RESTORATION OF ECOSYSTEM – I

URBAN FORESTRY

An urban area is defined as a town or a city with a population of more than 2,500 people although some countries set the minimum at 10,000 – 50,000 residents. Urban areas generally have relatively few trees, shrubs or other natural vegetation that absorb air pollutants, give off oxygen, help cool the air, muffle noise, provide wildlife habitats, and give aesthetic pleasure. Most cities are places that cut down the trees and then name the streets or localities after them. For example, the area called Chinchpokli in Mumbai is named after *Chinch* trees i.e. imli or tamarind (*Tamarindus indica*) that was abundant in that area.

Restoration of urban centres is essential for sustaining urban communities. It refers to the enhancement of the ecological integrity of degraded public lands and other open spaces. Restoration of urban habitats provides social and economic benefits to the surrounding community, natural diversion to urban surroundings, enlightenment and education to individual citizens about the importance of balanced ecosystems and the role that humans play within ecosystems.

Urban forests consisting of trees, grasses, herbs and shrubs along streets, in parks and residential yards and hill slopes can be developed in three ways – permitting the survival of remnant natural biota, the deliberate planting of trees and permitting the unmanaged reproduction of both native and exotic planted trees. The plants in urban forests offer several advantages while experiencing stress than in natural areas due to higher urban temperatures, soil compaction, restricted root zones and variation in the intensity of light and wind caused by buildings and pavements. The advantages include:

- Recreational opportunities for city dwellers who rarely experience natural forests or the wildlife that inhabits them
- Amelioration of local climate through evapo-transpiration and shading and by altering wind currents
- Reduction of air pollution caused by particulates that collect on foliage and are washed by precipitation from foliage to soil
- Removal of nitrogen oxides, ozone, sulphur dioxide, carbon monoxide and halogens to some extent
- Reduction of about half of the excess air temperature caused by urban heat islands
- Reduction of noise pollution directly by absorbing it and by altering human perception of noise
- Reduction of glare
- Control of erosion
- Waste water recycling
- Energy conservation

Of the different life forms, trees are the most important in urban forest as they have prominent roles by acting as air – purifiers, dust absorbing devices and small oxygen factories.

CASE STUDIES OF URBAN FORESTRY

Bengaluru: -

Bengaluru Urban Forest Division is co-terminus with Bengaluru Urban district. It also includes the Bannerghatta National Park area. During the early 20th century, the district was fairly wooded with trees on farmlands but at the same time the pressure generated due to requirement of industrial and domestic needs was resulting in degradation of forest vegetation in general. Bengaluru as a fast expanding city has pressure of encroachment on all kinds of government lands including forest. The natural vegetation consists of species like *Albizia amara, Albizia lebbek, Anogeissus latifolia, Shorea talura, Santalum album,* etc. The city, popularly known as the Garden City, also has some well-known tree parks like Lalbagh, Cubbon Park created earlier and the Medicinal Plant Garden named as Dhanvantri Vana at Bangalore University Campus. The Bengaluru Green Belt Division was established during October 1982 mainly to afforest all vacant areas in and around Bengaluru city and to enhance the dwindling green cover. With the establishment of this Division, the Forest Department initiated intensive urban forestry activities in the city by undertaking large-scale planting of trees in the city as well as in the degraded forest areas around the city. New techniques of raising tall seedlings were evolved and planting of small-sized seedlings was dispensed with. Large-scale nurseries were raised to meet the demands of the department and the public. For the outstanding work done in the field of urban forestry, the division was awarded with the "Indira Priyadarshini Vrukshamitra" national award in 1988. Urban forestry continues to be the main activity of the division. A large number of lakes and tanks in the city are also being developed under urban forestry.

The geographical area of Bangalore Urban division is 217410 ha. The extent of forestlands in the division is 4298.43 hectares (includes both notified and other Govt lands) comprising of about 1.97 % of the geographical area. The forests are of tropical dry deciduous type. Bangalore Urban division lies on the Deccan plateau. The topography of the division is mostly flat or with moderate slope. The southern portion of the division is gently undulating and hilly. The elevation of the division varies from 835 m to 953 m. The forests of Bangalore Urban division are not known for their productive purposes. Most of the forests have been converted into man-made plantations of *Eucalyptus*, *Acacia auriculiformis* and minor forest species such as *Tamarindus indica*. The disappearance over the years of many of the City's lakes and tanks has been a matter of great concern. Apart from serving the water needs of the City, these water bodies too contributed a lot to the aesthetic beauty of the City and to its salubrious climate. Many of these tanks are seasonally filled during the rains and dry in the summer. A few of them remain filled throughout the year. Tree species like *Syzygium cuminii, Terminalia arjuna, Pongamia glabra, Vitex negundo, Aegle marmelos, Mesua ferrea, Acacia nilotica,* etc. were recommended for plantation in the tank areas as fencing around the city. Avenue planting (roadside) is one of the oldest ways of keeping the locality green and providing healthy environment. This includes planting different kinds of plants in different avenues depending on the needs, location parameters like width of road, power lines, buildings, aesthetic needs etc. Species like *Bassia latifolia, Thespesia populnea, Polyalthia longifolia, Mesua ferrea, Mimusops elengi, Michelia champaca, Mallotus phillipinensis, Azadirachta indica,* etc. were suggested for plantation along the roadsides. The city forest and sacred groves consisted of species like *Pongamia pinnata, Putranjiva roxburghii, Terminalia chebula,*

Buchanania lanzan, Ficus benghalensis, etc. Suitable tree species were also planted around playgrounds, educational institutions, road dividers, traffic islands, etc. Since sandalwood (*Santalum album*) is one of the most popular species in and around the city, its plantation and conservation in large scale in the urban forests was given prime importance. Nurseries were instructed and guided on the growth, propagation and planting of sandalwood tree. Indigenous and native species were given utmost importance as compared to exotic ones.

The Conservator of Forests, Bengaluru had opined that formation of new forest ranges is absolutely necessary in view of scientific management and protection of forests and carrying out development works in four main taluks – Bengaluru South, Doddaballapura, Magadi and Nelamangala.

Important tree parks of Bengaluru city are highlighted as follows.

Lalbagh – Lalbagh Botanical Garden is an important landmark of Bengaluru. It has been described as a pendant in the necklace of the Garden City's parks. Quite appropriately, it has also been called as the lung of the teeming Metropolis. Lalbagh is a treasure house of plants. The rich floral wealth of Lalbagh extends over an area of 97 hectares (240 acres) accommodating 1854 species 673 genera and 890 cultivars of plants. The star attractions of Lalbagh are the famous glass house, the Lalbagh pond and the island.

Cubbon Park - The Cubbon Park has a history of over 100 years. It was established in the year 1870 by John Meade, the then acting Commissioner of Mysore. Lush greenery welcomes any visitor entering Cubbon Park through any of the approaches. Rich in plant wealth, many indigenous and exotic botanical species are found here. The park has about 68 genera and 96 species with a total of around 6000 plants / trees growing in its locale. Many ornamental and flowering trees both exotic and indigenous are found in the park. *Grevillea robusta* (silver oak) trees having the distinction of being the first oaks introduced to Bangalore from Australia are still found in Cubbon Park adjacent to the tennis pavilion. A number of beautiful tree avenues can be seen in the park. The avenue of *Araucarias* along with *Canna* beds on either side of the road from the Library to Hudson circle is a beautiful view. The avenue of *Swietenia* in the Northern side of the park, the Java fig avenue along the road leading to the Government Museum, the *Polyalthia* avenue along the road from the Queen's statue to King Edward's statue and the chestnut tree avenue from the Chamarajendra statue to Siddalingaiah circle lend subtle grandeur to the park.

Dhanvantarivana at Jnana Bharathi (Garden of Medicinal Plants) - Directorate of Indian system of medicine Bangalore in collaboration with Karnataka Forest Department took up cultivation of medicinal plants on Bangalore university Campus over an area of 37 acres in survey No.27 of Nagadevenahalli Village, located at Jnana Bharathi Bangalore university Campus. Bangalore. Major objective of raising the medicinal plantation was to collect and grow as many medicinal plant species as possible and to develop it as model to be copied elsewhere. This Medicinal garden is planted with 414 species consisting of 173 species of trees,82 species of shrubs,92 species of herbs and 42 species of climbers. As part of the extension work to disseminate information on medicinal plants a educational nursery is raised to sell the seedlings to the public. The demand for medicinal species of herbs like Tulasi, Ashwagandha, Nelanalli, Nelabevu, Alavera, Madhunashini, Ondhu

Elega, Adsoge, Amruthballi and shrubs like Puthranjeeva, Parijatha, Mehandhi, etc. Many awareness programmes are conducted here.

