urban areas.

Need to change our approach
Current tree planting practices involve monocultures of particular trees or fast growing exotic species for purpose of lumber. The monoculture of species unsuited to the habitat, soil and climate will need a lot of maintenance. The other kind of tree planting is tree planting done for beautification e.g. bonsai, dwarf trees, etc. They are apparently beautiful but need a lot of maintenance too.

Monoculture plantation may look green but do not enhance healthier ecological processes. In fact, such plantations are more vulnerable to plant diseases and insect pests in comparison to multi-species stand and harbour lower diversity. Introduction of non-native and exotic species are less adaptable than indigenous species and may cause harm to indigenous species.

Such monotypic plantation and cultivation of exotic species in urban area are currently largely prevalent but have limited biodiversity. Associations of flora- fauna type or flora-flora type are lost disturbing the already stressed ecological balance.

Over the past couple of decades, the on-going decline of public landscape maintenance and the arrival of new social and environmental movements, has initiated a search for ‘new’ planting styles to help create better public landscapes. Views differ on what these might be, however the majority opinion is that these plantings should have relatively low-maintenance costs, be as sustainable as possible, taxonomically diverse and support as much wildlife as possible.

Hence, a need was felt for a new planting method to be promoted i.e. planting based on ecological studies that is indispensable to restore green environments, to prevent disasters and to sustain local to global environments – The Miyawaki method.

The Miyawaki method for plantation is an ecological method of reforestation applied in Malaysia in Southeast Asia, in Brazil and Chile in South America and in some parts of China. Since 1973, Miyawaki’s team have been forming environment protection forests around newly built ironworks and power stations in cooperation with farsighted Japanese corporations such as Nippon Steel Corp., Mitsubhishi Corp. and so on. It has been found to be successful in each of the locations mentioned. Hence, we attempt to replicate this method in Mumbai.

This method promotes intensive mixed cluster tree plantation of native trees.Dense and mixed planting of community species of indigenous forests will need no watering, insecticides or herbicides, with some exceptions. Natural management is the best management.

This research is potentially relevant to many urban contexts; ‘public’ and ‘semi-public’ landscape. It is inclusive of difficult-to-characterize mix of spaces around public housing, commercial developments and institutions, car parks, left-over spaces from development, structure plantings of massed trees and shrubs and strips along paths, roads and other corridors.

Taken as a whole, these often very ordinary places are the landscapes we are most familiar with and which inform, and perhaps even shape, our attitudes to the world around us. In combination with private gardens, these urban spaces are also the landscapes where we have most of our first-hand experiences of ‘nature’.

It is interesting to establish that even after almost two centuries of experimentation, ecological planting can still be described as new, which suggests that it had never been part of mainstream practice. This needs to be changed by promoting this type of plantation in mainstream. Hence, this manual describes the way of using natural clusters in parks and gardens based on ecological rather than the purely aesthetic principles.

We have attempted to make this manual a user friendly guide for use in plantation schemes in Mumbai area as well as in MMR Region. It serves the purpose of suggesting a list of plant communities for urban greening in Mumbai and plantation techniques that can be considered for it. Second, it suggests design guidelines for such use in preparing landscape plans for urban gardens.

METHODOLOGY AND ANALYTICAL TOOLS

There are various analytical methods supported with statistical analysis that enabled us to estimate the biodiversity or type of vegetation under study. The methods available include geographical mapping of the vegetation zone, qualitative and quantitative studies of vegetation and many more. From the extensive literature review undertaken, no single method was found to be available to study plant association of ecological importance. A new method of interpreting the data to represent plant association, therefore, needed to be devised. The Cluster method and the Random Sampling for cluster method were applied in the forest and garden areas. This was done to investigate the flora–flora and flora – fauna association. The above sampling technique was used for the field study.(Ref stage one report for sampling techniques used)

Field surveys in the study areas (Urban & forest)

Specific urban areas in Mumbai were selected for survey, to find out the existing species variety, their role in maintaining ecological balance, their associations with other flora and fauna. Actual field visits with photographs helped to understand what has been planted and or is growing naturally in the few green sites seen in the city. The majority green areas are gardens and or plantations around housing colonies.

