CHAPTER 2

REVIEW OF LITERATURE
CHAPTER - 2

REVIEW OF LITERATURE

This is a piece of research on green infrastructure with particular reference to gated communities. To place this research in its due perspective, this review of related literature is undertaken. The focus of study here is green infrastructure and its relevance to development planning. An attempt has been made to collect relevant available material from articles in journals, books, government reports, newspaper articles, website etc. The available material has been presented in as organized a manner as possible keeping in view the objective as stated above.

In short, the purpose of literature review is to identify concepts related to the issue of green infrastructure which is the main theme of this piece of research work. The sub-theme is gated communities and the review of literature has been undertaken to give a relevant background to the same. There is an attempt to identify data sources, both secondary and primary and to arrive at an appropriate methodology for the research analysis. The literature review is also intended to structure the present thesis work.

The review of literature is presented hereunder according to the main theme, Green Infrastructure and the sub-theme, Gated Communities.

2.1 Green Infrastructure

Green Infrastructure is a concept the articulation rather than the fact, has originated in the United States in the mid-1990s. This highlights the importance of the natural environment in decisions about land use planning. In particular there is an emphasis on the "life support" functions provided by a network of natural ecosystems, with an emphasis on interconnectivity to support long term sustainability. (http://en.wikipedia.org/wiki/Green_infrastructure). Accessed on 05/10/10

Examples include clean water and healthy soils, as well as the more anthropocentric functions such as recreation and providing shade and shelter in and around towns and cities.
Green infrastructure is becoming increasingly important to forge a more wholesome relationship between the community and the environment. A green infrastructure approach repositions the role of nature in and around the city as an optional and valued amenity. The scenic backdrop characterizes the ecosystem services and is a platform for a more self-contained, vibrant community. Green infrastructure is a dynamic complex of interdependent systems that animates our cities, and we must calibrate our efforts to measure and express the performance of these green life support systems. Where this is in place, public and private investment flows naturally toward the richly layered and interconnected assets that provide multi-dimensional benefits of enduring value.

The idea of green infrastructure suggests a new genre of ‘high performance landscapes,’ integrating emerging ecological elements and urban infrastructural needs, which could reflect a contemporary ‘aesthetic of performance.’ The complex and assembled nature of ecologically high performing landscapes requires a more organized, operational approach. Resolution of these complex issues is a priority.

The planning and design framework here is based on 6 interdependent identifiable systems - the social, circulatory, metabolic, biologic, hydrologic, and geologic functions of green infrastructure in the city. Each system has its associated features and criteria of performance.

The physical elements are a community's green infrastructure support base and these can range in scale from a single tree to an entire watershed with greenery. Most assets perform more than one role, and through planning and design this multi-dimensionality can be enhanced. Assets are most effective when linked to form a mutuality network of green infrastructure.

Green infrastructure embodies a diversity of public and private benefits and values that fulfill the needs of nature as well as humans and sustain the environment and the communities. Green infrastructure systems help protect and upgrade natural ecosystems and provide a framework or background for future development. In doing so, they provide a diversity of ecological, social, and economic inputs and benefits which include enriched habitat and biodiversity, maintenance of natural landscape processes, cleaner air and water, increased recreational and transportation
opportunities, improved health, better connection to nature and an enhanced sense of place.

Well planned green space has also been seen to increase property values and decrease the costs of public infrastructure and public services, including the costs for stormwater management and water treatment systems. A nature provided facility for rainwater conservation.

Investing in Green Infrastructure can often be more cost effective than conventional public works projects. Just as all forms of built up infrastructure provide a wide range of public and private benefits, green infrastructure systems promote a wide range of essential ecological and social functions, values and benefits.

According to Benedict and McMahon (2000) Green infrastructure can be designed to shape urban form and provide a framework for growth. It works best when the framework pre-identifies both ecologically significant lands amidst suitable development areas. They state that, “Just like our built infrastructure, our green infrastructure should be carefully planned, designed, and invested far in advance for development. Green infrastructure planning should be a high priority in land-use planning and design. Green infrastructure planning should also be coordinated with planning for gray infrastructure - roads, bike trails, water supply, electricity, telecommunication and other essential community support systems. Integrated planning and design should connect the two in a more effective, economic and sustainable manner.

Green infrastructure initiatives should use approaches similar to those used for the planning, design and financing of built infrastructure. Green infrastructure should be:

**Designed Holistically** - Like our transportation system, green infrastructure should be designed to link diverse green space elements into a system that functions as a whole, rather than as separate, unrelated parts. Very much like connections between different wild life sanctuaries, which are otherwise seen as very much fragmented or torn apart.
**Planned Comprehensively** - Like our electric power and telecommunication systems, our green space systems need to be planned comprehensively to provide for ecological, social and economic benefits, functions, and values.

**Laid Out Strategically** - Like our roads and water systems, our green space systems need to be laid out strategically to overlay multiple jurisdictions and incorporate green space elements at each level of civic management. For example when roads or railways have to pass across green areas or forest sanctuaries, flyovers may be built.

**Planned and Implemented Publicly** - Like our built infrastructure systems, our green infrastructure systems should be planned and implemented with inputs obtained from an involvement of the public, including community organizations and private landowners.

**Grounded in the Principles and Practices of Diverse Professions** - Like the design and planning of our transportation, water, sewarage, electrical and phone systems, green space systems should be based on sound science and should build on the knowledge of professional disciplines such as landscape ecology, urban and regional planning, and landscape architecture.

**Funded Up-Front** - Like other infrastructure systems, our green space systems need to be funded upfront as a primary public investment. In other words, green infrastructure should be funded with other essential services, rather than with money that is left over or flinched from other services that have been provided.

Green infrastructure planning should take place at all levels and scales: from the individual parcel, to the local, regional and statewide scales. At the parcel level this could mean designing homes and businesses amidst green space. At the community level this could mean creating greenways to link existing parks. And at the wider statewide level this could mean protecting broad wildlife movement corridors to connect and defragment state and national forests.
Six guiding principles and strategies have been identified as critical to the success of green infrastructure initiatives. Taken together, these principles provide a strategy or framework for conservation or sustainable use of land while providing an interconnected system of green spaces that benefit people, promote wildlife and the general economy. They are intended to help provide design, planning, acquisition and other decision making guidance for community-based sustainable development. There are seven principles identified:

- Green infrastructure should be the bulwark for conservation and development.
- Design and plan green infrastructure in advance of other development elements.
- Linkage is the key.
- Green infrastructure functions across multiple jurisdictions and at different scales.
- Green infrastructure is grounded in sound science and land use planning theories and practices.
- Green infrastructure is a crucial public investment.
- Green infrastructure involves diverse stakeholders.

According to Lynda H. Schneekloth (2001) the green infrastructure of a city consists of those parts that contribute to the natural process of keeping water and air clean and of recycling of waste. It includes the parks and wild lands, stream corridors, utility corridors and vacant regenerating sites. These elements of city property, if considered as a single system similar to transportation or waste treatment, offer opportunities for keeping our cities clean and beautiful and for providing recreational space.

Benedict and McMahon (2000) state that –

- “Where-as green space is often viewed as something that is nice to have, the term green infrastructure implies something that we must have. Protecting and
restoring our nation’s natural life support system is a necessity, not a mere amenity.

- Where-as green space is often thought of as isolated parks, recreation sites or natural areas, the term green infrastructure emphasizes interconnected systems of natural areas and other open spaces that are protected and managed for the ecological benefits they provide to people and the environment.

- Where-as green space is often viewed as self-sustaining, the term green infrastructure implies something that must be actively maintained and at times restored.”

According to Schneekloth H. Lynda (2001) green infrastructure performs ecological, recreational and aesthetic functions. It improves the quality of the urban environment, provides access to natural habitats, avoids damage to the built form and in general contributes to keep all healthy. In the context of this study the emphasis will be on the recreational and aesthetic aspects of green infrastructure.

The functions of green infrastructure are:

**Air Quality Improvement:** Vegetation reduces air pollution as it filters dust particles and pollutants attached to them. Through photosynthesis, carbon dioxide is reduced and oxygen liberated.

**Microclimate Modification:** Nonporous urban surfaces absorb and hold heat during warm weather contributing to the heat island effect wherein temperatures can be between 8-10% higher than the areas with porous soil or water pervious surface. According to Lawrence Berkeley Laboratory (2002) the green infrastructure of a city is a natural air conditioner, the greater its cover and canopy, the greater the benefits. If strategically planted, trees serve as windbreaks, in part by lifting strong seasonal winds up and over the leeward structures and by breaking down strong wind patterns.

**Storm water management:** One of the most important benefits of the green infrastructure is in naturalizing the hydrological cycles in a city. The hard surfaces of the urban fabric increase the intensity of the run-off and the amount
of pollutants in urban waters. Instead of water soaking into the ground, it runs off quickly into storm drainage systems that flow into rivers and streams, causing increased flooding and erosion. The green fabric, on the other hand, absorbs water at the source, recharging groundwater, filtering pollutants, and slowing down the run off of water. This improves water quality, controls soil erosion, and is cost-effective. The availability of ground water increases and this helps as sources water become dispersed.

**Biodiversity**: The urban environment is home even to several other creatures than human beings, and one might notice that the more we encourage wildlife in the city environs at appropriate places, the more varied and enriched will be the quality of life. A rich variety of birds and animals is an indicator of a healthy environment. Wildlife in the city moves through riparian corridors along rivers and streams and large parks having native vegetation. The health of these habitats, however, depends to a large extent on their size and connectivity - one of the reasons for doing a green inventory of a city is to locate significant areas for wildlife habitat, sanctuaries and corridor links between natural conservation systems.

**Recreational opportunities**: One of the most frequent, visible and important functions of the green structure is for recreation, e.g., in addition to using riparian corridors as flood and erosion control and habitat links, these are prime areas for bicycle trails and nature hikes. Major parks, with large and diverse ecological endowments, provide space for active recreation and sports fields, but also for passive recreation, bird watching and school field trips for science classes. Each part of the urban green fabric should be considered as a multi-use structure. (Schneekloth H. Lynda, 2001, pp 7.4.2)

Land use categories that contribute to the green infrastructure include parks, waterways, cemeteries, church and school open spaces, city farms and community gardens, utility corridors, rail lines, quarries, vacant lands and even brownfields, which need to be identified and hopefully remediated. (ibid)

Regulatory provisions exist for the preservation of green space such as setbacks, easements, special review districts, public ownership, and so on. (ibid)
Two complementary urban design strategies—less paving and more vegetation—help increase the viability of the green infrastructure. Soil absorbs rainfall and nurtures flora, fauna, and humans, but impervious surfaces increase runoff, causing erosion and flooding, depleting subsoil water, and contributing to siltation and water pollution. A corollary to the principle of minimizing urban hardscape is to replace impervious surfaces with more water absorbing materials. One of the most obvious is vegetation. (ibid)

Site planning policies can help to avoid unnecessary paving. Some opportunities include:

- **Density zoning.** Local policy that uses overall density (a number of units per acre, or a percentage of acreage devoted to structures) works better than minimum lot sizes, because it allows flexible adaptation to site topography.

- **Cluster development.** Placing several buildings together surrounded by open space, rather than each in the center of its separate lot, can greatly reduce infrastructure costs, including paving.

- **Combined land uses.** Zoning that allows residences and workplaces to coexist makes walking, biking, or public transit much easier for workers. This is often a matter of removing barriers to coexistence from existing zoning laws.

- **Impervious surface limits.** Set a maximum percentage of the site area that can be made impervious. This must include both paved and roofed areas, existing and new. Where this level is set to 10% or lower, streams and other hydrological features of the area can be considered protected. Above 10%, impacts are serious enough to require mitigation; and where 30% of the area is impervious, degradation of the ecosystem is almost sure. In urban areas already far exceeding this threshold, incentive programs for reducing impervious cover can be effective.

This study of impervious and in contrast absorbing surfaces is important. The details about norms and their evolution have to be worked out. Proportion of these two types in individual land use norms – in small, medium and large private residential sites, multistoried apartments, public buildings, industrial and business establishments etc. -
have to be considered. Are these differentiated rules? How are they being arrived at and enforced? The bio-ecological and technological bases for these are all interesting. And could be a good piece of research for other researchers in the same domain.

- **Street width limits.** Oversized roads also have negative effects on traffic safety and diminish the quality of life for communities through which they pass. Current research shows that they are the cause of most accidents, and especially of serious injury accidents, is speed itself, and that wide, straight, flat roadways encourage drivers to speed.

- **Planted islands in turn-arounds.** Paving the center of a turn-around is of no use to drivers and can be replaced by permeable, planted surfaces as a matter of policy.

- **Pollutant collector.** These include paving at gas stations, carwashes, dumpster pads, and other point sources of concentrated pollutants. Isolating run off from contaminated sources keeps the flow on ordinary streets much cleaner.

- **Storm drain inlet labeling.** Knowledge of where pavement run-off goes can decrease public dumping of pollutants onto pavement and into drains. (ibid)

Moll and Young (1992) summarize the economic worth of a tree. “A single tree would provide this much-dollar value benefit for one year: air conditioning, $73; controlling erosion and storm water, $75; wildlife shelter, $75; and controlling air pollution, $50. The total is $273 a year. Compounding this amount for fifty years at 5%, the grand total is $57,151.”

This perception is very rational, relevant and appropriate. The basis of these quantifications, long term and short term valuations has to be attempted. Indian specifics have to be worked out as devices to assess contributions from possible green assets by other researchers working in the same domain.

Schneekloth H. Lynda,(2001) states that although there is much controversy about an exact definition of native plants, the general idea is to use plants that grow sustainably in a region either because they have been there for a very long time, co-evolving with insects, soils, animals and other plants, or that have “naturalized,” that is, have found a
niche to occupy. Native plants are more sustainable because they are adapted to local conditions, and they attract a diversity of birds, butterflies and animals because they are a known food source.

From the point of view of augmenting green endowments in a certain bio-geographic habitat, preference to sustainable local species of plants and animals is natural and obvious. But, there are biotechnology needs and these are being discovered and optimised; for example bio-detoxification of effluents. This entails resorting to raising of non-local species suitably and possibly hybridisation too. And these are matters of specialised bio-ecological-technological studies and research. And not immediately relevant here and may be taken up by students and other researchers.

Plants “can perform a number of functions better than any technological equivalent yet invented, notably in bioengineering and in cleaning up air, water, and soil pollutants. Because of their essential role in making life possible, as well as the social and financial costs of raising them, cultivated plants are too valuable to abuse” (Thompson and Sorvig 2000, p. 129).