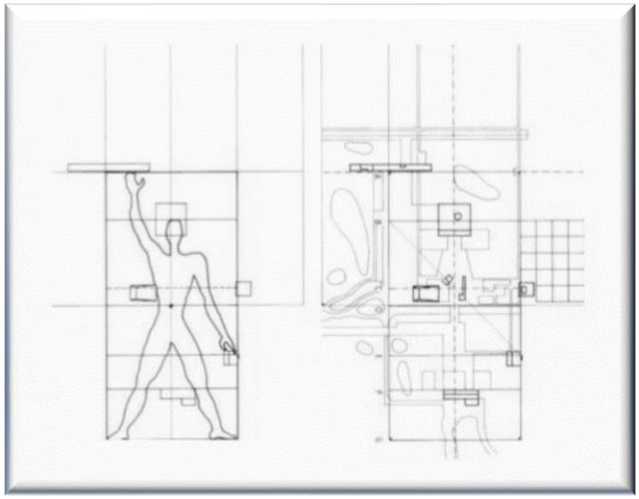
Arboretum at Kalkere, Bengaluru - An arboretum has been established at Kalkere in the year 1980. The valley portion having rich soil was planted with evergreen, semi-evergreen and moist-deciduous species. Dry-deciduous patches surround the valley. The evergreen and semievergreen patches were provided irrigation by drip as well as by pot for a long period. The arboretum is rigidly protected. There are about 80 tree species, 40 species of shrubs and climbers and large number of herbs. There is also a collection of 17 Nitrogen fixing tree species. The *Ficus* plot in the Arboretum here includes various species of *Ficus* like *F. religiosa, F. carica, F. krishnae, F. hispida, F. mysorensis, F. pandurata, F. microcarpa, F. racemosa, F. nervosa, F. elastica, F. triangularis,* etc. The Bambusetum is popular for species like *Bambusa balcooa, B. tulda, B. nutans, Dendrocalamus hamiltonii, Gigantochloa macrostachya,* etc.

Chandigarh: -

Chandigarh is a Union Territory as well as the joint capital of Punjab and Haryana states of India. It is one of the most significant urban planning experiments of the 20th century. It is a site of one of the greatest architectural creations of Le Corbusier, a famous architect. The city has a far-reaching impact, ushering in a modern idiom of architecture and city planning all over India. It is a bold experiment in modern civic design. It has thus become a symbol of planned urbanism. It is popular for its landscaping as for its architectural ambience too. Most of the buildings are in pure, cubical form, geometrically sub-divided with more emphasis on proportions, scale and detail.

The present area of Chandigarh city is about 114 sq.km. and the total population is about 10.55 lakhs. The city of Chandigarh is actually planned to human scale. The following areas uniquely represent different areas of the city.

- Head: Capitol (Place of power)
- Heart: The city centre
- Stomach: The commercial area
- Arms: University & industrial zone
- Lungs: Leisure valley, open spaces
- Arteries: Network of roads



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The entire city is divided uniformly into 'sectors', which was defined as a container of family life. Each sector encompasses 800 m by 1200 m, enclosed by roads allocated to fast-mechanized transport and sealed to direct access from the houses. Chandigarh has 30 such sectors.

The roads of the city are classified into seven categories, known as the system of 7 V's as follows.

- V1: fast roads connecting Chandigarh to other towns
- V2: arterial roads
- V3: fast vehicular roads
- V4: free flowing shopping streets
- V5: sector circulation roads
- V6: access road to houses
- V7: footpaths & cycle tracks

Since the infrastructure is well-planned and spacious, the city gets a systematic and disciplined look. But nonetheless, some 800 hectares of green open spaces are spread over the entire city. Major open areas include the Leisure Valley, Sukhna lake, Rock Garden, Pinjore Garden, Rose Garden, etc. The sectors are vertically integrated by green space in the form of parks oriented in the direction of the mountains.

Nagar Van (City Forests) - Urban forestry is an integral part of such city planning and development of Chandigarh. Urban forestry advocates the role of trees as a critical part of urban infrastructure. Adding more serenity to Chandigarh, the city forest also known as 'Nagar Van' was opened for public in 2019 by Chandigarh Administration. It is spread over a sprawling 100 hectares and situated near the Heart of City Beautiful i.e. Sukhna Lake. City Forests has been established under Nagar Van Udyan Yojana, which is an urban forestry scheme of Ministry of Environment, Forests and Climate Change. Maximum efforts have been made to keep this area natural without disturbing the natural habitat of existing fauna. The forest department has made lot of efforts in order to develop this Nagar Van. Before the development of city forests, this part of the lake forest was considered as a degraded forest. Maximum area of the forest was submerged in sewage water coming

from village Kansal. Due to sewage water stagnation, valuable tree species were dried up. Such dirty water was posing a threat to the valuable flora and fauna of this region. With the planning and execution of the Forest Department, traditional cleaning measures were involved and the natural ecosystem of this region was restored in the form of Nagar Van, which is highly commendable. Vegetation of Nagar Van includes *Acacia catechu* (Khair), *Butea monosperma* (Palash), *Acacia nilotica* (Kikar), *Cassia fistula* (Indian Labernum), *Mangifera indica* (Mango), *Ficus religiosa* (Peepal), etc.

Similarly, another such City Forest was established at Manimajra Village in a total area of 12.35 acres, which was earlier a brick kiln. As a result of dedicated and sincere endeavour of the forest officials, once a barren land, this is now a Green Belt, harbouring more than 40 species of trees. This forest is a paradise for morning and evening walkers and storehouse of fresh oxygen and relaxing place for the local inhabitants.

Shivalik Arboretum – This is situated near the Transport Light in Sector 26. This beautiful place spreads over an area of 11.115 acres. Previously a site full of industrial waste, the Forest Department took up the challenge of converting this barren land into vegetative land. Presently, this Arboretum boasts of a collection of prominent species of plants found in the Shivalik region like *Aegle marmelos* (Bael), *Albizia lebbek* (Shirish), *Bauhinia racemosa* (Kachnar), *Anthocephalus kadamba* (Kadamb), *Emblica officinalis* (Amla), etc. There are earthen tracks along which flowering plants are planted to serve aesthetic purposes. Interpretative boards showing information about the flora are installed all along the track to create awareness among the visitors.

Butterfly Park – Considering the fact that in cities, it is now difficult to see beautiful winged creatures like butterflies due to loss of habitat, the Forest Department of Chandigarh developed the Butterfly Park in Sector-26 in 2012. This park has been designed to facilitate an ideal environment for the breeding of butterflies. Host plants like *Mangifera indica, Salix* spp, *Citrus* spp., *Cinnamomum camphora,* etc. and nectar plants like *Dahlia*, T*agetes erectus* (Marigold), *Antirrhinum, Cosmos, Zinnia,* etc. have been planted inside the park to attract butterflies and also for the breeding of specific butterflies. In addition to nectar plants, butterflies also derive nourishment from pollen, tree sap, rotten fruits, etc. Rotten fruits are placed at different locations to attract the butterflies.

City Bird Sanctuary – Earlier in 1975, it was estimated that there were as many as 25000 green parakeets over sector-21 in Chandigarh. Due to increased urbanization in adjoining Chandi Mandir, Manimajra and Panchkula creating disturbing conditions for their ecology had urged the parakeets to find sector-21 as a new home. Thus, an urban wildlife sanctuary was created there, covering an area of 1.8 hectares. In common parlance, this has come to be known as 'Parrot Park' or 'Tota Park'. The park contains tree species like *Ficus infectoria, Syzygium cuminii, Schleichera oleosa, Morus nigra, Terminalia bellerica, Ficus religiosa, Psidium guajava, Casuarina equisetifolia,* etc. These species mainly provide shelter to Parakeets. Most of the trees have tall canopies, which appears to be a conducive factor for parrots to roost there and a kind of protection from the predators like vultures. Bushes include *Gardenia, Jasminum oleosum, Ixora, Malvaviscus,* etc. There is a shallow water point created and fed with a rubber pipe from the pump for the birds.

Botanical Garden – Chandigarh, situated in the foothills of the Shivalik is blessed with a climate that is suitable to accommodate a number of species of flora of different climatic regions. It was worthwhile setting up a Botanical Garden here with a purpose to conserve the flora of the region as well as those exotic and near extinct species. The garden spreads over 176 acres located near village Sarangpur. The Botanical Garden offers many facilities for the visitors. It has Energy Park building, lawns for recreation, benches, shelters, Meditation huts, cycle tracks, pedestal path, etc. The garden is divided into different sections like medicinal plants section, aquatic plants section, fernarium, cactus section, pinetum, sacred grove section, bambusetum, palmatum, Japanese garden, nutrition section, *Ficus* grove, Arboretum, Bulbous garden, tropical rainforest section, rare plants section, etc. having suitable plants species.