A study of natural forest habitats near to urban areas and at similar climatic and altitudinal conditions (not in core zone) that are present in urban was taken up to explore the possibilities of identifying then communities of native species that can be used in urban environments. Hence, clusters in forest areas closer to the urban settlements and similar altitude as prevalent in urban area were selected. A random sample study of cluster at lower heights of SGNP and Karnala Bird Sanctuary near road side with human inference was undertaken for the same. The field survey of forest clusters were studied in different seasons to find out actual cluster vegetation which were selected randomly.

The large scale, medium scale and the small scale gardens had good floral patterns because of exotic species. Ornamental plants are always more in manicured gardens than the indigenous plants. Hence they attract fewer fauna. These gardens also require high maintenance. Dominant features like water edge with mangroves, public parks, residential areas, typical joggers parks with ornamental plants seemed to have offering potential for different habitat for increasing of the biodiversity in urban areas, if more indigenous plants are planted. Road side plantations are observed at Mankhurd highway. In most of linear plantations repetition of single species of plants is observed. For example, Australian babul, Eucalyptus and Cassurina etc. These attract lesser fauna. It would be more beneficial for increasing the biodiversity, if the plants are planted in atleast three tiers. Different plants can be planted in combination making a three to four tier and attracting more faunal activity.

The above mentioned methodology and analytical tools helped us gather data and after elaborate analysis of the data and literature review we have suggested the Cluster Plantation technique that can be used for achieving better biodiversity in Urban areas and the type of indigenous species that can be used effectively to achieve four to five tier cluster plantations. Plant association of selected trees which were found in clusters

POTENTIAL GREENING SITES IN MUMBAI METROPOLITAN REGION

The Mumbai Metropolitan Region

The Mumbai Metropolitan Region (MMR)/ Mumbai Metropolitan Area is the metropolitan area consisting of the metropolis of Mumbai and its hinterland. The region lies between 18^{o} 33' and 19^{o} 31' north latitude, and between 72^{o} 45' and 73^{o} 28' east longitude. Geographically, the MMR forms part of the North Konkan region that lies towards the west of the Sahyadri Ranges. In this Region the Sahyadri recurves inwards and recedes further eastwards; and the river Ulhas draining westwards has developed a large alluvial infilled amphitheatre-like basin.

The Region consists of the mainland of North Konkan and the two large insular masses of Salsette-Trombay and Mumbai separated from each other by shallow creeks and tidal marshes which are mostly silted up and filled in. The Region on the whole is a low land, but not a plain. The average elevation of the areas above sea level is less than 100 metres but significant local variations are brought about by a series of north-south trending hill ridges.

Planning and Management of Urban Green Areas

Even if the urban nature perhaps cannot compare to "natural" nature, it is still of great importance. The nature that exists in the landscape is the source we should use for disseminating wild plants and animals into urban areas. That is why green corridors out in the countryside and leading into urban areas are vital, as is the transitional zone between urban and rural areas. In many places, the green structure is not cohesive and, thus, cannot provide the necessary transport routes. Just a minor interruption of a green corridor is sufficient to prevent it from functioning. Although binding the green network together in urban areas demands a great effort, it is absolutely necessary if we are to succeed in developing urban biotopes and in creating the conditions needed for richer flora and fauna.

Understanding Potential greening sites in MMR

For plantations with a view to enhance biodiversity in urban areas, it is essential to understand the following:

a. Different scales offer different potential

Large Scale:

Varying scales of open spaces offer possibilities of plantations of different sizes and compositions

(i) Regional park (ii) Catchment areas of dams (iii) Quarry sites etc.

Medium Scale:

Medium scale open spaces are maximum in numbers in urban areas. So finding appropriate too for their development (landscape) is very valuable.

These parks though segregated offer potentials for green connectivity or green corridors through urban areas. They (open spaces) give better opportunity for interface between urban population and biodiversity in terms of appreciation of flora and fauna (native), awareness, sensitizing people.