Schneekloth H. Lynda, (2001) suggests that beyond (or instead of) the curb, install grassed or vegetated areas called bioswales—linear, planted drainage channels. A typical bioswale moves storm water runoff as slowly as possible along a gentle incline, keeping the rain on the site as long as possible and allowing it to soak into the ground—contrary to conventional engineering practice. At the lowest point of the swale, there is usually a raised drain inlet that empties any overflow (during particularly heavy storms) into the nearest waterway. Along with the infiltrating function, bioswales cleanse runoff via their plants and soil microbes.

Robinette (1972) in his studies has given the following characteristics of plants and their role in solving environmental engineering problems:

- Fleshy leaves deaden sound.
- Moving and vibrating branches absorb and mask sounds.
- Pubescences on the leaves entrap and hold dust particles.
- Stomata in leaves exchange gases.
• Blossoms and foliage provide pleasant smells to mask odour.
• Leaves and branches slow down wind movement.
• Leaves and branches slow down rainfall.
• Spreading roots hold soil against erosion.
• Dense foliage blocks light.
• Light foliage filters light.
• Spiny branches deter human movement.

Robinette in dealing with “Plants and their Environmental Functions” (1972) has dealt with the environmental architectural functions of plants, which in brief are as under (along with some definitions of terms used by him for the various uses of plants).

‘Closure’ is using plants to finish off a space that has been left open.

‘Containment’ is providing a small space within a larger space.

‘Enframement’ is a technique used to draw attention to the most important space in the area.

‘Linkage’ is a technique used to join one space with another to make a larger area seem smaller and less alien.

‘Enlargement’ is a method of changing the apparent size of a large space by contrasting it to an infinite space of the skyscape and making it seem smaller in comparison.

‘Reduction’ involves the placement of plants in an overly large space to make the space smaller. Plants may be used to subdivide or divide space either horizontally or vertically to reduce the apparent size of the space.

In ‘space articulation’ plants can be used to subdivide space three dimensionally.
“Plants can also be used to break larger spaces into smaller, irregular or rhythmically distinguishable units.”

“Trees and shrubs are often used in homes and building settings to articulate or define entrances” in functional realization to provide direction or channel movement.

Plants provide screening for privacy and viewing. Judicious selection of plants is needed for screening or viewing, which may be necessary perhaps for a part of the year or all the year through. Junkyards, transformer installations and other disturbing units need to be kept out of view. Trees and shrubs do this job of screening.

“Screening can be both negative (blocking ugly surroundings, from view) or positive (enhancing surroundings)” (Grey and Deneke, 1978).

Neginhal S.G opines that man has used plants-trees, shrubs, herbs and climbers – since ages for their aesthetic appeal. They add beauty in all the circumstances of man’s living and provide naturalness to the otherwise man-made artificial, architectural constructions. The plants go on changing their leaf colours and shades in different seasons. They put on beautiful, coloured, scented, attractive flowers and add freshness and naturalness to our surroundings. The rustling of the leaves, and whistling of the wind when it passes through the plants (like the breeze passing through a grove of casuarina trees) add to our enjoyment and feeling of contacts with primal nature. Birds, butterflies and arboreal animals visit the trees for the flowers- nectar and fruits. These blessings of plants for men provide a feeling of dwelling among animate objects otherwise brimming with inanimate world. Trees also provide a feeling of solitude, if one is surrounded by vegetation. Grey and Deneke (1978) rightly say, “Needless to say, the city would be a forlorn place to live, if it were not for trees.”

Greenwalls and hedges offer effective alternatives to conventional landscape retaining walls of cast-in-place concrete, metal, or wood. A vegetated surface suits many functions and aesthetic preferences: it deadens and diffuses noise, makes graffiti impossible, cuts heat and glare, holds or slows rainwater, traps air pollutants, and processes carbon dioxide, while providing food and shelter for wildlife. Most greenwalls use small, light elements, installed without heavy equipment. Many require reduced materials, no formwork, and for some types no footings, saving money and
materials. Most deal flexibly with unstable soils, settling, and deflection—even earthquakes. Careful attention to irrigation and microclimate is richly repaid.

The choices for greenwall structures include: Block, Crib wall, Frame, Trough, Gabion, Mesh, Cell, Sandbag

Design considerations for greenwalls include:

- Microclimate on any vertical surface depends on compass orientation and is usually severe - hot/sunny, cold/shady, or alternating daily.

- Irrigation can be by spraying onto the wall, channeled down from the top, or (using drippers) run on or behind the face.

- Soil mix and plant selection are critical.

- Especially if the greenwall covers a building, plan scrupulously for maintenance of the underlying structure.

- Costs are often twenty-five to fifty percent less than cast-in-place concrete, but they can only truly be compared design by design.

- Be sure to plan for maintenance during plant establishment. (ibid)

In the words of Toronto environmental designer and author Michael Hough, every contemporary city has, “hundreds of acres of roof tops that for the most part lie desolate and forgotten.”

Schneekloth H. Lynda,(2001) states that roof gardens—at least as conventionally seen as rare exceptions and thus of minimal effect in most urban areas—do not adequately address the problem of sterile roof expanses. Conventional roof gardens are typically prohibitive to place on existing roofs, due to the added weight of earth required.

There are alternatives to conventional roof gardens that address the issues of low maintenance, hardiness and light weight. Variously known as eco-roofs, green roofs, or extensive roof gardens (in contrast to conventional intensive roof gardens). Eco-roofs typically cover the entire roof of a building with a continuous layer of growing medium, as thin as 50 millimeters (about 2 in.), that supports low maintenance
vegetation. They are not intended to be walked upon and generally do not intend pedestrian access. (ibid)

The requirements of an ecoroof are relatively modest, yet the environmental benefits are considerable:

- Improves the building’s thermal insulation.
- Reduces the urban “heat island” effect, by absorbing less heat.
- Produces oxygen, absorbs carbon dioxide, and filters air pollution.
- Stores carbon.
- Provides scope as wildlife habitat, especially for birds.
- Absorbs up to 75% of rain falling on it, thus slowing storm water runoff. (ibid)

Dr. Ian C. Mell states that whilst the specifics of green infrastructure development differ spatially and geographically, there is a growing consensus in assessing what it can achieve, and how it should develop. (http://journalofbiourbanism.files.wordpress.com/2013/01/ibu1_2011_mell.pdf Accessed on 21/04/2014)

Gill et al state that “The urban environment has distinctive biophysical features in relation to surrounding rural areas. These include an altered energy exchange creating an urban heat island, and changes to hydrology such as increased surface runoff of rainwater. Such changes are, in part, a result of the altered pattern of surface cover of the urban area. For example less vegetated surfaces lead to a decrease in evaporative cooling, whilst an increase in surface sealing results in increased surface runoff. Climate change will amplify and unfold these distinctive features.” They highlight the role of green infrastructure in adapting for climate change. (GILL S.E., HANDLEY J.F., ENNOS A.R., S. PAULEIT, Adapting Cities for Climate Change: The Role of the Green Infrastructure, Gill_Adapting_Cities.pdf)

According to Tzoulas et al “studies suggest that a complete Green Infrastructure may have a considerable potential for improving the health of urban residents. This assertion is based on the plausible speculation that environmentally induced changes in physiological, emotional and cognitive processes may produce changes in well-being
and health. Although subjective effects have been found more studies are needed to objectively quantify health benefits from Green Infrastructure. Even those studies with the best controls regarding socio-economic factors cannot compensate for the array of personal, temporal and cultural factors that also affect human health. Hence, despite accumulating evidence on the relationships between components of the Green Infrastructure and health, causal relationships are not easy to establish and quantify. However, sufficient evidence prevails to draw the conclusion that a Green Infrastructure is a significant positive public health factor”

(Tzoulas et al, Promoting Ecosystem and Human Health in Urban Areas using Green Infrastructure: A Literature Review, Tzoulas et al 2007.pdf)

McDonald et al assert that “As green infrastructure plans incorporate ecosystem and land-use components and processes over space and time, green infrastructure plans must focus on landscape scale approaches to conservation planning.”


Baycan-Levent, Tuzin et al, published an article Urban Sustainability and Green Spaces (2004) which deals with urban environmental quality. It is of perennial concern and anxiety in many countries. After the first wave of interest, notably regarding the problems of pollution of air and water, we witness now a new surge of interest in man-made nature in the form of urban green. More emphasis on urban green may prompt the emergence of innovative planning concepts in cities.

Vigil’s paper Environment of Urban Areas in India: An Ecological Approach to its Management (1997) highlighted that environment has always been a vital factor of life. He has touched upon different aspects of ecological approach to environment including greening of the city. The trees have a great capacity to emphasize or herald the presence of nature in the built-environment.

The collective work of Robert D. Brown, a landscape Architect and Terry J. Gillespie, a professor of Land Resource Science show in their book Microclimatic
Landscape Design discussed how to work with nature to create climatically pleasant spaces for human activities. With remarkable clarity, it covers both the scientific background and the design techniques needed for shaping spaces that increase comfort and reduce energy consumption.

Design with Nature (1967) by McHarg, L. Ian has done much to redefine the fields of landscape architecture, urban and regional planning and ecological design. It offers a practical blueprint for a new healthier relationship between the built environment and nature. Two chapters in the book discuss about nature in the metropolis. Lewis Mumford, introduces McHarg as a competent ecological planner who is aware of the destructive role that man has often played in changing the face of the earth and the constructive environmental design and scientific insight, which is the unique contribution of this book.

Platt, H.R. discusses ‘the enigma of open spaces’, in his book The Open Spaces Decision Process: Spatial Allocation of Costs and Benefits (1972) puts forth his proposal for a concept in the field of urban and regional planning which is at once so pervasive and surprising. Frank Lloyd Wright, Le Corbusier and Ebenezer Howard have discussed preservation of open spaces and natural ecology by local authorities in this book along with the ideologies of open spaces. The book discusses the process of urbanization or “intensification” of land use which implies drastic and even permanent alteration of its previous condition. It mentions that land may get eroded, desiccated, flooded, encased in concrete or mined and transported away. In the process, the capability of the particular land to support life and sustain ecological processes is likely to be impaired and even irreparably destroyed. Rutherford, questions the connotation: “loss of open spaces” and its varied guises as applied to different functions of land. For instance, does paving of agricultural land for making a highway destroy ‘open spaces’? For a Developer, open spaces means playgrounds and parking lots and ribbons of trees while a conservationist may be using ‘open spaces’ to mean an undisturbed nature sanctuary, enabling a sustenance of symbiotic links.

The author probes into the underlying nature of open spaces as an economic rather than as a design concept. The nature of open spaces is approached through a series of theoretical inquiries in planning, economics and law. The decision as to whether a
piece of land is retained as open space or is developed, is analyzed in a series of case studies.

**Miller** has published a book *Urban Forestry: Planning and Managing Urban Greenspaces* (1997) which discusses how to plan for, establish, and manage urban and community trees, forests, and other elements of nature in the urban ecosystem. He emphasises that trees and related vegetation have long been planted in cities is for a variety of reasons. During the past few decades individuals and society have placed an increasing emphasis on urban vegetation in an attempt to improve the quality of life in our city communities. Trees line city streets, fill residential yards and vacant land, surround factories, and are the most dominant feature of most parks and other green spaces. Trees exist in cities in accordance with a careful design and cultivation, by poor or no design, and by accident and neglect. Or, tree planting witnesses various degrees of attention as well as indifference and lack of planning.

Part 1 discusses why we have trees in cities and how we use them; Part 2 deals with appraisal and inventory of urban vegetation; Part 3, the final and most extensive section, addresses planning and management. Planning and management find strong application to public vegetation, especially street trees, part vegetation, and forested green belts. This book is meant to serve as a textbook for students of urban forestry and to serve as a reference book for city foresters, green belt managers, and commercial and utility arborists.

**Gardens in the City – New York in Bloom** (1999) contains scintillating photographs and fascinating details that reveal the diverse and often hidden landscapes of New York City. It brings to the world’s attention many historic gardens as well as many exciting new ones. The author has categorised gardens into different types such as the city garden, roof gardens, gardens in parks, along the avenues, museum gardens, historic house gardens, gardens at the office, hidden enclaves, community gardens, front yards and backyards, dining terraces and botanical gardens. The designed garden brings a special kind of visual pleasure, a certain sense of order, and the refreshment of nature to urban life. The green textures, vivid and tender colors, fascinating combinations of plants with other natural materials give both public and private gardens a vitality and beauty that adds immensely to the enjoyment of city living.
The author has noticed that gardens are growing on rooftops and in yards, along the avenues and in parks, in fine botanical gardens that work to protect the world’s natural environment, and in scores of community gardens that enhance their neighborhoods. There are gardens as expression of arts, gardens at the office, gardens at dining enclaves, gardens that are part of history, and gardens of the avant-garde that look to the next century. Each of the more than one hundred examples shown in this volume has its own distinct style and spirit, dramatizing the content.

**Swarup, Vishnu’s** book *Garden Flowers* (1997) is to acquaint the flower growers, particularly the amateur gardeners, with the different kinds of garden flowers, their uses in gardens and their methods of cultivation. The popular as well as Latin names of each flower, the botanical family to which it belongs and the place of its origin has also been mentioned. A few chapters in the beginning deal with the aesthetic and economic importance of flowers, the various kinds of flowers grown in gardens, a short history of flowers and of gardening in India and the important flowers that are natives of India.

**Laeeq Futehally** has written a book *Gardens* (1998) that discusses the importance of gardens and its aesthetic values and also a garden must be a functional place, a place where people can move or be still, and where children can run, play, climb trees, swing on branches etc. The author discussed the principle of garden design such as unity, spaces divisions, scale, time and light, shade, texture, tone and color, movement and style. The book has been divided into four divisions – principle of garden design, materials of garden design, industrial gardens and public gardens. The author has made an attempt to communicate at the level of values rather than of facts.

**Hough, Michael’s** book *Cities and Natural Process* (1995) deals with new and constructive ways of looking at the physical environment of cities. An alternative basis for urban landscape form is urgently needed, one that is in tune with, and will support, a growing environmental awareness of cities and nature.