URBAN FORESTRY AND ECOTOURISM

Concept of Ecotourism:

Ecotourism refers to various principles and dimensions indicating natural and cultural environments and social well-being of humans. Hetzer (1965) was considered to be the first person to use this term. He provided four main principles to ecotourism:

- Minimizing environmental impacts
- Respecting host cultures
- Maximizing the benefits to local people
- Maximizing tourist satisfaction

Growing environmental concern coupled with an emerging dissatisfaction with mass and other forms of traditional tourism led to increased demand for nature-based experiences of an alternative nature. At that time, less developed countries began to realize that nature-based tourism offers a means of earning foreign exchange and provides a less destructive use of resources. By the mid-1980s, a number of such countries had identified ecotourism as a means of achieving both conservation and development goals.

Ecotourism can thus be defined as “travelling to relatively undisturbed and uncontaminated areas with the specific objective of admiring, studying and enjoying the scenery and its wild plants and animals, as well as existing cultural features both past and present found in those areas” (Ceballos – Lascurain, 1987). Ecotourists are attracted to a natural area and have more active role through a non-consumptive use of wildlife and natural resources, through activities such as nature photography, botanical studies and observing wildlife. Ecotourism’s association with protected areas is valid because it enhances the conservation element. Ziffer (1989) considered ecotourism from an active stance, highlighting the conservation, nature-based, economic and cultural components of ecotourism. The concept enhances the increased pattern of visits to the natural environment, and also serves as an ethic of how to turn the natural environment ensuring a minimum impact on its resource base. According to Boo (1990), ecotourists are generally more accepting of conditions that are different from their home than other type of tourists. Their characteristics include living according to the local conditions, customs and food, with their activities ranging from a walk through a forest, to

exploring and studying the natural attractions of the destination. Ecotourism is thus an environment friendly activity as it does not involve consumptive attitude to nature, it fosters environmental ethics and ensures that the eco-tourists have an inspirational and emotional satisfaction as it aims at benefitting the wildlife and environment and ultimately it promotes local development and empowers the local communities.

Ecotourism is an amalgamation of two different concepts – ecology and tourism, but viewed jointly. According to UNESCO, ecotourism involves nature-based tourism where the goal of both tourists and the operators is the observation, appreciation and preservation of nature and traditional cultures. In general, ecotourism stands for the management of tourism in such a manner that man derives maximum benefit from nature without disturbing its innate balance. Environmental protection becomes a vital part of sustainable tourism. The global importance of ecotourism, its benefits as well as its impacts was first recognized with the launching of the year 2002 as the International Year of Ecotourism by the United Nations General Assembly.

Role of Urban forestry in Ecotourism:

Urban forests consisting of trees, grasses, herbs and shrubs along streets, in parks and residential yards and hill slopes can be developed in three ways – permitting the survival of remnant natural biota, the deliberate planting of trees and permitting the unmanaged reproduction of both native and exotic planted trees. Such parks and gardens in an urban setting, besides plantations in the roadsides and road dividers, traffic islands comprise urban forestry.

In addition to national parks, there are state, country and city parks. Most state parks are located near urban areas and thus are more heavily used than national parks. The vast areas of world's parks in different urban areas provide an important base for ecotourism with multiple benefits to man.

The parks in general have a vast potential for the promotion of ecotourism but, unfortunately, tourists, tour operators or others who are involved in the business do not strictly follow ecological principles and other guidelines and as a result, most of the urban parks are experiencing different forms of ecological death. In any country, urban parks, which are highly congested with human population, have very little scope for development into eco-parks. They share an entirely different concept that cannot stand in comparison to the size of biodiversity in national parks. They range from tiny lots to many square kilometers according to the available land and cater more to the specific taste and choice of regular visitors. To an avid tourist, urban parks do portray a miniature ecotourism spot of a short duration visualizing the aesthetic value of the contents. Therefore, parks in general have a special place in ecotourism. Urban parks have a lot of potential to provide aesthetic joy to locals on a regular basis and also attract tourists from within and outside the country because of their unique characteristics in terms of flora, fauna, traditions, art, etc.

Gardens are of two types – scientific and non-scientific. Scientific gardens include botanical gardens and arboreta and depict a different management maintained by government and other allied agencies for scientific pursuit. Such gardens have different perspective and offer tourism with certain restrictions. Non-scientific gardens include ornamental and recreational gardens. They are open to locals and tourists. These gardens are specific to their origin and service. They occupy more space in area and size and aesthetically

pleasant looking that generally invites well-mannered and old age people. Often, gardens exhibit many diverse species of flora, some being exotic or local in definite arrangement with well-organized traits. They occupy unique position as ecotourism spots for people migrating within the nation.

Botanical gardens complement the goals and principles of ecotourism. Many urban based botanical gardens play an important role in the expansion of ecotourism from traditional non-urban settings into the cities. They are crucial to the future of ecotourism as increasingly the world's population is being concentrated in urban centres and for many of these urban communities, city botanic gardens represent the only or at least regular opportunity to visit a natural or near natural setting. For these reasons, botanic gardens represent a key opportunity for tourism operations in their vital pursuit. Parks and gardens locally play a dominant role in making people more nature lovers and directing them towards making them sustainable tourists.

Regular visitors of such urban forests often prefer visiting them at weekends rather than choosing exotic locations far away. Mostly the parks and gardens are established locations and few are modified from natural landscapes. As generations pass by, the younger people and children prefer locations such as parks and gardens to isolate themselves and enjoy the nature on their own. Parks consist of locally available class of plants and shrubs of aesthetic value. Locally, parks do attract many people because of the role they play in depicting a model nature and interaction of various biological aspects. Parks are also home to birds that invite bird lovers and morning walkers. The local initiation of tourism and sightseeing habits start by few visits to the local parks and as enthusiasm grows further the visitors turn as nature lovers and ultimately, they become regular tourists. To a busy urbanite, parks and gardens are the only refuge that brings nature close to them at easiest and near distance. They offer fresh air, pleasant sights and relaxation. Popular parks do generate substantial foreign exchange from international tourists and globally share small properties and revenue earned from ecotourism.

Some cities have had the foresight to preserve significant blocks of open space in the form of municipal parks. Many countries use the waste and abandoned land to make urban parks for eco-restoration and conservation of natural resources. The best example of this is the Maharashtra Nature Park created along the Mithi river near Mahim in Mumbai. The entire eco-park was created on a garbage dumping ground. The decreasing forest land and green cover is drawing policy makers turn towards urban vacant lands to cover with green cover to compensate the loss elsewhere on forests. This concept has multiple benefits – calling tourists for nature visit, control of urban sprawl of population, to combat urban heat islands and pollution effects, and enhance urban fauna and facilitate promotion of ecotourism. In some countries, parks and gardens that initiated ecotourism has put control on urbanization by occupying vacant lands, which could otherwise be used for construction of buildings, complexes, shopping malls, etc.

HOLISTIC APPROACH TO STUDY: –

A. Industrial Areas:

The government town-planning agencies are involved in fixing norms for developments that may occur in their jurisdiction. Urban areas are nowadays are constantly expanding at a faster rate. Increase in industrialization is necessary to some extent to cope up with the increasing population for daily goods and services. At the same time, environmental concern is also a must. The requirements of these agencies have to be taken into consideration when carrying out environmental impact studies for such industrial areas. Everybody is affected by development. One is either a 'developer' or a 'project-affected person' displaced from his habitat. Before any new large industry is established, a few essential environmental aspects will have to be first considered. In the official Development Plan, the town-planning agencies earmark certain areas for industrial development. Road widths for the same may be prescribed. Certain water bodies, lakes, ponds, canals, etc. may be shown and their use and water quality may be envisaged differently from those considered in the Environmental Impact Assessment (EIA). Once an area starts to get industrialized, unwanted 'induced growth' also begins within that area. The effect of this can indeed be enormous. An induced growth implies unplanned residential growth, similar to a slum-like growth, populated generally by poor people looking for employment in the upcoming industries. Their presence leads to a further secondary growth of people involved in rendering services to them such as small restaurants, hotels, autos, etc. It is not easy to predict this growth quantitatively, but it can be safely said that induced growth is difficult to prevent and can have a greater socio-economic effect in the long run than expected. Similarly, once an area starts to get industrialized, traffic starts to build up. Roads may prove inadequate. Cross-roads may become traffic snarl-points. Parking may become obstructive. A whole lot of environmental and human health ills may follow.