Linear scale:
Useful tools in green lanes/ corridors. Linear scale open spaces are reality of urbanization. They are supporting urban functions such as transport / other infrastructure, hence, indispensible. At the same time they can play important role in serving as green corridors for fauna, serving as buffer to minimize the air and sound pollution effect on surrounding area.

b. Natural characteristics of surrounding area (Location)
Offers different physical habitats viz. hills, coastline, river edge, inland etc. This would effect on the plant communities they support. Same is true about altitude.

c. Urban Land use conditions
Impact of various urban functions on open spaces; in terms of their active and passive use.

Open Spaces with different physiographic features in MMR
Natural features within the city limits
Within the MCGM also we have varied phgysigraphic conditions
1. Hills (Sion fort/SGNP)
2. Creeks (Mahim)
4. River (Mithi River)
5. Plains
6. Coastal areas

Open spaces in and around the MMR region lie either along a more linear arrangement (Eg. Along river banks, railway tracks etc.) or fragmented and scattered around the region. It is essential to connect these fragmented open spaces to each other through green belts and buffer zones to promote movement and migration of faunal components and diversify the urban ecosystem. An important aspect of promoting such green belts and corridors is the vegetation. The type of trees/plants/shrubs should be:

a. according to the topography of the area and
b. should support the faunal component(s) in question.

For example, a certain tree that is usually found in and around creeks, may not grow as well in a grassland and hence, may not be able to support as many life-forms as it may in a creek like habitat. Hence, while selecting plants, such factors should be kept in mind, for a successful plantation.

Plantation plans for buffer in MMR Region
Most of the areas beyond municipal limits are under gram panchayat and agricultural land use. Buffer area along the various physiographic features like forest, rivers, streams etc serve as an essential corridor. These corridors give the opportunity to create and plant concentrating on the ecological and biological enhancement of ecosystem.
In accordance to the MOEF guidelines, buffer zones/ no development zones have to be maintained along rivers, streams, and other water bodies and wetlands. Well defined plantation plans and plantation guidelines will help in restoring the biodiversity in these regions. It is essential to create buffer areas along reserve forest, roads and rails also.eg Drawing 2 and 3. Also, refer Drawing 4,5A and5B
There is need of buffer in urban areas for distinct natural /physiographic features as creeks and hills. These landform also provide a opportune urbanised area. Example sited to demonstrate this is of Arrey Colony hill to Malad Creek. Refer drawing 4.
Proposed and existing open spaces in municipal areas appear to be fragmented and sporadic due to uncontrolled urban development. However one can see potential in connecting these open spaces by means of greening along roads or creek etc. This can lead to formation of green corridors.

To maintain and restore the bio diversity within urban limits it is advisable to generate biological corridors to maintain and preserve the ecosystem of the following area so that the richness of the open space is extended beyond its limits.
Two such examples are sited viz open space linkages along road in Malad and Goregaon area, open space linkages along creek in Dahisar area. Refer drawing 5A, 5B
ity for creating green connections in highly

INTRODUCING CLUSTER PLANTATION

With the huge reduction of natural ground cover, including over tidy gardens, mammals have very few habitats left which is the reason why atleast half of the garden should remain "un-manicured". For instance, an owl feeds its young on small rodents like mice and voles. But the further it has to travel to find them; its young have far less chance of survival. Hence, the emphasis is on a more natural “un-manicured” garden with indigenous species wherever possible.

If some wild flower seeds around these designated areas are scattered around and the grass is left to grow it will attract small mammals. Some berry trees, nut trees and hedgerow can be planted around the borders of the garden. The flora always tends to attract the animals through various ways.

Plants use colour to great advantage, some brightly coloured flowers attract insects that are essential for pollination. Bright red or yellow berries that attract birds offer a meal for the bird and ensure that the enclosed seed will later be deposited in another area. The insects that are attracted towards these plants are often diet for the birds which preys on them; this is also one of the ways for plants to attract the fauna. Compact vegetation should be allowed to grow in harmony. This brings up the concept of cluster plantations as they are known to exist in the wild.