**Handbook of Urban Landscape** (1981) edited by The Architect’s Journal Technical Section is intended as a desk-side guide for all designers of urban spaces, including architects, planners and engineers - and for students of these professions. Reviews on current trends in landscape design for urban situations - including housing, parks and
open spaces recreation, children’s play and gardens – are followed by a design guide on procedure with reference to the later information sheets and other publications used in designing and landscaping spaces.

Ian Laurie’s edited work *Nature in Cities* (1979) makes an attempt for increasing recognition of nature and the natural environment as the quality of life has brought about a growing awareness of the inadequacies of the natural environment in our cities, following large scale redevelopment, spreading urban growth, and the construction of huge new buildings. All too often nature has been ignored and driven out of urban areas by such changes, and any re-emergence is repressed rather than encouraged.

This volume of international contributions by leading landscape designers, biologists, and urban planners reflect this concern about natural urban environments, and brings together new design principles, which arise from fundamental man–nature relationships and from existence in cities where a diverse and balanced relationship has been established between the built and natural environments. These principles and examples are fully illustrated with photographs, drawings, plans and diagrams and the message of this book is that improved natural urban environments are possible, through positive planning and better techniques of urban space development and control.

Neginhal’s newspaper article “Flame of the forest” (2002) suggested that Gulmohur makes an attractive avenue tree. It should be planted on broader roads and in gardens and parks. In the month of May most of our streets seem to be on fire with masses of flowers of the May Flower Tree. The author has given the meaning of this tree in different Indian languages. In Hindi ‘Gul’ means ‘Rose or flower’ and ‘mor’ is the common name of the Peacock, which refers to its colourfully spread flowers. Hence it is called Gulmohur in Hindi. In Mumbai it is also called ‘Pentecost Tree or Holy Ghost Tree as its peak flowering season occurs around the time of the feast of Pentecost, fifty days after Easter. It is known as ‘Kattikai Gida’ in Kannada alluding to its long hanging fruits akin to swords. There is a great variation in the colors of the flowers, from orange red to scarlet. The deep scarlet colored flowering tree, however, is more spectacular and planting cuttings propagates the variety. The Author recommends that its surface spreading roots are likely to damage the buildings nearby.
so it should be planted on broader roads and in gardens and parks, away from the buildings. The tree is also prone to wind damages, when it is old. So tree maintenance and surgery is necessary for the upkeep of the tree in later years to prevent snapping of branches and uprooting of trees.

Kushala reported “New by-laws make rain water harvesting a must in every home” (2002), that solar water heater, rain harvesting system in commercial and residential constructions, earthquake-resistant buildings, two trees in every house, disabled friendly measures in buildings - this will be the new order once the provisions are made mandatory in future constructions in Bangalore.

The existing building by-laws of Karnataka Municipal Corporation Act will be amended and made applicable exclusively for the city, under a new name: the Bangalore City Municipal Corporation Building by-laws of 2002. The BCC has already approved the amendments. While granting license, the authority will insist on at least two saplings being planted and trees grown on sites where the site area exceeds 300 square meters. The provisions include the installation of solar water heater in all buildings for which permission will be given in accordance with the type of use and 100 liters of water provided for every unit.

A piece of research work like this depends on related knowledge domains and more specifically landscape design and landscape architecture. According to Dee, Catherine landform is perhaps the most fundamental element in landscape architectural design. Natural and artificial topography can be manipulated, modified, or conserved to fully or partially enclose space. The effect of gravity means that human beings consistently seek to create flat or horizontal spaces for many activities, including building, dwelling and a wide range of social, cultural and recreational activities. The designer must often decide how much intervention there should be to alter the natural or existing topography. Thus existing topography exerts a powerful influence on design forms and solutions. Parkland refers to large open grassy spaces scattered with individual trees or clusters of trees, usually naturalistic in form and with rolling topography.

She further states that the landscape architect must, be sensitive to the effects of topography on people’s choice of route. People often prefer to walk on steeply-sloping
ground rather than use steps with high risers, and will also make short cuts if a path on sloping ground appears to be too indirect. As with topographic space design, landscape architects must decide on how much to intervene and change existing topography in path design. Paths may make small interventions in natural topography and accommodate the lie of the land or require dramatic re-modelling of the existing landform. Ridge paths form routes raised on both sides above the surrounding topography. In their use, pleasure is derived from the prospect they allow in all directions and the feeling of exposure to wind, sky and sometimes water. Ridge paths can enclose and define space. Ridge path networks are developed on and are distinctive to wetland landscapes.

In natural environments, vegetation, soils, climate and topography combine to form distinct landscape types, patterns and habitats. These change over time and space and therefore do not have abrupt physical edges but instead are bound by transitional zones where one landscape gradually becomes another. These transitions can occur over kilometres or metres and are known as ‘eco-tones’. It is important for designers to understand these eco-tones for aesthetic and environmental reasons. They provide visual as well as ecological richness, dynamism and complexity.

Artificial and natural depressions in topography can act as foci, attracting people to sheltered or hidden ground. Bowls or craters provide distinctive microclimate and form in contrast to surrounding land. Natural topographic depressions may be modified for focal cultural functions such as theatre or the siting of sculpture. Artificially created bowls in public places often need clear purposes and gentle sides to avoid ‘pit-like’ characteristics.

Buildings can be sited and designed as landmarks in places. They can contrast with or accentuate topography and can also dominate high places. They are commonly endpoints to axes of paths, water, vegetation, or terraces. In form they can be a counterpoint to a landscape’s character and forms. Landscape and architecture can suffer when buildings are created as focal forms in inappropriate contexts.

As a space-forming element topography can be manipulated to create thresholds between two spaces or to provide for hilltop earth–sky thresholds. Passing between landforms or walking up and over topography and resting at the top or bottom creates
a sense of arrival and separateness. Topography can obscure places beyond and thus create a feeling of anticipation.

The above is an interesting piece of literature and opens up further avenues of research exploration emphasising topography. This is beyond the scope of this research work and may be pursued by other students and researchers.

Vegetation is a key as well as the most visible element of green infrastructure and a primary medium of landscape architecture not only for its aesthetic and structural properties and meanings but also for a wide range of environmental reasons. According to **Dee Catherine** as part of ecosystems, plants form habitats for wildlife and people and contribute to biodiversity, particularly in urban areas. They clean the air and positively influence the climate for human comfort and health. Being renewable, plants are major ‘components’ of sustainable living; providing food, building materials, fuel, medicines and chemicals.

Vegetation occurs naturally and is often used in the ground plane in design. Landscape architects select species and management approaches appropriate to context, visual function and use. Floor vegetation can unify a space through the simplicity of a few dominant species (for example, lawn or moss) or through pattern and species repetition. By incorporating vegetation in the sky plane, designers can provide memorable landscape experiences. Leaf canopies create a distinct character of space which attracts people to shelter and stay especially in sunny weather.

Ecological ‘corridors’ are important path concepts for urban landscape planning. Linear linking spaces of vegetation and water between built environments allow flora and fauna species to move, reproduce and colonise freely. Ecological corridors can form networks across cities, link to countryside and, if large enough, also provide recreational paths and resources. Vegetated paths provide highly sensory experiences. In addition, vegetation can play important structural and spatial roles forming paths by emphasising direction, thus separating or integrating paths with adjacent spaces. Roads in particular can be integrated into rural and urban contexts, and environmental effects can be mitigated with vegetation. Vegetation can also play way-marking, sequential, rhythmic and focal roles in paths.
Vegetation is a vulnerable surface in places of heavy public use. In less intensely used recreational places it is always desirable if management resources are available and climate allows. Vegetation can play important structural roles at entrance places for example with symmetrical arrangements or enclosure by hedge forms. Scented plants may be exploited at gateways. Vegetation also plays important sensory roles in places of rest or calm.

Vegetation can be arranged to frame views of more distant landscapes or landscape components, particularly foci. Tree canopies or vegetation trained on pergolas form overhead or complete frames. The complex and soft texture of foliage and branches ‘locks’ sky and distance into the immediate ‘space’ of the viewer, thus bringing them closer, mediating and giving scale to distant forms. A very important dimension in considering the detail of vegetation in design is the effect of linear and cyclic time. Plants change in habit, texture and form over time as they grow and change according to season in temperate climates. Plants are also dynamic in character as they move in the wind.

Water is a key resource for green infrastructure as without water there can be little or no vegetation! As per the National Building Code of India the surface water flow is increased in urban areas due to predominance of hard surfaces. Storm water management techniques assure conservation of water thereby increasing the potential ground water recharge. Filters facilitate draining pollutants out from surface water runoff through straining before discharge into the drainage way. Rain-water harvesting and sullage recycle systems need to be implemented on all new constructions over 1000 sq.m in urban areas. Water harvesting refers to the collection and storage of rain-water and also harvesting surface and ground water, prevention of loss through evaporation and seepage, and other hydrological and engineering interventions aimed at conserving water. Methods of ground water recharge maybe as follows: Recharge pits, Recharge trenches, Re-use of abandoned dug wells, Re-use of abandoned hand pumps, Recharge shafts, Lateral shafts with bore wells, and spreading techniques like percolation ponds, check dams or gabion structures.

A swale is a linear wide and shallow depression used to temporarily store, route or filter runoff. A swale may be grassed or lined. Bio-filtration swales and grass swales are vegetated channels with a slope similar to that of standard storm drain channels.
(less than 0.6 percent), but wider and shallower to maximize flow residence time and
promote pollutant removal by filtration through the use of properly selected
vegetation. It has to be designed to trap particulate pollutants (suspended solids and
trace metals), promote infiltration and reduce the flow velocity of the storm water
runoff. It shall be integrated with storm water system

Storm water wet lands are structures similar to wet ponds, which incorporate wetland
plants into the design. They have to be designed for treating storm water runoff, and
typically have less bio-diversity than natural wetland systems. A distinction should
be made between using a constructed wet land for storm water management and
diverting storm water into natural wetland. The latter is not recommended because it
would degrade the resource.

Wells, intended to supply water for human consumption or domestic purposes, where
provided, shall comply with the requirements of : The well shall be located:

a) not less than 15 m from any ash pit, refuse pit, earth closet or privy and shall be
located on a site upwards from the earth closet or privy;

b) not less than 18 m from any cess pit soakway or borehole latrine and shall be
located on a site upwards from the earth closet or privy; ‘

c) that contamination by the movement of sub-soil or other water is unlikely; and

d) not under a tree or otherwise it should have a canopy over it, so that leaves and
twigs may not fall into the well and rot.

In a building, provision is required to be made for storage of water for the following
reasons:

a) to provide against interruptions of the supply caused by repairs to mains, etc;

b) to reduce the maximum rate of demand on the mains;

c) to tide over periods of intermittent supply; and

d) to maintain a storage for the fire fighting requirement of the building
The water may be stored either in overhead tanks (OHT) and/or underground tanks (UGT).

Where a septic tank is used for sewage disposal, the location, design and construction of the septic tank shall conform to requirements of : A sub-soil dispersion system shall not be closer than 18 m from any source of drinking water, such as well, to mitigate the possibility of bacterial pollution of water supply. It shall also be as far removed from the nearest habitable building as economically feasible but not closer than 6 m, to avoid damage to the structures.

Waste- Water (sullage) is the discharge from wash basins, sinks and similar appliances, which does not contain human or animal excreta. Treated sewage or other waste water of the community may be utilized for non-domestic purposes such as water for cooling, flushing, lawns, parks, fire fighting and for certain industrial purposes after giving the necessary treatment to suit the nature of the use. This supply system shall be allowed in residences only if proper provision is made to avoid any cross connection of this treated waste water with domestic water supply system.

Efficient collection and disposal of domestic garbage from a building or activity area is of significant importance to public health and environmental sanitation and, therefore, an essential part of the construction of the built environment. The gated community being privately developed and located in the suburbs the preceding directive of NBC (2005) is important for the community to develop and maintain its own waste management system.

Vegetation is the most visible element of green infrastructure. According to Dee, Catherine vegetation also plays an important ecological and environmental as well as recreational role in greenways or ecological corridors. Ecological ‘corridors’ are important path concepts for urban landscape planning. Linear linking spaces of vegetation and water between built environments allow flora and fauna species to move, reproduce and colonise freely. Ecological corridors can form networks across cities, link to countryside and, if large enough, also provide recreational paths and resources.

Paths are adopted and made to enable people and wildlife to travel easily between and within places. Paths are not only places of movement but, for example in cities, streets
become social and recreational places. Paths are also places of recreation when they are travelled for pleasure. In design, the landscape architect considers both movement for pleasure and necessity alongside the static social activities that may occur and can be facilitated on paths. Good path design is thus a primary method of enabling and encouraging access and enjoyment of the landscape. Wide paths – particularly urban streets and promenades – are potentially more than just places of movement and can therefore be designed as spaces that facilitate static activities. Busy urban streets are places for sitting, buying selling and performance. Long linear spaces can be designed to function simultaneously as paths and spaces. The landscape design of streets is primarily concerned with detailing the space between buildings, but it may also involve working at earlier stages with urban designers or architects and engineers to develop concepts and strategies for networks and building space relationships. Pedestrianised streets and pedestrian zones on vehicular roads offer great potential as recreational ‘green spaces’. ‘Back streets’ and pedestrian-only paths are important paths in urban environments as they provide quieter alternative routes and settings for domestic and recreational activities.

Different users, uses and modes of transport have diverse design requirements. Landscape architecture involves the consideration of different modes of travel and also of different users and means of accommodating these and reducing conflict between them. In many urban landscapes the designer must resolve conflicts between motor vehicles and pedestrians. Intensity and frequency of use of a path influence a designer’s choice of width, form and surface. Perceived and actual safety and security are also important factors in path design. ‘Desire lines’ are tracks worn across unsurfaced ground that indicate frequent pedestrian use. If a surfaced route has been made but does provide (or appear to provide) the easiest way, desire lines occur. Desire lines can also indicate where paths are needed. Path design not only involves the creation of individual paths but path systems or networks. Consideration must often be given to hierarchical arrangements in which intensively-used paths are designed and linked in different ways to those used occasionally. Different paths will have different functional purposes; some for direct access, others for slower meandering exploration of the landscape. The design of path systems involves the organisation of relationships of these different types of paths.
Sodhi, P.S. states that the efficient and successful choice of plants should be made on the basis of their design characteristics:

1. **Functional & Structural Characteristics:** Plants in combination and individually, create space beneath, between & sometimes within the bulk of their canopies. Plants create landscape structure, which both defines spaces and serves the required function.