A tentative project proposal is first prepared to consider and understand its various funding, economic and other feasibility aspects. A formal, full-scale project proposal is then prepared after incorporating the latest design practices. A tentative site is selected and 'due diligence' studies to choose the best site/s. This is carried out to ensure that the site itself does not have problems, for instance problems inherited from previous owners of the land who might have released hazardous wastes of their own into the soil. Sometimes, the land itself may have unwanted toxic material or radioactive deposits naturally available at the site which would hinder subsequent activities. An elementary investigation is necessary to avoid later problems. Typically, such due diligence studies were not taken seriously in India until recent times. But slowly, the wisdom in conducting due diligence studies is being appreciated by commercial establishments in metros and industrial locations in India. Sometimes, instead of a project to be developed a product may be desired to be manufactured and marketed. If so, the EIA has to be further followed by a Life Cycle Analysis (LCA) of the likely environmental impacts due to its usage and final disposal. An LCA covers the product from what is popularly known as 'cradle to the grave'. Because of this approach of LCA, it differs from conventional tools such as environmental audit or EIA. LCA takes into account both local as well as global impacts and is hence more suited in the current environmental crisis. LCA can estimate various impacts on the environment such as climate change, stratospheric ozone depletion, troposphere ozone creation, eutrophication, acidification, toxicological stress on human health and ecosystems, the depletion of resources, water use, land use, noise,

etc. LCA has emerged as a very useful tool since its inception in the 1990's when Society of Environmental Toxicity and Chemistry (SETAC) has advised to conduct LCA for analyzing environmental problems.

The long-term effects of both public as well as private sector industries may not become so apparent in the initial years, but the detrimental effect on the ecosystem may nonetheless exist and show up gradually at which time it may be too late to do anything about it. A new industry may produce a hazardous waste whose presence may not affect anyone in the initial years but gradually ruin a soil or a whole ecosystem through release of its toxic contents.

Earlier, new factories or developments could be set up at any site one fancied for family reasons. One could easily go overseas and buy any old technology because it was cheaper in the initial cost. The earlier industrialists used to just do 'end-of-pipe' treatment of all wastes, whatever they used to be. Now, in the modern scheme of things, one has to take a holistic view of all projects whether they are of a civic nature or which involves the manufacture of commercial products. It is only by this way that all possible wastes (solid, liquid and gaseous) can be reduced as far as possible first in the manufacturing step and then in all the remaining steps so that they are fully reduced in volume and venom and are treated properly and the effluent reused as far as possible so that net minimum resources are used up and minimum residues go out to the environment. This is technically termed as "cleaner technologies" in production, operation and disposal. One can also consult specialists, environmentalists and the concerned industry associations to learn of the latest thinking in the industry concerning manufacture, waste disposal and environmental matters.

The following typical control strategies are generally adopted by industries for abating air pollution from their factories and meeting their national standards:

1. Avoid pollutant formation by using cleaner fuels such as those with low sulphur or ash content.
2. Undertake change in the processes such as using titanium dioxide instead of lead paint pigments.
3. Localize the spread of pollutants by having separate enclosure / layout for certain industrial areas.
4. Reduce concentration of pollutants before disposal by adopting necessary control equipments, for eg. Gravity settling, bag filtration, etc.
5. Dispose by dilution into the atmosphere.

The control authorities may prescribe various restrictions and even require that certain industrial operations be shut down during certain adverse atmospheric conditions.

B. Waste-Water disposal: -

'Wastewater' can be a very complex substance varying from domestic to a wide array of industrial wastewaters. Domestic wastewater includes typical domestic sewage, excreta, faeces, urine, sputum, soap, bathroom wastes and kitchen wastes. Wastewater from toilets is often called 'black' waters, while wastewaters from bathrooms, kitchens, etc. is called 'grey' waters. Industrial wastewater includes a large variety of wastes

from different manufacturing industries mixed in different proportions. Municipal wastewater is usually a mixture of domestic and industrial wastewater in different proportions.

The 'strength' of wastewater is expressed generally in terms of BOD or COD at a known temperature. In both the cases, higher the oxygen demand, greater is the presence of organic matter. If the BOD test is carried out over five days, it is called BOD_5 test. In developing countries like India located in seasonal rainfall areas, separate sewers are generally preferred, one for carrying the rainwater run-off during monsoons and another for daily domestic and industrial wastewater in the non-monsoon seasons. In India where rainfall is restricted to a particular season, separate sewers are used. The BOD_5 of domestic wastewater in such cases is generally of the order of 45 – 54 g/person/day at 20°C.

The type of sewerage system in urban areas depends upon the availability of water for sanitary purposes. Daily water usage in India varies from less than 25 litre/person/day in unsewered rural areas to as much as 120 – 150 litre/person/day in urban areas. A minimum usage of about 70 litre/person/day can be considered appropriate for providing a sewerage system which is designed to have a 'self-cleaning velocity'. It becomes necessary to ensure flow through the sewers to keep them flowing and not allow the excreta to be left stranded in the sewer lines. A higher flow of fresh water may be allowed in some cities where the water resources permit it. On an average, at least 80% of the water supplied to a community returns as wastewater. The rest is likely to be consumed in cooking, drinking, or lost in leakage and evaporation. Thus, for example, if a city like Mumbai is supplied water @ 180 litre/person/day, the wastewater is approximately about 145 litre/person/day and the BOD_5 comes out to be approximately 300 mg/litre. The COD value for the same is about 1.6 to 1.9 times the BOD_5 value.

Treatment of wastewater generally has one major and all-important objective – to protect the environment and public health. Environmental protection generally implies stabilizing the organic matter and releasing the nutrients for recycle to keep the ecosystem going, while health protection implies destruction of pathogens and preventing transmission of persistent and accumulative pollutants through the food chain.

According to the WHO, health protection requires Total Sanitation. Total sanitation is essential for obtaining tangible health benefits and includes 'sanitation' of all forms of water and wastes in a community which includes drinking water, wastewater, storm water and municipal solid waste. In any country, sanitation is difficult to achieve on a country-wide basis. In India, even our major cities are yet having less than ideal water supply system and are only partially covered by sewerage system. We have yet to install total sanitation systems in most of our cities and towns. Additional problems complicating sanitation in India are our rapid growth rate, poor water supply situation in many parts, general need for water conservation, the difficult electric power position, the difficult land availability position and severe lack of funds.

Sanitation includes three stages – the defecation stage, conveyance stage and the treatment and disposal stage. In areas where the water is scarce and one may not be able to have a water-carried sewerage system, then one of the following 'on-site' dry disposal systems may need to be used – bore-hole latrine,

double-pit latrine and eco-san. Another on-site disposal system often used is the septic tank which is preferred when water is available for using flushing toilets but no sewerage system exists to carry away the wastewaters. A septic tank followed by soakage in a pit or trench is one of the most commonly used methods all over the world. Where enough water is available for providing a sewerage system, the sewage may be collected from an area and made to flow to a site where some treatment can be given before discharging the effluent to an adjoining water body or land for irrigation. This is called as 'off-site' disposal.

Two types of sewerage systems are generally provided – a conventional centralized sewerage system having a major outfall at the end, or a decentralized sewerage system in short lengths serving smaller areas. The sewer pattern can affect both treatment methods (natural as well as mechanized) and water conservation practice. Natural methods of treatment are those which depend on the action of plants or microorganisms like algae, duckweeds, etc. all of which draw their oxygen from natural sources. The wastewater is passed through oxidation ponds. Mechanized methods of treatment involve machinery and can perform more or less uniformly throughout the year. It includes techniques like activated sludge, sequential batch reactors, trickling filters, aerated lagoons, rotating bio-discs, membrane filtration, etc. Availability of land area becomes the most important requirement for selecting one of the methods mentioned above.

Generally, in most of India, one of the following combinations of treatment methods can be recommended:

- For individual or small groups of bungalows with on-site disposal: septic tanks + soak pits
- For districts with several houses and off-site disposal: septic tank + constructed wetland + ground water recharge
- For small and medium-sized towns: oxidation ponds + land irrigation + ground water recharge
- For larger cities, metropolitan areas: aerated lagoons + reuse in local industry.

Another peculiar problem to an over-populated country like India is the problem of slums and their insanitary conditions. Indian cities have at least 20 – 25% of their population residing in slums and shanties. Metropolitan cities like Mumbai at least 50 – 60% of their population residing in slum areas where water and sanitation are both very difficult to provide. In slums, water supply is mainly through stand-posts and sanitation mainly through provision of community toilets. Efforts are being made to provide more sanitary system in slums, but sanitation is still a long way off. The wastewater disposal is provided mainly in the form of 'shallow sewers' as is done in countries like Brazil.