The fundamental unit of vegetation in general and even of clusters has been designated as “association”. This term, can be stated to be an abstraction, synthetically obtained by the comparison of a number of lists in selected sites in the field. This concept of an association is based on the fact, that there are certain species with a high-fidelity to each particular association.

The degree of aggregation/clustering of a species are an indication of the amount of association of individuals or groups of individuals of that species. In effect, it is a measure of the non-randomness of the distribution of the species. In general, most species show some form of aggregation or clumping. This may vary from a very loose association to a dense massing.
Nature comprises of many plant clusters which live together in harmony under particular environmental conditions. These plant clusters can be defined as a group of heterogeneous plant species with homogeneous characters that promote their existence in a beneficial manner. Heterogeneous plants are a varied group of plants different in plant habit i.e. herb, shrub, tree and comprising of different kind of species. Species which are different from each other in their genetic make-up may group together due to favourable environmental conditions forming plant clusters. These different species cluster together due to the availability of homogenous characters i.e. soil type, climate, nativity, other ecological factors and association with existing fauna. The homogenous characters thus act like a platform to promote homogenous character depending heterogeneous plant growth. In this manner clusters are formed. (Drawing 7A, 7B)
But the value of scientific understanding goes much further than simply helping to put an appropriate plant list together. Applying scientific principles can actually guide the way that plants are arranged to achieve a fully naturalistic effect, but one that also actually works as a functioning plant community into the indefinite future. Plant communities and associations tend to show identifiable patterns in the way that different species are arranged, both horizontally and vertically—these are related not only to environmental variation but also to the characteristics of the plants themselves and how they interact.

Promoting the culture of Cluster plantation

Promoting the culture of Cluster plantation with associated species being indigenous in nature may prove beneficial in maintaining the ecological balance of the environment in urban areas. This type of cluster plantation will aid in conservation of native biodiversity – both flora and fauna.

But it needs to be understood that any acceptance of such type of ecologically-informed approach to planting must fully embrace the concept of change. Change is fundamental to the processes that operate within semi-natural plant communities. It could be said that every ecological principle that a designer or manager needs to be aware of tends to be related in some way to this dynamic nature of plant communities. Change is apparent and important in all timescales, and for our purposes can be broken down into three main categories:

– Changes in the way a unit of vegetation develops over a single growing season or year
– Changes in the abundance, performance or visual presence of component species
– Longer-term changes in the character, composition or type of vegetation

Change also operates at the landscape scale where the manner in which different vegetation units are linked together can affect the way that plants and animals (including humans) can move around any given area. Processes operating at all these scales manifest themselves in the vertical and horizontal structure of vegetation, and in the very survival and long-term integrity and persistence of any given vegetation type.

The successful combination of different plant species is one of the main functions of planting design and landscape management. In traditional, horticultural-based planting design, aesthetic and functional considerations predominate: how do the different component species work together visually and how do they perform the tasks (such as dividing or filling spaces) for which they have been designed? Biological questions relating to how plants interact with each other and their surrounding environment as a community or unit of vegetation receive little or no consideration. This is mainly because the planting environment is generally modified to suit the requirements of standard landscape plants, whether this is through modification and importation of soils, fertilisation or irrigation, or through pruning and other maintenance operations, all of which entail an energy labour and financial cost.

OBSERVATIONS AND RESULTS

- **Growing percentage of exotic species and monoculture plantation**
  Survey of existing green areas such as gardens showed an increasing trend of planting the exotic species and monoculture thus reducing species diversity and reduction in number of associated faunal population such as avifauna, butterflies. (List available)

- **Availability of open spaces that can be converted into ‘green corridors’**
  Survey of the MM region with respect to the available open spaces yielded many potential sites suitable for planting.