   Trees, in the city are living building material used to establish spatial boundaries. They create spatial rhythms to heighten the experience of moving through the outdoor spaces, its ability to shelter, screen or shade, density of roof growth which will determine its ability to bind the soil and protect against erosion. Plants also provide a fitting environment for human activities while avoiding damage to ecology of the landscape.

2. **Visual & Other Sensory Aspects:** Plants offer an enormous wealth of aesthetic characteristics the appearance of their leaves, twigs, bark, flower & fruit, the fragrance of flower and aromatic foliage, the physical texture of bark & leaves even the sound of leaves when stirred by the wind or beaten by the rain.

3. **Plant Growth Habit & Cultural Requirement:** There is enormous diversity of size, habit foliage & other characteristics among the range of species; that helps to determine the habitat & ecological niche. In the first place, planting design can help us make the best use of our environment. Secondly, it helps to restore the balance between people, nature and in some extent to the wild life and finally it offers many opportunities for enjoyment of aesthetic delights.

4. **Plants and Their Uses:** Plants are positive design elements in any environment and they can enhance the environment, if used with proper understanding

   - **Trees (basic planting):** This relates to the contemporary requirement in landscape design for mass planting of large groups, woodlands, which with the topography or land form, produce the large scale spatial arrangement of the landscape. The species selected for this group should be hardy, vigorous in growth, indigenous for ecological reasons and exotics which have become established as part of local scene. *e.g.* - *Acacia auriculiformis, Lagerstroemia flos reginae (pride of india), Pterospermum acerifolium (kanak champa),*
Alstonia scholaris, Putranjiva roxburghii (jalpiti), Azadirachata indica (neem), Dalbergia sissoo (sheesham) etc.

- **Trees (special effects)**: Trees in this section should include those sufficiently individualistic, spectacular or strong in character to occupy the isolated positions, either because of these qualities or because they do not mix easily in visual sense with other trees. *e.g.* - Ficus bengalensis (banyan tree), Cassia fistula (amaltas), Bombax malabaricum (silk cotton tree), Cassia nodosa (pink javanica), Jacaranda mimosae (neeli gulmohar), Chrosia speciosa, Mimusops elengi (mulsari) Callistemon lanceolatus (bottle brush) etc.

- **Trees (barriers)**: Barriers formed with plants are needed in landscape for screening the unpleasant views, for dividing up the landscape into spaces, for providing shelter from wind, for protection against pollution, for defining boundaries and for assisting in the creation of beautiful landscape. *e.g.* - Casuarina equisetifolia, Grevillea robusta (silver oak), Ficus benjamina, Polyalthia longifolia (ashok), Putranjiva roxburghii, Schleichera trijuga (kusum), Golden bamboo etc.

- **Shrubs (basic planting)**: The use of shrubs in the mass as a basic constituent of the planting of Landscapes. It should have the qualities of hardiness, vigorous growth with a greater emphasis on evergreen plants. *e.g.* - varieties of Acalypha, Bougainvillea, Cassia biflora, Cassia alata, Duranta, Ficus panda, Euphorbia, Thevetia, Taberneamontana (chandni), Palms such as areca, china, phoenix, rhaps etc.

- **Shrubs (special effects)**: Similar principles of selection apply to this as for trees (special effects), but at the same time it should be noted down that a number of shrubs planted together can produce special effects specially at the time of flowering. *e.g.* – Caesalpinia pulcherrima (peacock flower), Calliandra haematocephala, Poinsettia, Mussaenda, Justicia, Ixora, Bamboo-buddha valley, Franciscea latifolia (yesterday, today and tomorrow), etc.

- **Shrubs (barriers)**: Impenetrability is essential unless the barrier is for visual purpose, thus the twigs or thorns are considered as an advantage. Other things
to consider are the ability of the plant to accept pruning, either to control growth or to produce topiary effects. *e.g.* – *Bougainvillea, Duranta plumieri, Duranta plumieri varigata, Duranta goldeana, Murraya* etc.

- **Shrubs (edging):** To outline the flower beds or other kinds of plants and to create line effects. *e.g.* – *Duranta goldeana etc.*

According to **Seem, Kamal Sudhir**, the success of landscape design with plants depends on how to choose the appropriate plants for a particular situation. Thoughtful selection of the trees, shrubs, climbers, bulbs, foliage plants, grass, groundcover and aquatic plants transform the barren landscape into meaningful landscape. Efforts should be made to select an appropriate plant material for the given situation based on the following criteria:

- Habit
- Colour
- Season of flowering
- Form
- Rate of growth and Environmental considerations.

**Trees:** The selection of trees should be based on season, size, form, situational preferences of surroundings and artifacts.

**Flower Colour**

<table>
<thead>
<tr>
<th>Colour</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td><em>Alstonia scholaris, Baiiasea minor, Magnolia pterocarpa</em> <em>Milingtonia hortensis</em> and <em>plumeria acutmaata.</em></td>
</tr>
<tr>
<td>Yellow</td>
<td><em>Cassia fistula, Bauhinia tomentosa, Saraca indica,</em> <em>Peltophorum pterocarpum</em> and <em>Tabebuia spectabilis.</em></td>
</tr>
<tr>
<td>Red</td>
<td><em>Bombax ceiba, Amberstia nobilis, Cassia marginata</em></td>
</tr>
<tr>
<td>Scarlet</td>
<td><em>Barningtonia monandra, Cassia pavarnica</em> <em>Crennigena,Kelnbovia hospita.</em></td>
</tr>
<tr>
<td>Purple</td>
<td><em>Lagerstroemia speciosa, Bauhinia purpurea, Melia azadirach,Pachira, rosea</em> and <em>Tabebuia rosea.</em></td>
</tr>
</tbody>
</table>
Orange, Red, Crimson, Scarlet: Butea monosperma, Colvia racemosa and spathpdea campanulata.

Blue, Mauve, Violet: Jacarpanda aquisatifolia, Guaicum officinale, Millenia avaliolia and Solanum grandugkirum

Greenish Yellow: Monodora grandiflora, Casealpnia

Creamy White or Yellow: Michelia champaca, Madhuca Indica, Magnolia grandiflora, and Terminalia Arjuna

**Season of blooming**

Ever blooming: Callisetermon lanceolatus, Mimusops elengi, Plumenia acuminata and Thespiesa populnea.

Winter blooming: Bauhinia purpurea, Butea monrosperama, Monodora grandiflora

Spring blooming: Tabebuia, Amheristia niobilis, Bombax ceiba, Jacaranda, Saraca indica, Spathodea

Summer Blooming: Erithrina indica, Cassia, Jacaranda, Lagerstroemia spp.

Rainy season Blooming: Plumeria alba, Anthocephelus cadamba, Barringtonia racemosa, Casia Marginata, P. rubra, Covillea racemosa

**Range of Tree sizes**

Dwarf trees (3 to 5m): Albizia lebbek, Bisantha, Bixca orellana, Brownera grande eps, Crodia sebestena. Wevthnia blackein Parkinsonia acuminata, Plumeria rubra.

Medium size (6 to 10m): Caesalpinia, Lagerstromia throreli, Melia azadirach, Plumeria acmnnata, Saraca Indica, Tabeulia spectabilis.

Tall tress (more than11 m tall): Peltophorum roxburghii, Bombax malabaricum, Cassia monisia, Chorisia speciosa, Jacaranda, Millingtonia hortensis, and spatholea campanulata.

Giant trees: Ficus bengalensis, Bombax ceiba, Colvillea racemosa.

**Growth Habit of Trees**

Oval: These plants are suitable for frame or screen. *Populus alba*, Albizza julibrissin, Crataeqs cerusoalli Cornus sp., Betula pendula Cassia fistula

Vase shaped: They can be used above the large shrubs or small trees. *Melia azadirach, Plumeria acutifolia, P.alba, P.obtusa, Saraca Indica, Almus Americana.*

Pyramidal: It can be used as an accent plant. *Pinus roxburghii, Araucaria cooki, Thuja compacta, Quercus palustris, Stercula foeditida, Polyalthia longifolia.*
Round:
These plants can be used in the lawn as specimen. 
*Plumeria alba*, *Chorisia speciosa* *Mimusops elengi*, *Morus rubra*, *Quercus*.

Columnar:
They frame the views and structure in the landscape setting. *Juniperus chinensis*, *Betula pendula*, *Quercus robusta*, *Eucalyptus robusta*, *Polyethia pendula*.

Weeping:
It can be used as a focal point.
*Salix Babylonica*, *S. alba*. *Putranjiva roxburghii*, *Callistemon lanceolatus* *Tecomelia*.

Round to spreading:
These plants mass well to create grove effect.
*Dalbergia sisso*, *Dillenia Indica*, *Ficus glomerata*, *Thespesia populnea*.

Fan shaped:
They can be used as a focal point.
*Cycus revoluta*, *Borassus fladellifer*, *Oredoxa regia*.

Trees with scented flowers:
*Anthocephilus cadamba*, *Alstonia scholaris*, *Cananqium odoratum* *Michelia champaca*, *Mimusops elengi*, *Dillenia indica*, *Gardenia latifolia*, *Custravia augusta*, *Magnolia grandiflora*, *Nyctanthes arbortristis*.

Wind Resistant trees:
*Eugenia jambolana*, *Caesalpinia pulcharima*, *Peltophorum pterocarpum*.

Salt Resistant trees:
*Azadirachta Indica*, *Acacia sp.*, *Butea monosperma*, *Azadirachta Indica*, *Bassia Latifolia*, *Eucalyptus citriodora*, *Phonix dactylofera* and *Phyllanthus emblica*.

Drought Resistant:

Wet Land trees:
*Nyctanthes arbortristis*, *Dillenia Indica*, *Michelia champaca*, *Saraca Indica*, *Thespesia populnea*, *Salix Babylonica*, *Eucalyptus eostata*, *Guaicum officinalis*.

Fast Growing Trees:
*Pongamia glabra*, *Sesbania grandiflora*, *Cananqium odoratum*, *Erithrina Indica*, *Thespesia populnea*, *Populus sp.*, *Salix sp.*, *Euclyptus sp.*, *Thuja compacta*.

Shade givers:
*Pteropsperum acerifolium*, *Albizzia lebbek*, *Peltophorum*, *Michelia champaca*, *Anthocephalus cadamba*, *Dalbergia sisso*, *Glyricidia Maculata acer sp.*, *Cornus florida*.

Trees tolerant to Dust and Smoke:
*Acacia auriculiformis*, *Alstonia scholaris*, *Butea monosperma*, *Ficus Benjamina*, *F. benghalensis*, *Madhuca Indica*, *Pongamia glabra*, *Ficus religiosa*, *Terminalia Arjuna*, *Albizzia lebbek*, *Bombax ceiba*. 

47
Trees for Noise Reduction: Terminalia Arjuna, Alstoniascholaris, Azadirachta Indica, Butea Monosperma, MangiferIndica, Madhuca Indica, Juniperus chinesis, Eucalyptus Citradora, Kigelia pinnata

As per the National Building Code (2005) the following criteria shall be considered in planting design:

1. Plant Material
2. Soil conditions
3. Availability and quality of water
4. Availability of sunlight
5. Quality of air
6. Maintenance
7. Functional Aspects of Design with Plants
8. Planting for Shelter and Soil Conservation
9. Air Pollution Control by Plants

1. Plant Material

The major sets of factors that influence the choice of plant material are related to the characteristics, both botanical and physical of plant material and the context in which the plant material is to be used. The inter-relationship of these sets of factors is the basis for developing a sound approach to the process of designing with plants.

– Physical and Botanical Characteristics of Plant Material

The information on plant material should be available in a systematic format to include definition, significance and design implications of the following aspects:

(a) Nomenclature (botanical and trade-name);

(b) Origin, family and natural habitat;
(c) Growth characteristic and form as a function of habitat;

(d) Physical characteristics, for example bark, texture, foliage, etc.

(e) Propagation and maintenance; and

(f) Use in landscape design.

– Vegetation Types (Evergreen and deciduous): Some examples of the functional implications of using evergreen and deciduous plant material for specific situations are:

(a) **Evergreen trees for:**

(i) Places requiring shade throughout the year,

(ii) Strong visual screening

(iii) Part of windbreak or shelter planting, and

(iv) Areas where leaf lifter is to be discouraged.

(b) **Deciduous trees for:**

(i) Greater visual variety,

(ii) Partial visual barrier,

(iii) Areas where under-planting is to be encouraged (for example grass),

(iv) Emphasis on branching and flowering pattern, and

(v) Areas where shade is not required throughout the year.

– **Growth Rate and Age of Vegetation:** Growth rate is directly related to the life span of tree and slower growing trees have a life span extending to hundreds of years. The fast growing trees to the exclusion of slower growing varieties is not recommended. Landscapes are developed to sustain future generations; slow growing long lived native trees shall be emphatically included in all major planting schemes.
Growth Habits of Various Kinds of Vegetation and Their Form: The overall physical form of a plant is usually the result of the foliage density and branching pattern. It may also be expressed as the proportionate relations between height and canopy spread. The later is direct expression of growth habit. The following classification into basic types may be useful

(a) Trees of fastigited or columnar habit –

Examples of trees of this type are:

*Casurina esquisitifolia* (beet wood)

*Grevilea robusta* (Silver Oak)

*Polyathia logifolia* (Ashok)

*Populus species* (Poplar)

Though the branching pattern of each is different, the overall shape is similar

(b) Tall trees with canopy –

Examples of trees of this type are:

*Dalbergia sissoo* (Sheesham)

*Tamarindus indica* (Imli)

*Terminalia arjuna* (Arjun)

The canopy shape does not fit into any specific geometrical category

(c) Trees of spreading habit –

Example of trees of this type are:

*Delonix regia* (Gulmohar)

*Lagerstroemia flosreginae* (Pride of India)

*Pithecolobium saman* (Rain Tree)

Though these trees vary greatly in size, their basic form is similar
(d) Trees of weeping habit –

Examples of trees of this type are:

*Callistemon lanceolatus* (Bottle brush)

*Salix babylonica* (Weeping willow / Peking willow).

The above classification is helpful in choosing various combinations of the above types to achieve desired function and visual objectives.

2. Soil Conditions

Physical as well as chemical properties of the available soil are important. These may or may not be amenable to change; they would therefore affect the choice of plant material considerably. Physical properties include consideration of light (for example sandy) and heavy (for example clayey) soils, and their structure. Chemical properties pertain to the presence or absence of nutrients and salts; soil, alkalinity or acidity.