The speed with which sanitation and water disposal demand increases with time is exponential, especially in the urban and the semi-urban areas. It will keep improving rapidly with further time.

URBAN ISSUES

Urban Transport System: -

Transportation of all types becomes the lifeline of any metropolitan or a megacity. Movement of people and goods keep the economy going. It is an important sector of the urban system. An efficient

transport system facilitates the smooth functioning and development of cities. Nowadays, all types of public transport are available right from autorickshaws, taxis, cool cabs, buses, trams, local trains to metro trains and monorails. People use them to commute from home to work and back. As an example, the Delhi Metro Rail that was constituted to decongest the roads of Delhi started a run for 22.06km in 2002. At present it covers more than 204 km covering Delhi and the NCR. It has not just eased the movement of people but also has given momentum to further urban sprawl. Besides these, private vehicles also clog the roads to a large extent. Transportation as well as the lack of it is helping to make the urban environment unacceptable and increasingly uninhabitable. Yet transportation more than anything else could help redevelop the cities and create the new urban settlements that we desire. For instance, the Delhi-Mumbai Industrial Corridor (DMIC), an ambitious project of the Government of India initiated in December 2006, was envisaged on 1499 km of western dedicated freight corridor of railways, is an attempt to develop infrastructure and industry along the route of the corridor. Other similar projects in different stages are Chennai – Bengaluru Industrial Corridor, Bengaluru – Mumbai Economic Corridor, Eastern Coast Economic Corridor, Amritsar – Kolkata Industrial Corridor.

The undesirable effects of unplanned urban transport system are obvious everywhere:

- The crowding, confusion and congestion of motorized traffic in a setting is never designed for mechanized movement. People are known to get stuck in traffic snarls for too much time with total uncertainty.
- The pollution of the atmosphere is another big concern. About 60% of it is due to the internal combustion engines. Nowadays battery and electric operated vehicles are slowly increasing in the cities though on a small scale. Eg. In cities like Amritsar and Delhi, electric rickshaws have already become a means of public transport. It doesn't cause any pollution but it requires good maintenance.
- Due to the increasing vehicular traffic, there is also a steep rise in the cases of road and rail accidents. The Mumbai – Pune Expressway, for instance, is popular for such fatal accidents on a regular basis. Tens and thousands are killed and injured by mixing machines with pedestrians. Road deaths and casualties are one of the serious problems faced by the urban dwellers. In India, pedestrians and two-wheelers are worst hit in road casualties. According to a report by the Centre for Science and Environment (CSE) in the Times of India on 24th June, 2014, on an average five persons die in road accidents daily in Delhi, in which four of them are either pedestrians or two-wheeler riders.
- More number of vehicles leads to more noise in the environment which disturbs the peace. The excessive noise of buses, trucks, trains and airplanes disturbs the peace of the community.
- If one looks around the streets, lanes and by-lanes of any city today, one finds them lined with parked cars and other vehicles throughout. Such endless rows of parked cars have converted the streets into garages and also spoil the aesthetics of the city. This is more because of such vehicles which have been just dumped by the owners and have not been in use for a long time. They simply gather dust; become a breeding ground for mosquitoes, insects as well as anti-social elements sometimes. The "Operation Khatara" initiated by the well-known Mumbai Mirror daily has revealed that approximately a total

area of 1.25 acres in a city like Mumbai is lost only to these unwanted parked vehicles. Sometimes, such vehicular scrap is also dumped into the mangrove sites, thereby destroying its ecosystem too.

- The miles of dismal asphalt streets – one-fourth of the area of the city – lined with billboards, filling stations, garish eating places, poles and wires – become a part of the linear slums of the automotive age.
- The growing distances from recreation and the countryside, and the increasing time and frustration of getting from one city to another keeps rising, adding to the frustration levels.

The transportation revolution of the past two decades has completely changed the urban future. When the urban industrial growth began, transportation determined the character of cities. The speed of urban growth and the relative poverty of the times made cities planless, tasteless and aesthetically hapless. The form and character of transport affects the internal structure of the cities. Suburban growth in recent times has become a reality due to the improved transportation facilities. Integrated transport and land use planning will enable efficient movement and consequent less congestion on roads and containment of travel demand. Workplaces and residences should be planned together. Self-contained small clusters are desirable in the city region. According to Agarwal (2006), it is important to consider the congestion impacts, emission characteristics and energy efficiencies to ensure sustainable mobility.

Many urban areas in India are improving in terms of transportation but still a lot needs to be done. Mumbai became the first city in India to introduce the monorail as a means of public transport though the areas that it covered were not much useful to a large section of people. The entire city is now being interconnected by the extensive network of metro lines, which are being constructed. The first metro rail to be introduced in India was in Kolkata. It has been immensely useful to the people since 1986. Similarly, trams are also found only in Kolkata. Now, many other cities have also started metro services for the people, like in Delhi, Bengaluru, Lucknow and Hyderabad. In an urban setting, sharing of autos and cabs by people is observed and must be encouraged so as to reduce the requirement of the fuels as well as the pollution associated with it. One vehicle carrying four people rather than four persons taking four different vehicles in the same direction automatically reduces three more vehicles on the road, for instance. Since Mumbai lies along the coastline, public waterways are also being planned for inter-city transport at a cheaper price. Extensive plantations of good canopy trees like rain tree (*Samania saman*), neem (*Azadirachta indica*), gulmohar (*Delonix regia*), etc. can become buffers for absorbing the dust and the noise that can drastically reduce the environmental problems without compromising on the need for transportation. Chandigarh is the best example for such a well-planned city. The streets are lined by avenue trees; there are huge traffic islands at regular intervals and at the same time, the road dividers are also used for planting shrubs and trees. Other cities can follow such an example. Non-motorized modes of transport, which includes cycle, rickshaw and walking are greener modes of travel. The use of such modes should be encouraged. Public transport should be made one of the preferred modes as it occupies less road space, consumes less fuel and emits less fuel per passenger per kilometer travel in comparison to personal motor vehicles. In India, Bus Rapid Transport System (BRTS) runs in cities like Jaipur, Indore, Rajkot, Vijayawada, Pune, etc. Monorail has been operational in Mumbai. Planning for the same is going on for other cities like Chennai, Kolkata and

Coimbatore. With the promotion of public transport and non-motorized modes and discouragement of private transport, the vehicular emission per person could be reduced. However, this should be in consonance with improved vehicular technology, use of cleaner fuels and taking off the obsolete vehicles from the roads. National Green Tribunal (NGT) of India has banned vehicles older than 15 years. The need of the hour is to adopt and promote bio-fuels such as ethanol, bio-diesel, green diesel, etc. The Thyagarajar College of Engineering at Madurai devised a novel method wherein waste plastic bottles were used in producing tar that was ultimately used for constructing roads. This also solved the problem of plastic waste disposal to a large extent. This idea has been used by other cities too like Tatanagar in Jharkhand. The roads also remain long-lasting.

In many parts of the world, planned new cities with a high-quality environment have proved to be feasible because transportation and communication have been used together. For example, with the advent of the GPS, one can directly decide which route to take in a city based on the traffic conditions. Thus, instead of improving transportation to accommodate congestion, one should use transportation as a developmental tool to bring about new urban settlements and new designs within established cities, both providing the environmental quality that science and affluence now make possible. Urbanization is a continuous process and the problem of transportation is one of the crucial aspects to be dealt with in urban areas. The gap between the demand and supply for transportation facility should be minimized with proper planning and policy intervention. There should be a paradigm shift towards adopting sustainable measures in city transport planning. Promotion of non-motorized vehicles and giving the due regards to pedestrians would make the city structure sustainable for living.

Energy Demand: -

Few centuries ago, most of the power available to human society was limited to solar energy trapped by green plants which produced organic matter. The energy requirements of man were modest and could be fulfilled by solar energy mainly. But now, due to increasing urbanization and changes in lifestyle compiled with modern technologies, the situation has changed drastically. The industries of our country claim a large share of the total energy (about 45%), followed by transportation (11%), domestic establishments (about 22%) while agriculture requires about 17%, according to CSO, 2013.