- **Suggested plant species for initial plantation in MM Regions**
  From the data gathered during the survey, a list of plant species identified as suitable candidates for cluster plantation in plains of MM Region, it is also suggested that these tree species can be accompanied by the plantation of native herbs, shrubs or climbers found in clusters during our survey. Each of this species is studied for it’s ecological value addition- List available)

- **Model for Cluster Plantation**
  Understanding of the spatial planning of the urban land uses like residential areas, combined land uses and infrastructure layouts, landscape designs were made in such a way so as to facilitate mixed species cluster plantations along with the functional requirements of urban open spaces.

- **Preparation of a user friendly manual**
  From the data collected and construction of the proposed model for promoting cluster plantation, a user friendly manual can be prepared which can be used by the decision makers, executers, implementers and also a lay-man.

Table: 1Several Native Plant species identified for cluster plantation

1.Trees	
Common names	**Botanical Name**
Anjan	*Hardwickia binata*
Sita Ashok	*Saraca indica*
Charcoal Tree	*Trema orientalis*
Bael	*Aegle marmelos*
Bartondi	*Morinda pubescens*
Bahunia	*Bauhinia purpurea*
Burmese pink cassia	*Cassia renigera*
Indian laburnam	*Cassia fistula*
Devils tree	*Alstonia scholaris*
Palas	*Butea monosperma*
Indian cork tree	*Millingtonia hortensis*
Indian medlar tree	*Mimusops elengi*
Jackfruit tree	*Artocarpus heterophyllus*
Kamini	*Murraya paniculata*
Shirish	*Albizia lebbeck*
Margosa tree	*Azadirachta indica*
Pride of india	*Lagestroemia speciosa*
Putranjiva	*Drypetes roxburghil*

2.Shrubs	
Common name	**Botanical name**
Crossandra	*Crossandra infundibuliformis*
Malabar Hill Borage	*Paracaryposis malabarica*
Wild Caper Bush	*Capparis sepiaria*

3.Climbers	
Common name	**Botanical name**
Candy Corn Plant	*Moullava spicata*
Bitter Apple	*Citrullus colocynthis*
Chinese Cucumber	*Momordica cochinchinensis*
Puncture Vine	*Tribulus terrestris*

4. Herbs	
Blue Pussy leaf	*Nelsonia canescens*
Umbelled Bitter Cress	*Cardamine subumbellata*
Stinking Cassia	*Senna tora*
Red hogweed	*Boerhavia diffusa*

A total of 70 clusters were studied and all plants were listed. However only those plants were selected which could be growth in the urban areas. This was determined by studying the buffer zones/areas between the forest boundaries and the urban settlements. The common species found in both these areas were then selected as candidate species for cluster plantation.

Also these plants were selected on the basis of the ecological services offered by them such as promoting association with other plants and faunal species , being tolerant to pollution ,their carbon sequestration capacity etc. Parameters such as easy availability of seeds or planting material, rate were also considered while selecting these species.

Model for Cluster Plantation- Figure 1

Taking references from Miyawaki's experiments a typical 5tier cluster can be achieved in 50 sq. m area. However it should be noted that it is not possible to achieve the open space of desired area. In these situations it is possible to achieve cluster plantation starting from length of either side of open space should be minimum 3 m. One such example of cluster plantation in 9 sq. m area is shown in the diagram below.