3. Availability and Quality of Water

The water requirement may be derived by data of humidity and rainfall of plants natural habitat. The water table of the area where the plantation is to be done has a crucial bearing on the design with plants as well as a financial implication for reduced maintenance if planted appropriately.

4. Availability of Sunlight

The growth rate of plants are directly related to sunlight availability; such as plants that require (a) full sunlight, (b) partial sunlight, (c) predominantly shade, and (d) complete shade.

5. Quality of Air

Growth may be affected by chemical pollutants such as sulphur dioxide or physical pollution such as dust. Certain plants have the ability to withstand pollution, such plants are imperative for industrial areas, roads, highways, etc.
6. Maintenance

The success of a designed landscape depends upon the growth of vegetation over an extended period of time; therefore maintenance of landscape is also a design component.

7. Functional Aspects of Design with Plants

(a) Improve existing environmental conditions with respect to soil, drainage, microclimate, air pollution;

(b) Create a designed physical environment through the organization of open space; and

(c) Interpret and express the contemporary understanding of the man-nature relationship, that is, design with plants on an ecological rather than horticulture basis.

Shrubs: The functions are similar to those of trees. Shrubs may be used together with trees to reinforce the functions, for example, noise barrier, shelter belts, enclosures, etc. Other forms in which shrubs may be used are:

(a) Hedges: These require regular maintenance

(b) Shrubbery: Here plants are allowed to retain their natural shape; they therefore require little maintenance.

Shrubs provide barrier, which may either be visual or physical (hedges). Barriers may be required in a range of situations, for example they may be only for defining space, or they may be required for security and have to be, therefore, necessarily impenetrable.

Groundcover: Groundcover plants are those which naturally grow to a very low height. Some of the uses for which they may be used are:

(a) Stabilization soil on steep slopes such as embankments.

(b) As a low maintenance substitute for grass (where the surface is not to be used).

(c) For providing variety in surface treatment.
(d) Contrast with paving materials, for example to soften rigid lines of paving.

(e) As a subtle means of demarcating space, as for example, in places where tall plant would be visually intrusive.

(f) In combination with other plants to provide contrast or harmony in form.

**Climbers:** Certain climbers because of their spreading habits may also be used as ground cover (for example *Asparagus spp.*). Climbers are useful for shading exposed walls from direct sunlight. They may also be used for stabilizing soil on embankments (for example, *ficus stipulate, Ipomea biloba*). On sites where a high degree of security makes fencing necessary, climbers and spreading plants like Bougainvillea species may be trained on boundary wall.

**8. Planting for Shelter and Soil Conservation**

The use of vegetation for controlling wind is widely recognized as an effective way of conserving soil and reducing erosion by wind. Vegetation may therefore be used for modifying the microclimate, by obstructing, guiding, deflecting or filtering wind current. Vegetation areas designed to fulfill these general functions are usually classified as windbreakers and shelterbelts. Windbreaker is grown protective planting around gardens and orchards. Windbreakers generally consist of single or double row of trees. Shelterbelt provides an extensive barrier of trees with several rows of trees. Plant species are chosen with particular regard to their physical and growth characteristics, and their effectiveness in achieving the desired results.

**Function:** Windbreakers and shelterbelts fulfill essential microclimatic functions in rural and urban environments. Benefits accruing from plantation of shelter planting may be as follows:

(a) Reduction in wind velocity resulting in the arrest of movements of soil particles.

(b) Prevention of soil erosion.

(c) Modification of micro-climate; moderation of change in air temperature.

(d) Protection of crops from being blown by high winds.

(e) Reduction in evaporation of soil moisture. Increase in soil moisture content varies from 3 percent to 7.8 percent Water loss due to evaporation is lessened.
(f) Increase in soil moisture due to greater dew fall in sheltered areas has been found to be 200 percent higher than on exposed ground; heaviest dew fall is over a distance of 2 to 3 times the height of the shelterbelt.

(g) Beneficial effect on growth of plants that are affected by high winds.

(h) The zone of influence of shelterbelt on crop yield extends to a distance of 20 times the height of the belt, with the maximum effect being observed 10 times the height of the tree belt, on the leeward side.

**Wind Erosion:** Some of the basic functions of windbreaks and shelterbelts in arid and semi-arid areas are to conserve soil and reduce erosion by wind. The latter is a natural phenomenon in and lands having very little rainfall (125 mm- 250 mm) and in areas adjoining a river, lake or sea. Wind erosion is a serious problem in areas where the ground is virtually bare and devoid of vegetation.

**Techniques for control of wind erosion:** The principal method of reducing surface velocity of wind, upon which depends the abrasive and transportation capacity of wind, is by vegetation measures.

(a) Porosity is important in the effectiveness of shelterbelt and proper selection of tree species is necessary. Porosity near ground level is desirable.

(b) Effectiveness of shelter planting depends more on height and permeability than on width. The width influences the general microclimate but above a certain minimum width, it does not affect greater reduction in wind velocity.

Protection obtained varies in relation to height (H) of shelterbelts as given below:

<table>
<thead>
<tr>
<th>Distance</th>
<th>Wind Reduced by (in percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>90</td>
</tr>
<tr>
<td>2H</td>
<td>75</td>
</tr>
<tr>
<td>5H</td>
<td>50</td>
</tr>
<tr>
<td>10H</td>
<td>20</td>
</tr>
</tbody>
</table>

This indicates that it is better to have several windbreaks 5H to 6H apart rather than large forest stands with wide open spaces in between.
Species suitable for wind breaks are:

(a) For Dry and Arid Regions

(i) *Acacia auriculiformis* (Australian Blackwood)
(ii) *Ailanthus excelsa* (Maharukh)
(iii) *Albizia lebbeck* (Siris)
(iv) *Azadirachta indica* (Neem)
(v) *Casuarina equisetifolia* (Beef-wood)
(vi) *Dalbergia sissoo* (Sheesham)
(vii) *Eugenia Jambolana* (Jamun)
(viii) *Grevillea robusta* (Silver oak)
(ix) *Peltophorum ferrugineum* (Cooper pod)
(x) *Tamarindus indica* (Imli)
(xi) *Pongamia glabra* (Indian beech)
(xii) *Tamarix articulate* (Tamarisk)

(b) For Coastal Area

(i) *Anacardium occidentale* (Cashew)
(ii) *Ailanthus malabarica* (Alston)
(iii) *Cassuarina equisetifolia* (Beef-wood)
(iv) *Pongamia glabra* (India beech)
(v) *Sesbania aculeate* (Sesban)
(vi) *Thevetia Peruviana* (Yellow oleander)
(vii) *Thespesia populnea* (Indian Tulip)
(viii) *Vitex negundo* (Sephali)

9. Air Pollution Control by Plants: Air pollution may be caused by areas or point sources such as cities, industrial areas, factories or by linear sources such as highways. Vegetation buffers can minimize the build-up of pollution levels in urban areas, by acting as pollution sinks.
**Effect of Plants:** Plant leaves function as efficient gas exchange systems. Their internal structure allows rapid diffusion of water-soluble gases. These characteristics allow the plant to respire and photosynthesize, and they can also remove pollution from the air.

Some of the beneficial results of plantations may be:
(a) They are good absorbers of sulphur dioxide.
(b) Parks with trees have an SO2 level lower than city streets.
(c) Roadside hedges can reduce traffic generated air borne lead, on leeward side.
(d) Heavy roadside planting in the form of shelterbelts can result in a reduction in airborne lead.
(e) Complete dust interception can be achieved by a 30m belt of trees. Even a single row of trees may bring about 25% reduction in airborne particulate.

The above account on **Planting Design Considerations** from the **Handbook of Landscape** brought out by the **Central Works Department** in addition to being an important reading for this research work opens up several new areas of research exploration that may be taken up by other researchers interested in this subject domain.

According to **Neginhal S.G** trees in cities serve various purposes. They are chiefly planted for shade and to beautify urban areas. Bio-aesthetic planting in towns and cities enhances living values, which cannot be assessed in terms of money. Of late, trees are also utilized in controlling and solving environmental problems arising out of urban expanses or industrial developments, which may include air, dust, sound pollution and solar radiation. Trees are required for health considerations. They also enhance beauties of the architectural buildings and provide picturesque ambience.

**Evergreen, Semi-Evergreen and Deciduous Trees:** Trees may be broadly grouped into three categories viz. Evergreen, Semi-Evergreen and Deciduous. Evergreen trees do not fully shed their leaves all at once. New leaves are added almost throughout the year, as the older ones are being shed as in Mango (*Mangifera indica*), Champak (*Michelia champaca*) and Banyan (*Ficus benghalensis*). Some trees remain leafless
for a very short duration, and soon put on a new flush of leaves. In these the gap between leafless condition and putting on new leaves is very short, and is spread over only a few days, like in Arjuna (*Terminalia arjuna*) and Purple Bauhinia (*Bauhinia purpurea*). These may be called as Semi-Evergreen trees. The tropical deciduous trees fully shed their leaves once in a year, normally in the dry season, and remain leafless for a long duration, often over a couple of months, when only the bare bole and branches are seen, as in the case of Flame of the Forest (*Butea monosperma*) and Indian Laburnum (*Cassia fistula*). These are called as Deciduous Trees.

Types of Trees: Trees may be further classified as ‘dwarf’, ‘medium-sized’, ‘large-sized’ and ‘straight growing’, depending on nature of their growth. Parijat (*Nyctanthes arbor-tristis*) is dwarf; Bauhinias are medium-sized; Arjuna and Banyan are large-sized, and Silver Oak is straight and tall growing. While some trees put on ornamental and fragrant flowers like the Magnolias and Chalta (*Dillenia indica*), others provide only shade like the Neem. Some trees yield edible and utility fruits like the Jamun (*Syzygium cumini*) and Amla (*Phyllanthus emblica*). There are trees with ornamental foliage and branching like the Kadamba (*Neolamarkia cadamba*). Many trees are deep-rooted, and do not cause damage to the nearby buildings. Some like the Gulmohur have horizontally spreading roots, and cause damage to the buildings. The tree-planting authorities, therefore, need to acquaint themselves with various growth patterns of trees for taking up urban planting.

Indian Trees: There are a number of Indian trees bearing ornamental and fragrant flowers suited for planting in our urban areas. The ornamental flowering trees include the Indian Laburnum (*Cassia Fistula*) bearing pendulous golden-yellow sprays, the Pride of India (*Lagerstroemia speciosa*) displaying attractive pink or purple flowers, the Bauhinias with orchid-like flowers, the Flame of the Forest (*Butea monosperma*) and the Ashoka (*Saraca asoca*) putting on orange-red sprays, the Red Silk Cotton (*Bombax ceiba*) with bright crimson red flowers filled with nectar for attracting birds, the Yellow Silk Cotton (*Cochlospermum religiosum*) with strikingly beautiful golden yellow inflorescence.

The trees bearing fragrant flowers include the Alexandrian Laurel (*Calophyllum inophyllum*), the Champaka (*Michelia champaca*), the Parijat (*Nyctanthes arbor-tristis*), the Kanaka Champa (*Pterospermum acerifolium*), the Kadamba (*Neolamarkia*
cadamba), the Bakul (*Mimusops elengi*), the Surgi (*Mammea longifolia*) and the Iron Wood Tree (*Mesua ferrea*).

The other popular trees are the shade giving trees like the Neem and the Karanja (*Pongamia pinnata*), the juicy fruit-yielding trees like the Jamun (*Syzygium cumini*) and Mango, and the Mohwa (*Madhuca spp.*) with the flowers exuding intoxicating smell of Basmati-rice.

Exotic Trees: Trees with aesthetic values are preferred in urban areas. With this consideration many exotics, brought from various parts of the world over the centuries, were introduced into our cities. The Mughals brought Chenar (*Platanus orientalis*) from Western Afghanistan to enrich the gardens of Kashmir, about 400 years ago. The Britishers introduced many exotic trees into our cities and parks. The popular Gulmohar (*Delonix regia*), bearing crimson red flowers, was brought from Madagascar in about 1840 A.D. The Jacaranda (*Jacaranda mimosifolia*), bearing showy purple flowers, was brought from Brazil. The African Tulip Tree (*Spathodea campanulata*), producing attractive vermilion bell-shaped flowers, came from Central Africa. The Splendid Amherstia (*Amherstia nobilis*), the most beautiful flowering tree in the world, is from Myanmar. Likewise the Badminton Ball Tree (*Parkia biglandulosa*) is from Malaysia, the Cannon Ball Tree (*Couroupita guianensis*) from Tropical South America, the Christmas Trees (*Araucaria spp.*) from South America and Australia, the Magnolias (*Magnolia spp.*) from North America and East Asia, the Tabebuias (*Tabebuia spp.*) from Paraguay and Argentina.

These and many more brought from outside into our country over the years are adopted and naturalized so much so that many have found local names like Shivalinga or Nagalinga for the Cannonball Tree, Java-ki-Rani for the Java Cassia (*Cassia javanica*), Nili Gulmohur for the Jacaranda, Akash Neem or Jasmine Tree for the India Cork Tree (*Millingtonia hortensis*), Pagoda or Temple Trees for the Plumerias and so on. These rich inheritances of exotic trees coupled with our native handsome plants have certainly increased the aesthetic appeal of our cities.

Proper selection of species is needed for planting trees along the urban streets and avenues. The selection depends on the width of the streets, which may be narrow or broad. Dwarf growing trees need to be planted on narrower streets, and large growing trees on broader roads. Very large growing trees require to be planted on highways. Foul smell of certain localities and garbage-sites can be cleverly tackled with trees
bearing fragrant flowers. Tall and straight growing trees fit well into the avenues devoid of overhead cables. Below are given the tree species to be planted on different types of streets and roads in urban areas.

Trees for Narrow Streets (around 3m in width): Narrow streets are often ignored by the planting authorities. The main excuse given is non-availability of space for planting. Normally such streets are found in the older areas of the city or in the slums areas which are thickly populated. In addition the streets may be infested with overhead cables. But such streets need not be treeless. The trees that do not obstruct movement of people or over shoot the over-head cables need to be planted on such roads, choosing from the Coral Jasmine/Parijat (*Nyctanthes arbor-tritis*), the Bottle Brush (*Callistemon lanceolatus*), the Mehndi (*Lawsonia enermis*), the Night Shade (*Solanum grandiflorum*), the Perisan Lilac (*Melia azedarach*) trees.