One of the major problems with large urban settlements is that industry, transport and domestic energy requirements – all tend to increase in geometric proportion with the city size. A small village or town is not significantly dependent on motor transport, which means that it is not a heavy oil consumer. There is little commercial consumption of power because there is hardly any night life in a small town. Much of the low-tension load, therefore is for domestic lighting within individual houses. In a large city, business houses and places of entertainment are major power users. Travel distance being great in a large city, fuel consumption by motor vehicles is also very high and there is much less dependence on bicycles or animal drawn vehicles. In a small settlement, cooking fuel requirements are met partly by fuel wood and partly by agricultural waste. In contrast, agricultural waste is not available in an urban area. If wood is used for cooking,

smoke pollutes the environment and demand for fuel further accelerates deforestation. If coal, kerosene or gas is used, there is further depletion of fossil fuels. To the extent that electricity is used for domestic purposes, including cooking, more thermal power plants have to be set up and more coal extracted. All this has a major impact on the environment, directly through air pollution and indirectly through mining, deforestation and rendering large tracts of land almost waste and sterile. Energy, and how the energy demands are met, therefore become very major environmental considerations in urban settlement planning.

No urban developmental plan in India makes any specific provision for energy resources, which could be cost effective, provide adequate access to energy to even the poor, and which would be sustainable as well as eco-friendly, though the inclusion of such resources has begun recently and the use of ecologically efficient energy resources has been in the limelight since a few years. There was a time when Mumbai's transport needs were served largely by electric suburban trains, which are aptly called the lifeline of Mumbai, thus greatly reducing the need for motor vehicles. But the situation is grim as the number of private vehicles has shown a steep rise since few decades owing to better lifestyle and desire for luxurious and comfortable travel. Countries like the Netherlands, UK, France, US, etc. pay people as an incentive if they take up cycling as a mode of transport, but in India, the mindset is different. The designing of buildings and commercial offices can also be made eco-friendly in such a way that they do not require artificial cooling in summer and are naturally warm in winter. Such buildings do not consume vast amounts of energy and release heat into an over-heated environment through air-conditioners.

Increase in demand for aviation fuel is also another major problem these days due to increase in the air traffic connecting major urban settlements throughout the country. Besides, there is tremendous loss of such fuel if a flight gets deviated from its scheduled time because it has to keep circling at a height till it gets a clearance for landing. Alternative sources of such fuel are being researched. One potential source was found to be bio-diesel. The fuel extracted from the seeds of *Jatropa* was found to be promising in this respect. In August 2018, a flight completed its first successful journey from Dehradun to Delhi using the biodiesel obtained from this plant. Such renewable sources, if tapped properly, can be used for fulfilling most of the urban transport demands in India.

A large part of energy used by mankind is in the form of electrical energy for the generation of which other forms of energy are used, a practice which often involves much wastage. The estimated electricity consumption increased from 43,724 GWh during 1970-71 to 7,72,603 GWh during 2011-12, showing an increase of 11.26%. In India, total installed electric power generation capacity is about 102.34 thousand megawatts. About 73% of this power comes from combustion of fossil fuels or thermal power. Hydro-electricity contributes about 25% while nuclear power contributes about 2% only. The share of coal and petroleum is expected to be about 66.8% in total commercial energy produced and about 56.9% in total commercial energy supply by 2021-22. Combustible renewables and waste constitute about one-fourth of Indian energy use. The total consumption of energy from conventional sources increased from 44,448 peta joules during 2010-11 to 47,264 peta joules during 2011-12, showing an increase of 6.33%. In 2010, the real GDP growth of India was the fifth highest in the world. This high order of sustained economic growth is

placing enormous demand on its energy resources. As a result, there is much imbalance in the demand and supply of energy among all sources of energy mainly in the urban areas.

CLIMATE CHANGE TRACKER

BIBEK BHATTACHARYA

THIS WEEK: The Energy Equity Gap

Wealthy countries have a far larger per capita energy footprint. ISTOCKPHOTO

An unequal world

One of the most hotly debated aspects of international climate change negotiations stems from the question of equity. Should wealthy Western economies be doing more to cut their emissions? Should the burden of mitigation fall more on them than on countries burning far fewer fossil fuels?

It has always been clear that economies that have a higher historical emissions footprint, like Europe or the US, should be doing much more. But a new study, published earlier this week in *Nature Science*, backs the argument with some interesting figures. The paper, *Large Inequality In International And Intranational Energy Footprints Between Income Groups And Across Consumption Categories*, was prepared by a team of economists from the University of Leeds, UK. The researchers went through data from the European Union and the World Bank to rank per capita energy consumption across 86 countries. The finding, as reported by the BBC, is that the wealthiest 10% in the world consume nearly 20 times as much energy as the poorest 10%. When it comes to transport, the wealthiest 10% consume 187 times more energy than the poorest 10%. But here's where the international distribution becomes important. For example, the paper states that 20% of UK citizens, and 40% of German citizens, are among the top 5% of global energy users, whereas for India it's just .02%. Much of the energy disparity comes from the ability to afford private transport. Asking rich countries to cut emissions at a higher rate is only fair.

But even within India, far too few people consume far too much. In 2018, the Credit Suisse Global Wealth Report stated that the richest 10% in India own 77.4% of the country's wealth (the top 1% owns 51.5%). As the Leeds report shows, India's poorest have an energy footprint of only 8.06 gigajoule per capita per year. The richest have an energy footprint of 156.28 gigajoule per capita per year. So while we call on richer countries to do their bit, India can do a lot more for its own citizens by incentivizing public transport and putting curbs on private vehicles.

Follow the series with #MintClimateTracker. Click on the QR code to listen to the first episode of Mint Climate Change Tracker.

-Mint, dated 21st March, 2020

RESTORATION EFFORTS

Gardens and Parks: -

Gardens are primarily constructed for their aesthetic appeal. They provide a place for recreation and also add greenery to the surroundings which helps in purifying the atmosphere and maintaining the balance of atmospheric gases.

Planning of garden is an art and science of all factors which regulate it like geology, soil condition, geography, rainfall, history, availability of space, light factors, etc. In the development of garden and landscape especially in olden times not much importance was given to exotic varieties. The local varieties of plants were grown in the backyard of the house and over a period of time it became a gene bank for particular species. For example, most of the houses in earlier days had *parijatak* plant (*Nyctanthes arbortristis*) for its fragrant flowers which were used as offering to God. In ancient India every temple had a garden to supply continuous flowers for making of garlands to be offered to God and every temple had a specific tree or plant which is called "sthalvriksh" and this plant was propagated in that particular surrounding. Therefore, a natural landscape developed, at some times, protection was given to the plant. As the population grew, space

becomes limited and therefore many areas which had these types of concepts were lost to industrial process as well as housing. Therefore, the need for green space and recreation centres became essential. Therefore, slowly the concept of gardening developed on a large scale.

In any country, urban gardens are created in a city and they share an entirely different concept. They range from tiny lots to many square kilometers according to the available land and cater more to the specific taste and choice of regular visitors. Urban gardens have a lot of potential to provide aesthetic joy to locals on a regular basis and also attract tourists from within and outside the country because of their unique characteristics in terms of flora, fauna, traditions, art, etc. One such example is the Rock Garden of Chandigarh, which was single-handedly planned by Nek Chand and attracts tourists from all over the country and the world.

Gardens are of two types – scientific and non-scientific. Scientific gardens include botanical gardens and arboreta and depict a different management maintained by government and other allied agencies for scientific pursuit. Non-scientific gardens include ornamental and recreational gardens. They are open to locals and tourists. They occupy comparatively larger area and are aesthetically pleasant looking that generally invites well-mannered and old age people. Often, gardens exhibit many diverse species of flora, some being exotic or local in definite arrangement with well-organized traits.

Botanical gardens are often run by universities or other scientific research organizations, and often have associated herbaria and research programmes in plant taxonomy or some other aspect of botanical science. In principle, their role is to maintain documented collections of living plants for the purposes of scientific research, conservation, display and education, although this will depend on the resources available and the special interests pursued at each particular garden. A contemporary botanical garden is a strictly protected natural urban green area, where a managing organization creates landscaped gardens and holds documented collections of living plants and/or preserved plant accessions containing functional units of heredity of actual or potential value for purposes such as scientific research, education, public display, conservation, sustainable use, tourism and recreational activities, production of marketable plant-based products and services for improvement of human well-being.

Parks and gardens in an urban setting locally play a dominant role in making people more nature lovers and understand the importance of plants in any ecosystem. Some gardens are also home to birds that invite bird lovers and morning walkers. To a busy urbanite, parks and gardens are the only refuge that brings nature close to them and at easiest and near distance. They offer fresh air, pleasant sights and relaxation. Sometimes, they also highlight the local biodiversity.

Some cities have had the foresight to preserve significant blocks of open space in the form of municipal gardens. Many countries also use the waste and abandoned land to make urban gardens. The decreasing forest land and green cover is drawing policy makers turn towards urban vacant lands to cover with green cover to compensate the loss elsewhere on forests. This concept has multiple benefits – calling tourists for nature visits, control of urban sprawl of population, to combat heat islands and pollution effects and

enhance urban flora. In some countries, parks and gardens have put control on urbanization by occupying vacant lands, which could otherwise be used for construction of buildings, complexes, shopping malls, etc.