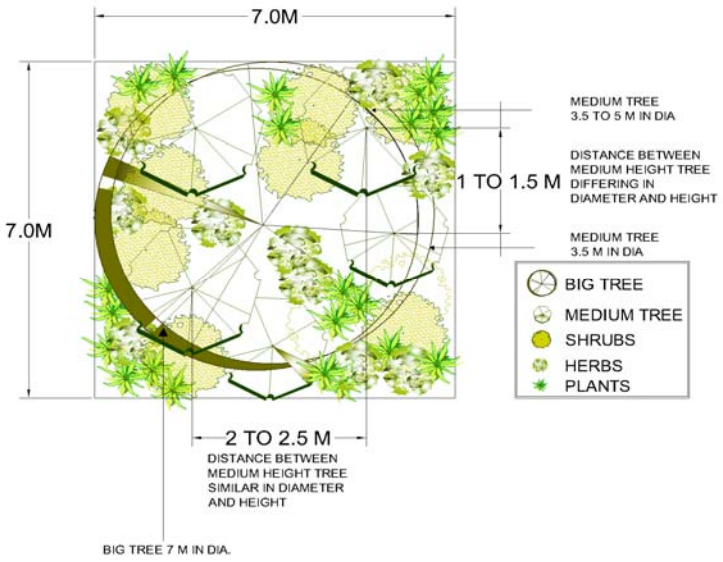

Figure 1. A Model suggested for cluster plantation in urban areas

An Ecological approach to landscape design

An ecological approach to landscape vegetation like cluster plantation can be radically different. Aesthetic and functional considerations can be equally applicable, but questions of ecological compatibility and long-term dynamics are also a central concern. Rather than specifically arranging plants in their final desired positions, and subsequently ensuring that that is where they remain, cluster planting can be more akin to starting and managing a successional process. However, compared to the vast bulk of ecological literature on the functioning of semi-natural plant communities in the wild, there has been surprisingly little application of ecological ideas in terms of the way plant communities and clusters function in landscape or ornamental planting.

The study of existing topography at various urban locations can underline the current shortcomings in maintaining the required green areas. By studying the plantations of buffer areas, the areas on forest boundaries and green belts in the urban areas with human interference, can give us an idea

about more tolerant plant species. These species might play a vital role in the initial period of plantation by supporting the cluster growth.
The outcome of this study could define certain endemic species growing in forests that are suitable for urban planting and would slowly replace the exotic species. The native species being more adaptive, would be expected to promote a better environmental balance in terms of ecological associations between the floral and faunal species. Introducing adaptable species from forests would also break the monotony of monoculture at the urban sites. Since the species chosen are of endemic nature, they would be expected to show better adaptive values than the exotic ones. This would reflect in reducing the cost and man power used in their cultivation and maintenance.

Study of forest areas throw some light on the type of soil and other ecological conditions required for existence of a particular association and strategies could be developed to replicate similar conditions in the urban areas to foster cluster plantations beneficial for greening the proposed sites.

The results of this study have been useful in formation of this “Plantation Manual” enlisting various useful species for urban greening and strategies for their cultivation and sustenance. This would help government agencies or private companies to implement the greening projects with ease.

The area under this study was one urban city i.e. Mumbai and the same model can be proposed for similar urban greening projects across the state and other urban cities in India.
One of the key aspects of this project at the implementation stage is making sure that the species identified for the cluster plantation should grow well in the urban areas for which environmental conditions play a vital role. Therefore environmental engineering for successful plant propagation would be a major area of research to be focused on.

A successful ecological model, supportive of proposed plantation for urban greening, would draw inputs from the current study regarding the prevailing ecological status of the forest and urban areas. Necessary corrective measures for altering the habitat can be planned and implemented according to the site and plant species selected.
From our observations it could be concluded that there are many candidate species from the forest regions, some of which are also growing in the city that can be used for urban greening. Some of these plant species also have other floral and faunal associations that bring about a better ecological balance that may enrich the environment.

These species therefore can also replace the monoculture plantations, mostly made up of the exotic species, observed in modern gardens. Each of the species selected can also be given ecological value or credit based on the ecological services performed by that plant.

Conclusion:

This research work proposes the way of using natural clusters in parks and gardens using indigenous plant species, based on ecological rather than the purely aesthetic principles.
This method promotes intensive mixed cluster tree plantation of native trees.
Promoting the culture of Cluster plantation with associated species being indigenous in nature may prove beneficial in maintaining the ecological balance of the environment in urban areas. This type of cluster plantation will aid in conservation of native biodiversity – both flora and fauna.
Rather than specifically arranging plants in their final desired positions, and subsequently ensuring that that is where they remain, cluster planting can be more akin to starting and managing a succession process. Thus, in many urban cities, identifying and converting the available urban open spaces into ‘Green Corridors’ will become a reality in near future.

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