Trees for Medium-width Streets (around 10m in width): Trees to be planted on these streets serve two purposes. They provide shade and greenery to the pedestrians. They also minimize air pollution like dust, sound and solar radiation. They reduce air pollution by absorbing toxic gases like carbon and sulphur dioxides. The trees to be planted on such avenues should grow to medium-size, as although the streets are a little broader the space for accommodating them is limited. Species like Bauhinias, Cassias and Champak are recommended to be planted on these streets.

Trees for Broader Roads (around 20m in width and above): Avenue trees on broader roads provide shade and greenery to the inhabitants and to the pedestrians. Large-growing, umbrageous, flower-bearing trees are better suited for these roads. The trees should have umbrella-like crowns that spread in all directions. Trees with sparse or elongated crowns like the Jacaranda and Silver Oak should not find place here. If the road is over 30 m in width, a double avenue of trees may be provided. Trees preferred on these roads may include the African Tulip Tree, Gulmohar, Badminton Ball Tree and Kadamba.

Trees for Streets with Over-head Cables: Streets with over-head cables should not be planted with tall growing trees like the Indian Cork Tree, Silver Oak, Casuarina etc. Such trees obstruct the over-head cables by overshooting. So, the trees growing to
small size need to be planted on such streets, which may include Parijat and Bottle Brush.

Trees for Highways: Trees for highways are to be of different sort. They should be large growing and long lasting. More than being ornamental in nature, they should be umbrageous. They should also yield edible fruits for use of men, animals and birds. Trees like Neem and Tamarind with economic benefits should be a good choice, apart from the shade giving trees like the Banyan and Peepal.

Trees for Gardens: Gardens are normally smaller in comparison to tree-parks. These may be owned by the private citizens, corporate bodies, industrial houses, educational institutions, the municipal or corporation authorities. The size of the garden may vary from a few gunthas to a few hectares. As the space is limited the trees to be planted in gardens should grow to small size have to be appropriately chosen. Aesthetics, fragrance, colourful foliage, shade, all these need to be included in a good mix. These trees may include Ashoka, Bakul, Parijat and Golden Bamboo to mention a few.

Trees for Parks: The parks are larger in extent, and spread over several hectares. These are visited by the citizens for morning walks, recreation, acquainting oneself with various plant species, for bird watching and so on. The trees required for parks may be either small or large growing. In fact the trees suited for the gardens also fit into the parks. In general all types of trees are suited for parks. The trees for such areas need not be locally representative, and may include local and exotic species. Depending on the objectives in creating such parks the species to be planted have to be selectively identified for planting.

Ornamental trees with beautiful flowers like the Badminton Ball Tree, Pride of India, Gulmohar suit parks. Some trees may not put on showy flowers, but they may have values from other angles. They may be shade giving trees like the Banyan, or may be medicinal plants like the Neem. The trees may be queer looking like the Baobab (*Adansonia digitata*) or rare like the Splendid Amherstia. Fruit-yielding trees like the Mango or Jamun, and various species of Palms and Bamboos are also welcome. On the periphery straight and tall growing trees like the Silver Oak and Indian Cork Tree may be planted.
Trees for City Woodlots: City woodlots are raised on the larger waste lands available either in the cities or at the outskirts of the cities. Lands for these have to be preferably in major blocks. Woodlots are required for keeping the urban areas environmentally healthy. In such areas utility species like the Casuarina and Silver Oak are normally raised.

Trees for Orchards: Areas with better soil and water supply may be utilized for raising orchards for growing fruit trees like the Mango, Sapota and Coconut.

Trees for Residential Buildings: Trees for residential buildings need to be chosen for utility as well as for aesthetics. As the space is limited, the trees should grow to small size. Trees like the Gulmohar should be avoided, which cause damage to the buildings and the plinth with their horizontally spreading roots. The trees should not cause damage to the lawns. They should have ornamental, sacred or economic values.

Depending on the size of the sites, the buildings may have smaller or bigger compounds. The trees planted in smaller compounds should grow to smaller size. The bigger compounds can accommodate larger growing trees. Small growing trees like the Bottle Brush and Bodula (Firmiana colorata) are welcome in smaller compounds. Large growing trees like the Kadamba (Neolamarkia cadamba) and the Pride of India (Lagerstroemia speciosa) are suitable for buildings with bigger compounds. Citizens normally make mistakes in selecting trees for planting in their compounds and later repent for the wrong choice. It is, therefore, advisable for the householders to familiarize themselves with the trees and their type of growth before planting them in their compounds.

Householders with home gardens need to have ornamental trees that bear showy flowers like Java Cassia, Yellow Silk Cotton. Trees bearing both ornamental and fragrant flowers are preferred like the Parijat, Bakul and Champak, apart from fruit-yielding trees like the Jack Fruit and Mango. Trees that will be of some use for the kitchen, like the Drumstick Tree (Moringa oleifera) and Curry-leaf Tree (Murraya koenigii) are popular too.

Trees that yield economic products like the Soapnut (Sapindus spp.) and medicinal plants like the Mehndi and Ashoka for treating minor ailments are found on the must-
have lists of garden lovers. Indians also prefer to have trees with sacred background in their compounds like Bael and Ashoka.

While planting around residential buildings, ornamental trees should be planted in the foreground and utility trees like the fruit-bearing plants should be placed at the backyard of the houses. Trees should be planted in pits lower than the level of the building-foundations to prevent damages to the buildings by roots.

Playgrounds and Community Sites: In the centre of the playgrounds and community sites, kept open for use of the games and public utility, nothing should be planted as the open space is required for games and other activities. However periphery of such open places may be utilized for planting tall and straight growing species like the Mast Tree or Silver Oak. Tall growing trees do not obstruct the games and community activities. All the same they provide some shade and minimize pollution of air, dust and sound. In addition they attract birds and butterflies. Along with the tall growing trees some shady and ornamental trees like the Champak, Karanja may also be planted in between the tall growing trees.

Keystone species: Scientist consider fig species (*Ficus spp.*) as ‘keystone species’, species that have large ramifying effects on the ecosystem through direct and indirect pathways (or species which control structure and function of a community or ecosystem), which are crucial to the overall health or function of the ecosystem. Like a keystone supporting an archway, keystone plants like various Ficus specius bear fruits all year round, and so support a broad spectrum of fruitivorous birds and mammals during times of scarcity of food. In an observation, two different species of squirrels and about twenty different species of birds were seen on the Goni Mara (*Ficus mysorensis*), when in fruit. Extinction of the keystone species is likely to cause major changes in the composition of the species and ecosystem processes. Hence it is environmentally necessary to maintain viable flowering (nectar bearing) and fruiting (edible) population of plant species for the health of biodiversity in both rural and urban environs.

Environmental Values of Trees: Trees are required in the cities to serve various environmental purposes. Of late trees are also being considered and utilized in controlling and solving environmental engineering problems arising out of urban
expansions and industrial development. These may include air, dust and sound pollutions; radiation and glare reduction; management of sewage, waste water and industrial effluents; control of soil-erosion and water shed protection.

Role of Trees in Reducing Air and Dust Pollution - Gaseous Air Pollution: Trees reduce gaseous air pollution by way of absorption. Studies in the USSR have shown that a greenbelt of trees of 500 meters width around factories reduces sulphur dioxide contents of the air to an extent of 76 per cent, and nitric oxide concentrations by 67 per cent.

Release of Oxygen: As is known, plants absorb carbon dioxide and release oxygen. Plants produce oxygen in the process of photosynthesis, thereby pumping large quantities of oxygen into the atmosphere. It would be interesting to know that one hectare of woodlot absorbs about 3.7 metric tons of carbon dioxide and releases 2.5 metric tons of oxygen.

Collection of Dust: Dust in the cities settles on the leaves and branches of trees. Thus the dust is prevented from flying into the buildings and atmosphere. The flying dust collected on trees is washed down to the soil during the rains. So the trees serve as dust-bins or filters. One hectare of tree-growth collects about 30 metric tons of dust. A greenbelt of trees with 50-100m width decreases atmospheric dust level up to 52 per cent.

Role of Trees in Controlling Solar Radiation, Air-temperature, Humidity, Glare and Sound: The climatic factors that affect the comfort of the city-dwellers include solar radiation, air temperature, humidity and precipitation. In a residential building these factors are mechanically controlled to artificially create comfortable milieu by using fans, air conditioners, air blowers, and even by door and window curtains to keep away light and dust. But what happens outside our residences? These mechanical and artificial provisions are impracticable and financially prohibitive by any engineering means. Thanks to the availability of vegetation, these outside factors could be greatly controlled and manipulated to a great extent.

a) Solar Radiation and Trees: Solar radiation descends on earth after almost half of it is absorbed by clouds, and diffused by atmospheric dust particles. It is also partly absorbed by gaseous pollutants like carbon dioxide, ozone and water
vapour. Approximately one half of the solar radiation ultimately reaches the earth.

Solar radiation is felt more in the cities than in rural areas. Cities tend to be warmer than country-sides to the extent of 0.5 to 1.5 degrees Celsius. In cities devoid of vegetation, solar radiation is absorbed by the asphalt and concrete roads, concrete buildings and steel structures and their roofs. These absorb more heat and lose heat early than the soil and vegetation. On this account the atmosphere of the cities gets heated. This process also brings down the relative humidity. Vegetation prevents infra-red radiation and absorbs solar radiation to a great extent. They use it to their advantage during photosynthesis.

b) Air temperature, Humidity and Trees - Trees as Natures Air Conditioners: In winter the deciduous trees shed the leaves, allowing much-needed warm solar-radiation to percolate in the surroundings. In summer these trees put on dense cover of foliage which intercept, partly reflect, and absorb solar-radiation, thereby lowering the temperature to the comfort of human beings. Plants ameliorate summer temperature by their biotic process known as evapotranspiration. So trees have been called as Nature’s Air Conditioners. By experiment it is found that one tree may transpire 400 litres of water per day (if soil moisture is available to that extent), which means it can do the work of five room air conditioners of 2500 kcal/hour capacity, each kept working for 20 hours a day. A tree cover of 22 per cent can lower the city-temperature by about 20 per cent as compared to open areas without vegetation.

c) City-glares and Trees: Both primary and secondary glares can be shielded by judicious planting of trees and other taller vegetation. Creating lawns also controls glare of the sun’s rays that are reflected much to our discomfort. Trees raised along highways control glare in the early mornings and late afternoons at the time of rising or setting of the sun, ensuring driving comfort for the vehicle users.

d) Sound Pollution and Trees-Sound and Health hazards: According to a study by the Indian Medical Association (IMA), noise pollution is emerging as a major human health hazard in metropolitan cities. The study says that prolonged
exposure to loud sound in everyday life acts as a biological stressor leading to sustained activation of the autonomic nervous system and the pituitary-adrenal axis resulting in various health disorders like hypertension, peptic ulcer, emotional unrest, fatigue, mental depression besides retarding the level of concentration. The study warns that the majority of citizens would have impaired hearing, if they continue to be exposed to the sound of 50 decibels and above.

Trees control Sounds – Tree-belts and Green-belts: Sound pollution due to movement of automobiles, trains, factories, loud speakers, building construction, radios, televisions, hawkers etc. Adversely affect human confort and health as detailed above. Planting of trees is needed to control sound pollution, which depends on placement of plants against the source of sound, the species, height of the plants and their density. Plants deflect, reflect, refract, absorb and mask the sound.

Sound of clearing dustbins by municipal authorities is reduced by 50%, if dense plants are available 30 metres away to act as barriers. Sound created by a land mower gets reduced by 40%, if green belt made up of 2 metres height and 3 metres thick planting is created between the sound and the resting place. Noise that the children make while playing is reduced by 50%, if sound barrier made up of dense planting is available at a distance of 16 metres from the dwellings.

City Woodlots and Tree-belts for Absorption of Sound: City woodlots mitigate sound at the rate of 7db per 30 metres of distance at frequencies of 1000 cps or less. Attenuation of highway sounds to the extent of 10 dB is obtained by providing tree-belts of 30 metres wide and 15 metres tall on the highways. This amounts to 50% reduction in sound as the decibels are on a logarithmic scale. If the tree-belts are wider, reduction in high-pitched sound even over 10 dB may be obtained. Narrow dense belts of trees in cities provide effective noise barriers by reducing sound by 3 to 5 dBA (dBA is decibels corrected for human hearing). In city areas the houses along the city streets may be screened against the automobile noise by planting a row of trees nearer the buildings with another row of bushes or shrubs, with the total width of both these rows being 6.3 metres.
Masking of Sound by Trees: Leaves, boles, branches, twigs, flowers, fruits, even fallen leaves absorb sound waves. Thick, fleshy leaves with longer petioles are more effective as sound barriers. Breeze or wind blowing over the leaves, twigs and branches create pleasing sounds by movement, which mask the offensive sound created by human agencies. The foliage of Peepal (*Ficus religiosa*) and Casuarina make pleasing sounds when the breeze passes over these trees. The pleasant sounds and calls of the birds, which often visit the trees also mask the man-made undesirable sounds. Artificially created piping music in the busy areas of offices, banks, shopping centres etc. acts as a mask over the noise created by office machines, fans, conversations of men etc.

Uses of Urban Vegetation: Vegetation cover ameliorates our living conditions. It provides shade, greenery, ornamental flowers, edible fruits and shelter for man, birds and even pretty insects like butterflies. Trees are used in the architectural and aesthetic planning and landscaping. They improve urban milieu by reducing major air pollutants. Sound, glare and dust pollutions are decreased. City liquid wastes and waste waters are recycled to provide a cleaner atmosphere.

The benefits of urban vegetation may be broadly classifies under the following major categories:

1. Amelioration of weather
2. Engineering uses
3. Architectural uses
4. Aesthetic uses
5. Sacred and commemorative uses
6. Recreation and Wildlife
Amelioration of Weather: Trees intercept, reflect, deflect and absorb solar radiation.

Scientific studies reveal that the comfort of human beings is actually related to the controlling of the descending infrared radiation of the sun’s rays. Trees carry out this job efficiently. This again depends on the kind of trees available.

Leaves partly reflect and partly absorb the solar radiation. If the density of leaves is more, if the leaves are bigger in shape and thicker, if there are more branches on the trees, that spread instead of growing skywards like in the Mango trees, the interception, reflection, deflection and absorption of solar radiation is more than in counter situations.