Some well-known gardens in India are listed below which have become huge attraction for tourists over the years and have added charm to the respective urban areas:

1. Shalimar and Nishat Gardens - Srinagar, JK
2. Rose Garden - Chandigarh
3. Coonoor Botanical Gardens - Ooty, TN
4. VeermataJijabaiBhosleUdyan - Mumbai, MH
5. Indian Botanical Garden - Howrah, WB
6. Lalbagh Botanical Garden - Bengaluru, KA

[Many other examples from national and international level can be mentioned as per your choice.]

Reclamation: -

Land reclamation, usually known as reclamation, is the process of creating new land from oceans, river beds, or lake beds. The land reclaimed is known as the reclamation ground. Generally, big cities and urban areas located on the coast carry out reclamation in order to expand the urban infrastructure with the growing pressure of the increasing population.

Land reclamation can be achieved with a number of different methods. The simplest method involves filling the area with large amounts of heavy rock and/or cement, then filling with clay and dirt until the desired height is reached. The process is called "infilling" and the material used to fill the space is generally called "infill". Draining of submerged wetlands is often used to reclaim land for agricultural use. Deep cement mixing is used typically in situations in which the material displaced by either dredging or draining may be contaminated and hence needs to be contained. Land dredging is also another method of land reclamation. It is the removal of sediments and debris from the bottom of a body of water. It is commonly used for maintaining reclaimed land masses as sedimentation, a natural process, fills channels and harbors naturally. Based on these, the land reclamation methods can be categorized into five major types:

1. Dry method - The dry method is the simplest one but is vulnerable to soil liquefaction. Heavy rocks and cement are used in this method.

2. Hydraulic reclamation method – It is carried out at a depth of 6-8 metres. Borrow source and barge carriers are used to fill materials to achieve reclamation.

3. Re-handling method – Temporary storage pits are created in this method by using a natural depression or by dredging using a cutter suction hopper dredger.

4. Hydraulic filling method – Trailer suction hopper dredger is used in this method. The fill material is dredged from the borrow source and pumped by discharge pipe. This method is not suitable for shallow and soft sea-beds.

5. Sand spreading method – A spreader with a small floating barge is used. Winch system and bulldozer is used for movement so that the sand spreads uniformly across the reclaimed land.

There are various examples of small nations and cities across the world where reclamation has been successfully carried out. The Hong Kong Airport, Palm Jumeriah, Stadium in Qatar, Singapore are some of the excellent examples. The shore of Jakarta Bay is another interesting example. Land is usually reclaimed to create new housing areas and real estate properties, for the rapidly expanding city of Jakarta. So far, the largest reclamation project in the city is the creation of "Golf Island", which is still ongoing. In India, Mumbai is the unique example of reclamation. In fact, the city was a group of seven islands many decades back. These seven islands were joined to each other mainly by reclamation from the sea and the creeks. It took over 150 years to join these seven islands by reclamation. The Bandra reclamation is a popular hang-out place in suburban Mumbai. Kurla, Bhandup wetland and Bandra - Worli Sealink are other good examples from the city. Recently, the coastal road is being planned to be constructed in Mumbai which will stretch from Marine Drive to Bandra, aiming to decongest the ever-increasing traffic movement along the stretch. This will involve more reclamation from the sea.

Environmental consequences of reclamation:

Reclamation of land from water bodies, if carried out in the right way has its own significance too. Before industrialization, the main reason for reclamation was to increase the agricultural land. In South China, farmers reclaimed paddy fields by enclosing an area with a stone wall on the sea shore near a river mouth or river delta. Rice grown on such grounds was found to be more salt tolerant. Another way in which such lands can be used was the creation of fish ponds, which is commonly seen in Hong Kong. Sometimes, such reclaimed areas also attract species of migratory birds. In some cases, draining of swampy or seasonally submerged wetlands is carried out to convert them into farmlands. It doesn't create any new land but alters the natural one in such a way that the land becomes more productive. Otherwise, it would have been restricted to only a wildlife habitat. It is also an important method of mosquito control.

Beach rebuilding is a type of reclamation in which the beaches are repaired using materials like sand or mud from inland. This can be used to build up beaches where erosion from longshore drift is a common occurrence. It stops the movement of the original beach material through longshore drift and also retains the natural look of the beach. Many such beaches can be seen in and around Mumbai, for example, the Chowpatty beach, beaches near Palghar, etc.

Reclamation, if carried out over a longer period of time and without considering the local environment, can have disastrous consequences. Draining the wetlands for ploughing is a type of habitat destruction. In some parts of the world, new reclamation projects are restricted or no longer allowed due to environmental protection laws. Reclamation projects have strong negative impacts on coastal populations. Sometimes, some species can take advantage of the newly created area, acting as invasive species.

Due to sedimentation and land clearing, two major ecosystems of the coast are badly affected – the coral reefs and the mangroves. This happened in Singapore where lot of coral reefs are found. Following the demand of more land space due to growing population, the population of coral reefs decreased due to land

reclamation. About 60% of the coral reefs got destroyed due to the reclamation work. One such affected species was the mushroom coral (*Heliofungia actiniformis*). Corals provide shelter for several aquatic organisms in the sea, such as fish. Clearing these coral reefs could disrupt the food chain and ecosystem of these aquatic organisms that depend on it. Corals are usually moved to another place when land is to be reclaimed. The corals might not be able to survive in that certain habitat, and thus die out. In some countries, where the project is large-scale, they do not even bother to re-plant the corals elsewhere, instead just reclaim the land *on* their habitat, causing them to die out immediately. Marine life, such as fishes, might not have enough food after the underwater plantations are destroyed due to reclamation of land. This applies to the food chain. The waters might also be polluted from the soil used to reclaim land, causing the fishes to die and blocking out sunlight, depriving the underwater plants of growth. Marine habitats are also destroyed, as mentioned earlier; therefore, the marine creatures would be forced to move to another new habitat. Some might not be able to adapt, and thus die out. Some would just die without even finding a new habitat, as they cannot move long distances in water. Similarly, the number of phytoplanktons too reduced in the water due to inability to obtain sunlight for carrying out photosynthesis. The living environment of marine plankton and benthos has been affected by reclamation projects. The investigation of living environment of marine plankton and benthos in Tianjin Harbor Industrial Zone was carried out three times from 2006 to 2008. The results showed that the Shannon-Weaver diversity index of phytoplankton and zooplankton decreased from 3.01 to 1.71 and 1.7 to 0.58, respectively. In addition, the diversity index of Shannon-Weaver of benthos decreased to zero from 1.28. The results showed that reclamation projects would change the living environment of marine organism, decrease the diversity of biology and change the structure of community.

Mangroves are the barriers that prevent tidal waters from crashing on to the coastal areas. Destruction of mangrove forests is increasing exponentially especially in India, in the name of development. The area for increasing roadways and railways has led to shrinking of mangrove areas. Recently, many small village residents in Navi Mumbai started receiving sea waters into their homes during every high tide due to lot of reclamation work done in that area for development activities like new airport and port harbour construction, besides many private housing projects. According to environmentalists, Navi Mumbai has its entire area touching the sea. Tides, being a natural phenomenon, there is entire marshy land to hold the water during high tide. But due to the negligent government policies, many marshy lands have been filled for projects and housing, forcing sea water to enter human habitations. Sea erosion in such a case is clearly not natural. Many residents of South Mumbai are protesting against the construction of the proposed coastal road because too much of land would be reclaimed from the sea and it will lead to extensive flooding in those regions.

Reclaimed land is highly susceptible to soil liquefaction during calamities like earthquakes, which can amplify the amount of damage that occurs to buildings and infrastructure. Subsidence is another major issue. Drained marshes will eventually sink below the surrounding water level, increasing the danger from flooding.

As a restoration method, reclamation thus involves intensive scientific and ecological assessment of the area where it is to be carried out. The impacts can vary from one place to another. Environmental impact of the work needs to be considered the top priority before carrying out reclamation work. It must be ensured that the loss created due to reclamation should be compensated for by replantation programmes at other

places. If done in an ideal way like this, then the reclamation can be said to be successful as a restoration measure of the urban ecosystem.

RELATIONSHIP OF FOLLOWING WITH PLANTS

Health: -

Health applies to the total environment: resources, diet, open space, housing, recreation, medicine and others. A suitable environment is the first requirement of all living beings. Human health is first of all dependent on the maintenance of the environment which is compatible with the basic needs of the human as an organism.