Tall and stout growing trees like the Mahogany or Neem with dense foliage control solar radiation more efficiently by intercepting and filtering it. In regions with extreme climatic variations, deciduous trees like the Arjuna or Karanja play an important role in controlling the solar radiation in the urban areas. In winter these trees shed the leaves allowing the much-needed warm solar radiation to percolate into the surroundings. In summer these put on dense leaves that intercept, reflect and absorb the radiation, thereby lowering the temperature to the comfort of human beings.

Control of glare and reflection: Trees can be used to screen glare and reflection of sun’s rays. Plants block and filter glare, both primary and secondary, during the day. Trees on the highways control early morning and afternoon glare. Night light can also be controlled by proper selection and placement of trees around terraces, patios and along streets.

Trees retard loss of heat during the night: During night time the atmospheric temperature lowers due to loss of heat from the surface of the city to the atmosphere. On a cloudy night the cooling is less and on a clear night the cooling is more. At night the canopies of the trees retard loss of heat as these serve as a sort of screen between the warm surface of the city and the cooler night air. In other words, under tree canopies night temperatures are higher in the wooded areas than in the open. Studies have revealed this difference may be to the extent of 5 to 8 degree Celsius. Again this depends on the structure of each city, which may vary from narrow streets to broad streets, from tall skyscrapers to low houses, factories, parks, availability of water-sheets, topography and so on.
Dr Krishna M.B in his booklet ‘Composing Corporate Garden Landscapes’ states that corporate garden landscapes are often beautiful to look at. They are ornamental and are a frequent proof of a devoted team of gardeners and justifiably proud owners.

If one pauses, one notices something amiss, how devoid of people these gardens are! They do not offer shelter from the sun, or quiet spots for contemplation, or even winding paths for that peaceful stroll. These are precisely the aspects that could have been easily incorporated.

In addition, these beautiful gardens require constant effort, energy and finances to maintain their looks. Local climatic conditions are also not taken into account while creating them, thus compounding the issue. The result is that a lot of gardens today have little functional or utility value, and serve no ecological or pedestrians’ needs.

The author further states that the booklet is an edification of the alternative, to brief the corporate who are looking at getting more out of their garden, at a lower cost to the organization and to the environment. The booklet specifically addresses issues that one should consider when planning large corporate gardens generally spread across an acre or more. Many of the concepts would be applicable to small spaces too. In essence, it hopes to shift the emphasis from the manicured to the semi-rustic landscape. The ideas put forward by the author are particularly significant for this research work and a detailed account of the same is an essential part of the literature review and has been given below.

Shade Does Matter: We often plant trees along roads on which cars ply, while people walk in the hot sun from building to building. After all, it is we who require the shade, not an inanimate car which zooms along a road without getting affected by shade or sun. It is those in colder climates who require the sun, and the soft warmth that it brings with it there. We, in the dry hot tropics require shade.

Trees collectively alter the microclimate of an area, providing insulation, reducing dust and air pollution, altering humidity and making outdoor spaces so much more comfortable. The reduction in heat can be dramatic, and one can often feel the temperature difference between an area with and without trees, the moment one steps across from one to the other. This was substantiated by recording the temperature
difference on the same stretch of road with and without trees, measured on the Outer Ring Road at Hennur Cross in Bangalore and representing the same with a graph.

There is a growing body of evidence that demonstrates how green spaces can offer lasting economic, social and environmental benefits. By planting trees, we can see for ourselves the amelioration in microclimate and also gain carbon credits for a greater common good. There could be lower electricity bills through glare and sun control, and lower power consumption for air conditioning, especially in cars and smaller buildings. It therefore, translates to direct cost benefits.

The Role of Trees: Many of us hesitate to plant trees in our gardens due to the fact that trees signify permanence. It is so much easier to plant shrubs and grow lawns, which can be removed easily and at will. But the benefits of planting trees far outweigh these seeming drawbacks. In addition to the role they play in managing the microclimate, trees have other benefits.

As a noise barrier: Line of trees can help dampen noise and sometimes even add pleasant sounds of their own. Casuarina trees, for example produce soft seashore like sound when wind blows through them.

As a windbreak: A row of trees and shrubs can act as an effective wind break. Good wind protection can be expected for a distance equal to about twenty times the height of the shelter belt on the leeward side.

Aesthetics: It is possible to select various species of trees to ensure almost continuous presence of flowers or fruit, marking the different seasons each year. Many of the trees planted for aesthetics in our parks, gardens and roadsides, almost a century ago were selected keeping this in mind. This principle has unfortunately been largely forgotten.

Health and well being: There is scientific evidence to prove that contact with nature in urban areas can improve health and psychological well being of people, especially those who spend long hours within buildings. It is also said that access to nature promotes lower blood pressure and reduces stress.

Wildlife support: Tree clothed campuses actually look like woodlands and support a much higher diversity of life than what mere lawns and flowerbeds would do. Birds
and butterflies are the more colourful of urban forms. Birds could add many pleasant sounds to the surroundings by their song and calls.

Being a role model and an informal education resource: More often than not, proximity to gardens, trees and nature encourages people to learn more about them. It could even prompt them to take up planting and cultivating gardens on their own after they get to appreciate the difference greenery can make to their surroundings and neighbourhood.

A corporate garden with an abundance of trees will encourage an appreciation and respect for trees among its own associates.

Trees in the Landscape: Planting a tree or shrub is not difficult at all. We need to realize that planting a tree now, makes our surroundings look beautiful only many years later. In selecting trees and shrubs, the space available and the functional role should be the main considerations, besides aesthetics and habitat requirements of the species.

A tree is a permanent fixture. It cannot be moved about like a plant in a pot. Much care and thinking are therefore required in choosing and growing trees. Location is crucial for a tree.

A tree grown in the open tends to have a broader crown when compared to a tree growing in a restricted space. In restricted spaces when planted in a tight cluster, individual trees could lose their natural shape. If the space chosen is damp or shaded throughout the year, tree species which bloom in the dry season when they are leafless would perhaps not even flower.

Wildlife in the Landscape: Contrary to popular belief, there is a surprising assortment of small animals even in urban areas. For example more than 150 butterfly species and over 330 bird species have been recorded in Bangalore and its environs over the century. More than a tenth could easily be found in any large well designed garden or park.

For a garden to be a good wildlife habitat it is imperative that there needs to be a fair amount of variation in form and composition of the vegetation. Unlike humans who
have been able to modify the environment, other animals have to adapt themselves to their surroundings. Different species have specialized themselves in various ways and so choose different habitats and microhabitats. The way they live too, is adapted to the way they get their food and raise their young. A design that incorporated variety, therefore, is always better. Smaller wildlife could be encouraged in the campus garden by providing a rustic semi-wild corner with shrubbery, piles of loose stones in small heaps (which, for example, encourages lizards) and by dripping taps (or drip nozzles) which encourage bees which come to drink water, or even birds. There are a few points to bear in mind when choosing trees for wildlife.

Many of our birds take nectar from flowers, especially from those which are showy. Similarly local fruit eating birds tend to eat only small fruits of just about a centimetre or less, though a mango could get pecked into. Bats are attracted by scent and visit flowers and fruit trees at night. Parakeets also eat tree seeds. Squirrels, of course take all these, and bark too!

Diversifying the Landscape: Increasing the variety in the greenery of the landscape not only encourages wildlife but often improves visual appeal. Many components could be added that break the homogeneity and monotony in the landscape. A line of trees, all of the same species, for kilometres along a road looks monotonous. Breaking the monotony here and there enhances the appeal, and breaking homogeneity increases biodiversity.

Hedges and hedge lines, shrubs and shrubbery, are crucial components of a garden. Since shrubs are smaller than trees, they require much less space and can be grown in places where trees cannot even be considered. To be effective, shrubs, shrubbery, hedges and hedge lines need to be bushy, at least in most places. A bush provides more cover and gives a feeling of security to small animals and birds. Not all animals live on trees, and many birds like tailor-birds and other warblers prefer shrubbery over trees. For birds which fly down to the ground to feed, like say doves or thrushes, shrubbery and hedge lines provide an effective screen from human presence.

Hedges, like lines of trees, lead the eye and help focus on views. They can be used as screens when they are bushy. It is not that only low hedges should be grown, tall hedges of say, a metre and a half or two in height are also required. Hedges could
effectively break-up open spaces into smaller compartments, and are essential for a good garden. They can be used to create ‘garden rooms’.

Greenery on walls and tree trunks: Creepers, leaners and climbers can effectively break the monotony in architectural structures. Species like Ficus pumila or Ficus repens stick to flat cemented and stony surfaces and form an effective green layer. Leaners like Bougainvillea and Quisqualis can be used to effectively cover corners in bushy thickets. They could attract munias, sunbirds and flower-peckers to build their nests in it. Plants like Monstera, Pothos, Syngonium and pepper can cover tree trunks in dense green, if sufficient shade and moisture are provided.

Arches, trellises and pergolas with appropriately chosen climbers can not only create a multi-dimensional look and ambience, but also encourage birds, to come there to feed and build their nests. Flowerbeds and grasses attract and support many varieties of butterflies and other smaller forms of life. Grass seeds are eaten by doves. In lawns which are trimmed, grasses would never come to bear seed.

Gravel and stone-lined paths add a charm of their own. They also enhance seepage of water into the ground. The pathways could be shaded, providing a cool ambience. Small piles of stones at some unused corner, or demarcating walls with holes and gaps create a habitat for small animals like insects and lizards, which birds could feed on.

Leaf litter: Leaf litter is effective mulch. It helps retain soil moisture, prevents heating up of the soil and provides a good habitat for insects and earthworms. Many birds like mynas and babblers feed on them.

Damp areas and ponds: A wet sheltered corner, with a little dripping water like a leaky tap, can attract bees, other insects and sometimes even birds during dry weather. This can be coupled with bowers and similar densely vegetated spots. All ponds and depressions need to have at least half of their shoreline with a very gradual slope. This slope should reach up to the very top, so that frogs and toads, shrews, and other small animals that fall into the water can easily climb out.

Small space gardens: Many of the points mentioned above could effectively be used in the frontage of city buildings where space is a premium and all that is available is a small garden strip.
Designing the Campus: The master plan is thinking for the future. Planning is a very important step which allows a design to be implemented in phases, which in turn can reduce expenses. Leaving the plan accessible and on record is imperative. Future generations of staff, if they need to effectively participate and contribute to the garden, need to know what thoughts went in when a garden was designed or a set of trees planted. The whole process should take into account the future development plans of the institution.

The site analysis deals with an inventory and assessment of all existing features like buildings, trees, roads and paths, and so on, that can influence the landscape design. It is about assessing the situation and conceiving a framework.

The use analysis is the process of assessing the needs and uses of the people who are going to work in that campus, which the design is meant to serve.

Zoning the campus: It makes sense to zone the campus into different use areas. The plan has to take into account, the intensity of human use in different zones of the campus, and the projected intensities in the future.

Planting can then be planned accordingly. Blooming and shade giving tree species can be planted in areas frequented by people where they will be appreciated. Wildlife attracting trees and shrubs could be planted in the less frequented sections like the car-park, where people come only to park or to pick up the cars and which for the greater part of the day, would be left undisturbed.

Accommodating wildlife: Creating a wildlife-friendly area does not mean that the planting scheme needs to be devoid of aesthetics. The arrangement could accommodate designs which look good and at the same time serves to attract wildlife.

Keeping the view: Tree planting along buildings should be away from windows and doors, so that the view from the window or door, and the light, are not blocked. Using showy species in the foreground and leafy green species at the background enhances the aesthetics. Blooming trees look much better when framed against other green trees – there is depth and context!
Dr Krishna M B further explains with a case-study of a hypothetical park layout where planning for trees could be as follows. This is to highlight few issues that one needs to look for. The original design has too few large trees to give effective shade in a hot place. The elaborate pathway is sparsely shaded; hence people will have to walk in the blazing heat most of the day. There are only small trees and shrubs, in relation to the width of the pathway. Trees are permanent fixtures. They are located too close to the periphery where they are at risk of road widening, or else eventually damaging the compound walls.

An element that is well thought out and appropriate is that the western side of the park is more densely populated with trees, while the eastern side has been left relatively free; this is suitable for tropical areas when one wants to minimize the harsh effects of the western sun.

An alternative to this design is where there is a tree gradient with the tallest and the largest trees towards the centre and smaller trees and hedges on the outside. This builds up better humidity and growth conditions for plants, and looks more aesthetic.

Since the pathways are in shade, the park benches along the route are also shaded.

Manicured Lawns: Lawns and turf have been likened to the green ‘canvases’ of a garden. However, while naturally growing grass, intermixed with other smaller plants here and there, is not a problem, the water, pesticides, herbicides and fertilizers used to maintain a manicured lawn or turf raises serious concern.

Compared to naturally growing uncut grass, closely mowed lawns, even of the same species, require almost twice the amount of watering as their wilder congeners. They also require much use of herbicides, pesticides and fertilizers, to maintain that verdant green. It is said that some three to ten times the amount of chemicals needed for agricultural fields are used on lawns and turf.

These chemicals then get washed into the soil by liberal watering and are carried to ground water resources causing serious problems. Most of these chemicals are very toxic to animals like earthworms, frogs and birds that frequent our gardens, and could fail to be effectively biodegraded. Many of these chemicals are even carcinogenic.
So, in most cases at least, it might be wise to substitute lawns with semi-wild grass, and in the shade with dicot ground cover, and allow a few wild plants to grow in between. There is always an option to clean out other plant growth amidst the grass, if it becomes excessive. But till such point, the grass with its other plant community could effectively support many little animals, like butterflies and birds, which find food from these plants and add colour and charm to our environs.

Miscellaneous Tips: Slope of the shoreline of garden ponds and pools should never be steeper than 1:3 and preferably in the region of 1:7. This is to enable birds, insects and other animals to take water without falling in. Even if they do, they should be able to come out easily.

Pesticide and herbicide use should be kept to the bare necessary minimum, both by dosage and frequency. We also need to be tolerant of a little utilization damage by animals and plants, if we are to encourage them to live in our midst.

Making Car Parks Green: Outdoor car parks do not get the attention they deserve. By mere, virtue of their innate pattern of use, car parks are ideally suited to deliver on many fronts. Often car parks do not have any shade, either green or man-made, and the cars get pretty hot by the time they are collected. For most cars at least, this translates to cars being parked out in the sun for the hottest part of the day. This would lead to an increased use of air-conditioners, which essentially means that they are using up more energy. This could perhaps also lead to other scenarios where the plastics in the cars parked in the sun could be releasing hazardous volatile organic compounds like plasticizers, softeners and fire retardants into the cabin, which the driver and co-passengers would be inhaling later.

There is a safety consideration too. The path that cars navigate to get into and out of parking lots often overlaps the path used by humans to get to and from the car to the buildings. Safety considerations in car parks cannot be overemphasized. Cars and people need to have different roads and paths to navigate! A well designed car park will consider the following elements: navigation paths of cars and human traffic, green shade for the cars, optimum angle of the parking slots, unused spots in the slot for replenishment of ground water. If foot traffic is less in the area, the car park can also be considered for wildlife zoning.
Trees and Architecture: Greenery is inherently beautiful. There are many architectural uses that greenery, especially trees and shrubs, can be put to. We could add beauty to hardscaping and buildings by placing them with greenery. Trees can be used to enhance, give a background to, and lead the eye towards an object of interest, especially along pathways. They can be used to divide space horizontally, vertically or in three dimensions. They can also be used to break space into comfortable compartments. Trees can enhance the feeling of distance or make themselves appear closer.

In a park-land for example, coarser and darker foliage tends to appear closer while fine and light texture appear more distant. It is just that trees and shrubs can effectively articulate space and help us to use space much better! The creation of ‘space’ is a fundamental principle of architectural design. Much of architectural planning starts off by visualizing an open space as if it were some clearing in a forest. Traditionally, ‘spaces’ are demarcated around various objects of interest. The perception of these spaces and the impression they give is altered by greenery for the better.

Many of the principles in landscape design derive from the compositional rules of fine art. The difference is in the fact that while a picture or a painting is a single view, a landscape is seen from ever-changing viewpoints. But still, the same principles apply. Balance, symmetry, color, scale, pattern, texture, contrast, sequence, etc., are all applicable to landscape design, but that is outside the scope of this little booklet. The recognition of form, pattern, process and evolution is very inherent in biology, and its component part, ecology.

Strangely, it has not been so to architectural landscape design. It is not just form, but patterns and processes too, that we need to take into account when architectural landscapes are designed.

We need to also acknowledge and accept that we share this world with other wildlife, both plant and animal. They are bound to come into our spaces, though more often than not, we go into and destroy theirs!

Choosing Trees: There would be many reasons why we chose the kind of trees that we do. Since trees take a long time to grow and are semi-permanent, the choice has to be made with care. Here are a few aspects to consider and set you thinking.
Color: Trees which come into one mass bloom are spectacular when in flower, but are usually so only for a short period. Most of them require a marked dry season for it. If they are watered, if there is rain, or moisture in the soil, the leaves are retained.

Scent: Most of the scented-flower trees are night blooming, with the flowers being retained during the day in many cases.

Foliage: There is an enormous variation in size and shape of leaves. Many, especially of the family Fabaceae, have fine leaflets, which give a feathery look. Large leaves are easy to pick when fallen on the ground. Some could have needle like foliage, like the pines and Casuarina.

Shade: Most trees, if they are not subject to drought-like conditions, retain leaves for a good part of the year. Even small trees could be effective. Choosing trees with multiple uses make sense. Trees which come into ornamental bloom while retaining leaves should also be fine. So would species with edible fruits.

Wildlife: Fruit and nectar are taken by birds, bats and squirrels. These warm-blooded animals are not generally very choosy. With insects, it is a different case, where there is a certain amount of species specificity. Nectar is a general resource which many butterflies and bees take. A certain amount of damage might be just visible if looked for, when animals feed on plants, and should be expected if the garden has to support wildlife. One way of avoiding pesticide use is to use ‘exotic’ tree species, which generally do not get heavily infested since they do not have pests adapted to them in the introduced area.

Form: Tree shapes vary. There could be tall trees like the Conifers or the Mast Tree. There could be high broad crowns like that of the Rain Tree, or the rounded crown of a Mango. Tree shapes could be used very purposefully in garden landscapes.

Tradition and Worship: Some trees are traditionally planted in certain places. Ficus species are roadside favourites, and in many cases also near temples. Many scented species could find a place near temples and in homes. The number of species different religions endorse seems to have a lot with the kind of biomes they originated from!
History and Heritage: Ceremonial planting, and commemorative planting adds to the history of the area!

The analogy between a corporate landscape and a gated community landscape is quite evident. Although not directly within the scope of this piece of research work it has a tremendous potential for other students and researchers in the same subject domain.

2.2 Gated Communities

According to Thomas W. Sanchez, Robert E. Lang, & Dawn M. Dhavale the term gated communities for most people conjures up images of exclusive developments with fancy homes and equally fancy lifestyles. At the gates stand guards who screen all nonresidents or the uninvited. Much of the popular and academic literature on gated communities promotes this view. (http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.124.9830&rep=rep1&type=pdf) Accessed on 22/04/2014)

As understood in modern urban design parlance, a gated community is a form of residential community or housing estate containing strictly-controlled entrances for pedestrians, bicycles, and automobiles, and often characterized by a closed perimeter of walls and fences. (http://www.google.co.in/search?q=define%3AGated+communities&btnG=Search&hl=en&rlz=1W1GGLR_en&sa=2) Accessed on 03/11/2010.

Gated communities usually are equipped with small residential streets and include various shared amenities. For smaller communities this may be only a park or other common area. For larger communities, it may be possible for residents to stay within the community for most day-to-day activities. Gated communities are a type of common interest development, but are distinct from intentional communities. http://en.wikipedia.org/wiki/Gated_community) Accessed on 03/11/2010.

In countries with a low Human Development Index and/or high Gini coefficient, characterized by high inequalities, gated communities attempt to provide security to the upper class as well as expatriates. (ibid)

Some gated communities, usually called guard-gated communities, are staffed by private security guards and are often home to high-value properties, and/or are set up
as retirement villages. Some gated communities are secure enough to resemble fortresses and are intended as such. (ibid).

**Gated Communities are a world-wide phenomenon and there are several variants.**

In **Brazil**, the most widespread form of gated community is called "condominiofechado" (closed housing estate) and is ardently desired by the upper classes. It is like a small town with its own infrastructure (backup power supply, sanitation, and security guards). The purpose of such a community is to protect its residents from the prospect of outside disturbance. (http://en.wikipedia.org/wiki/Gated_community) Accessed on 03/11/2010.

In **Panama**, people buy houses in gated communities because of the high levels of security. The majority of these gated communities are built for the middle and upper middle classes. They are preferred over condos and apartments because of lower community payment, higher levels of privacy, and lower house prices (ibid).

In **Argentina**, they are called "barrios privados" (literal translation "private neighborhoods") or just "countries" and are often seen as a symbol of being wealthy. However, gated communities enjoy dubious social prestige (Many members of the middle and middle upper class regard gated community dwellers as nouveaux riches or snobs). While most gated communities have only houses, some bigger ones, such as Nordelta, have their own hospital, school, shopping mall, and more. In recent years, this influx of people going from the big cities to the gated communities has experienced a backlash in Argentina. Visiting Buenos Aires, the renowned geographer and urbanist JordiBorja from Spain who teaches urban planning at the University of Barcelona criticized gated communities calling them "the negation of cities". Architect and university professor Marcela Camblor, who heads the Urban Design Dept in Florida, USA told the La Nacion newspaper that "the gated communities experiment has failed", calling them "unsustainable from the economic, social, and now even energy point of view" (ibid).

In post-apartheid **South Africa**, gated communities have mushroomed in response to high levels of violence and crime. South African gated communities are broadly classified as "security villages" (large-scale privately developed areas) or "enclosed neighborhoods. Some of the newest neighborhoods being developed are almost
entirely composed of security villages, with a few isolated malls and other essential services (such as hospitals). A common mode of development of the security villages involves staking out a large land claim, building a high wall surrounding the entire zone, then gradually adding roads and other infrastructure. In part, property developers have adopted this response to counter squatting, which local residents fear are associated with crime, and which often results in a protracted eviction process. Crime syndicates have been known to acquire property in some of these security villages to be used as a base for their operations within them. (ibid)

They are popular in southern China, namely the Pearl River Delta Region. These communities are often purchased by overseas Chinese, Hong Kong Chinese, and new-rich local Chinese. Most famous one is Clifford Estates (ibid).

In Saudi Arabia, gated communities have existed since the discovery of oil, mainly to accommodate Westerners and their families. After threat levels rose since the late 1990s affecting Westerners in general and Americans in particular, gates have become armed, sometimes heavily, and all vehicles have been inspected. Marksmen and SANG armored vehicles appeared in certain times, markedly after recent terrorist attacks in areas nearby, targeting Westerners (ibid).

Gated communities are very rare in Europe.

**Criticism:** Proponents of gated communities maintain that the reduction or exclusion of people that would just be passing through, or more generally, of all non-locals, makes any "stranger" much more recognizable in the closed local environment, and thus reduces crime danger. This view has been attacked as unrealistic - since only a very small proportion of all non-locals passing through the area are potential criminals, increased traffic should increase rather than decrease safety by having more people around whose presence could deter criminal behavior or who could provide assistance during an incident. Another criticism is that gated communities offer a false sense of security. Some studies indicate that safety in gated communities may be more an illusion than reality, showing that gated communities have no less crime than non-gated neighborhoods.
Given that gated communities are spatially a type of enclave, Setha M. Low, among other anthropologists, has argued that they have a negative effect on the overall social capital of the broader community outside the gated community.

**Amenities:** Amenities available in a gated community depend on a number of factors including geographical location, demographic composition, community structure, economic status of residents and community fees collected. When there are sub-associations that belong to larger more inclusive master associations, the master association may provide many of the amenities. In general, the larger the association the more amenities that may likely be provided. Amenities also depend on the type of housing. For example, single-family-home communities may not have a common-area pool, since individual homeowners have the ability to construct their own private pools. A condominium, on the other hand, may offer a community pool, since the individual units do not have the option of a private pool.


Most gated communities in Bangalore are in the old CMC areas like Bannerghatta and Whitefield. (ibid)

Vinod Chandran, who moved into Prestige Ozone, a gated community in Whitefield says that: “It’s been a great experience living in a gated community. The children have lots of playing area and there’s good security. In many ways, it’s not very different from colonies of many public sector enterprises like HAL, ITI... They all provide a gated area, with a lot of common space and amenities too.” (ibid)

Poornima Dasharathí has tried to highlight the similarities or differences under certain common headers between gated community, apartment complex and individual houses in Bangalore. The following is a summary of her findings with respect to security, maintenance, ambience, transport, shopping, other facilities and residents:

**Security:** In both gated community and apartment complexes there is 24 hour watch at the community entrance. The security works in shifts. Still the watch is not that effective as the security is only at the entrance. In the case of individual houses in
some areas, Ghurkhas claim to parole in the night. Some families keep a watchman to do a night watch while they are temporarily away from home.

**Maintenance:** In both gated community and apartment complexes the maintenance is usually quite good. One doesn't have to go in search of a plumber/electrician/gardener as they are paid employees of the community. In the case of individual houses the owner has to find the local electrician who'll have a shop around the corner. It's always difficult to get such persons for small jobs and the quality of work might vary.

**Ambience:** Gated Communities have ample space, good parking lots and generally kept clean. The open area, good gardening gives the area a nice feel. However there are some for whom such exclusivity can be boring and would like some action on the street. Apartment Complexes too provide all the amenities a gated community would. Also many of them are located within the city and hence are very convenient to commute. Individual houses lose out on this end. However it makes up by providing ample action on the street. From the grocer shouting his wares, the noises of the autos to uninvited visitors like salespersons and courier boys ringing the bell at inconvenient hours.

**Transport:** The community is located in the suburbs. People commute in their own cars. School children are ferried through school vans/buses that enter the gated area. However for those who need an auto, it does come at an exorbitant rate. Buses don't stop here even though they might find commuters especially to the Airport. Most Apartment residents have cars and autos do commute in & out of the complex. For complexes that are located within the city limits transport is not much of a problem. In most middle class areas people use cars, autos for convenience. The lower middle class & the elderly use the buses.

**Shopping:** Malls and smaller retail outlets have sprung up to serve the community needs. However the prices are slightly higher than inside the city. In some apartment complexes retail outlets are located within the complex for basic needs. Most complexes also have a local ATM. Some huge residential enclaves like Brigade gateway claim to provide complete townships with hospitals, malls, banks etc. The
houses score on this point. Shops are just around the corner. One can walk down the street to buy vegetables or newspaper and do not have to use the car.

**Other facilities:** In gated communities and apartment complexes the integrity of domestic help needs to be established. Helps have to provide their residence and Id proof and their salaries are usually higher in gated communities than in houses. In the case of individual houses maids are sought through neighbors or nearby relatives. Some tend to be loyal while others move away for better opportunities.

**Residents:** In gated communities the residents are mainly from outside Karnataka, businessman, IT, young Bangaloreans, foreigners, pilots - middle class to upper middle class. In apartment complexes the residents are mainly Bangaloreans, Non Kannadigas, IT engineers who live temporarily in the city, mainly middle class. In the case of individual houses the residents are usually Bangaloreans who had been provided BDA sites, government employees, lower middle class and upper class. ([http://bangalore.citizenmatters.in/blogs/show_entry/692--gated-communities](http://bangalore.citizenmatters.in/blogs/show_entry/692--gated-communities)) Accessed on: 12/11/2010

A Ravindra, advisor to the chief minister, Karnataka, on urban affairs states that the emergence of gated communities clearly illustrates socioeconomic clustering in our cities. [http://www.deccanherald.com/content/63883/bridging-gap-ghettos-gated-communities.html#top], Deccan Herald, Friday 12 November 2010. Accessed on 12/11/2010

Gated communities have been rising as the preferred destination for home seekers in Bengaluru over the last decade. They offer a structured space both for living in individual homes and as a community, with a variety of amenities - club houses, swimming pools, community centres, parks, and more.([http://bangalore.citizenmatters.in/articles/print/2524-estate-manager-workshop-nov18th-brookfields](http://bangalore.citizenmatters.in/articles/print/2524-estate-manager-workshop-nov18th-brookfields))

**Accessed 12/11/2010**

With gated communities becoming increasingly popular in recent times, the department of town and country planning is now rethinking on proposing separate regulations for such development with separate terms and conditions based on existing

Karnataka’s Advocate-General Ashok Haranahalli, has said that roads and open spaces in gated communities cannot be closed to the general public, as it belongs to the concerned civic authority.  (http://bangalore.citizenmatters.in/articles/view/2398-advocate-general-haranahalli-gated-communities) Accessed on 28/01/2011