Modern environment is increasingly becoming artificial and man-made. This poses a two-fold threat to human health: firstly, it contains elements which are outright noxious; secondly, it is undergoing rapid, drastic, and often irreversible changes which more and more endanger the delicate balance of the ecological system and nurture human capability for adaptation.

Man is required to use to his own advantage the limited resources of the earth, and is in fact, the only species capable of creatively cooperating with nature to ensure his own progress and survival. Yet, for most of his time on earth, man appears to have believed that he could exploit, contaminate, and alter the world about him without endangering the environmental milieu on which his life depends.

Recent history and increased population pressures, now demonstrate the shortsightedness of such a view. Almost incredible advances in science and technology have given man a new and awesome power to alter or even destroy his own environment. His skill and ingenuity in manipulating the environment have produced tremendous benefits to human life. Man has seriously depleted the world's natural resources, and devastated much of the earth's surface. The waste products of his technology and his own biological processes have grossly polluted the land, air and water. Man, ironically in this century has begun to discover that his basic social and psychological drives are increasingly frustrated by pressures of the artificial, urbanized world which he himself has constructed.

The bacteriological, chemical, physiological and psychological insults which man has injected into his environment are clearly associated with the rising toll of chronic disease throughout our society. Even therapeutic drugs, with their manifested benefits, pose subtle threats when considered as part of the total chemical assault sustained by modern man. Thousands of consumer products, from foods to television sets, offer potential hazard to human health and safety. These too constitute part of modern man's total environment.

It has become clear that if we are to maintain an environment that is conducive to human health and well-being, while continuing to enjoy the benefits of modern science and technology, we must recognize the interrelationships and interdependence of all factors in the ecosystem of which man is a part. The effects of environmental manipulation are far reaching and interacting. For example, pesticides are now present

throughout the environment, polluting our water, concentrating in the food chain, threatening the extinction of beneficial species of wildlife, and building up in the fatty tissues of human beings. Chemicals, for example, are ingested with the air we breathe and the water we drink, as part of medicinal formulations, in the form of food additives or traces of veterinary drugs or pesticide residues on foods. They have the dangerous potential of interaction and intensification of the effect on human health.

Our efforts to maintain a healthy environment in the past have largely ignored these interrelationships and have too often failed to view man as a part of the ecosystem.

The main cause of damage caused to the environment is by destroying the plants. Deforestation is rampant throughout the world in the name of development. Plants have a profound influence on the health of the people. The main way in which it does is by improving the quality of the air that one breathes. The secondary metabolites produced by higher plants mostly become medicinal ones for us. They are able to keep away disease causing pathogens. For instance, it was observed that the incidences of malaria were nil wherever tulsi (*Ocimum sanctum*) plants were planted. Huge trees having good canopy like neem (*Azadirachta indica*) can cool the immediate environment by as much as 5°C. That is evidently seen in our forefathers who used to live closer to the nature and plants with a good healthy life span.

We need to now re-examine and reassess traditional ways of doing things to ensure that all the systems and subsystems which we devise to maintain ourselves on the planet truly contribute to the total health and well-being of those they were designed to serve.

Tourism: -

In general, animals are popular tourist attractions, while plants are not. The manifold role of plants in tourism as also tourism's effects on plant life have been virtually ignored. Plants are mostly overlooked just as general plants 'form the inconspicuous background of our daily lives'. Plants are perceived as immobile, passive, non-sentient beings, with whom humans are unable to interact, because they do not share human senses. Because plants supposedly cannot feel pain, it is assumed that they cannot be mistreated, hurt of abused by human behavior. Killing a plant involves less feelings of guilt than killing of an animal. These differences in perception of their respective traits led to a prioritization of animals over plants in tourism and influenced the roles allotted to each. An important consequence of this state of affairs is that in tourism studies, the plant-tourist interface has been virtually neglected.

Thus, plants play a major and diverse, but little recognized, role in tourism. Tourists are involved with plants, sometimes intentionally but more often unintentionally, in a great variety of ways and situations. Plants play a major, direct or indirect role in the tourist industry. Plant parts are utilized as materials in the construction of tourist establishments, frequently to endow them with a 'natural' look. Plants surround tourists in their hotels and on excursion to markets, historical sites, entertainment venues and natural attractions, and flowers of different species are often presented to and worn by tourists. A few tree and flowering plant species, often labeled as 'megaflora' are important tourist attractions. For example, plants of

Orchidaceae have generated interest among tourists all over the world, especially those visiting north-east India. The San Francisco Orchid Society (2017) organizes yearly excursions to view orchids in places such as Crete, the Brazilian Amazon and Ecuador.

Plants and herbs have been traditionally used for remedies and healing and are now widely deployed in the rapidly growing niche of wellness tourism (Koncul, 2012). Researchers have investigated the role that different olfactory sensations have on tourists. Hansen (1991) mentioned that Southern India 'evokes a summer night with the delicious fragrance of flowering shrub called *raat kee rani,* Queen of the Night'. The Aromatherapy centres in Kerala providing healing and massage therapies using aromatic oils extracted from plants is still popular all over the world.

Tourists are also seeking to better understand traditional knowledge of wild edible plants in many regions. Plants are also given consideration because of their role in medicine and ethnobotany. Guided field trips to the Omora Ethnobotanical Park in the Cape Horn region gives tourists an opportunity to experience the beauty of the austral bryoflora (bryophytes) while at the same time providing sustainable incomes for local people. Noxious plants like poison ivy and poison oak are species that tourists must be aware of, and often fear, in moving from urban to rural or wilderness landscapes.

According to Beardsworth and Bryman (2001), he distinguished a range of four types of settings, based upon the degree to which such settings are 'framed':

i. Fully-natural (i.e. unframed) settings, such as the remaining 'untouched' wildernesses, particularly primary forests, deserts, swamps, High seas, etc. in which there is no regulatory interference by humans. Such settings provide visitors with the experience of the undisturbed ecological complexity and interdependence of many varieties of plants, and offer an opportunity to encounter rare or impressive mega-fauna, such as huge, old trees (eg. *Sequoia sempervirens*) or rare orchids. For example, the living root-bridges is a popular tourist attraction in Meghalaya.
ii. Semi-natural (i.e. lightly or partially framed) settings, such as nature preserves, national parks and sanctuaries. Restrictions are imposed upon animal or plant species; some rare or attractive ones are preserved to keep the ecological balance. Visitor mobility and access to rare or attractive plant species is facilitated by infrastructure and signage.
iii. Semi-contrived (i.e. substantially framed) settings, such as botanical gardens or spice or herb gardens. Such settings feature replanted plant species, often in their replicated natural environments. Botanical gardens are arranged by geographical location and/or ecosystem type for purposes of education. Such settings offer visitors a learning experience, in addition to the opportunity for recreation in a secluded natural environment.
iv. Fully-contrived (i.e. fully framed) settings, such as formal gardens, flower festivals, flower shows or flower markets. These are the most commodified settings for plant tourism. In such cases, the flowers are detached from the living plants and are separately exhibited, displayed or sold.

Tourism and recreation in natural and semi-natural settings have a significant, and sometimes critical impact on plant life. According to Ballantyne and Pickering (2013), the IUCN has red-listed 462 vascular plants in Europe that are critically endangered, endangered or vulnerable. Many of the threats include trampling, collection, climbing and mountaineering, construction of tourism infrastructure, habitat degradation, fishing and track development. Similarly, out of 250 such listed plants in Australia, 98 of them are threatened by tourism and recreation. The indirect effects of tourism also include spread of weeds and pathogens from tourist activities. The spread of *Parthenium* in India is well known.

Environmental ethics have received a great deal of attention over the last 40 years in Western philosophy, while there is a tradition in Asian philosophy spanning approximately 2500 years, mainly in Buddhism. The principal sets created based on this have relevance to linking tourism, plants and morality. For example, the justification behind plucking flowers in any type of natural setting.

Plants constitute an unmarked, inconspicuous, virtually ubiquitous background, unnoticed but critical, for the functioning of the tourism industry. Their extrinsic moral value is undeniable: without plants, other forms of life, including animals and humans, could not exist. New avenues of thought should open up regarding the possibility of affording plants a higher level of moral consideration in the realm of tourism.

Culture: -

Plants have been a part of one's culture since time immemorial irrespective of any religion. Man shares spiritual or cultural relationship with many plants. Some plants like *Ocimum sanctum* are worshipped and conserved. Such plants offered in worship are protected and grown in and around places of worship. Some plants are also associated with some Gods and Goddesses and considered sacred. Faith, taboos, clan names, totems, etc. are associated with many native plants. Man derives satisfaction or some consolation by placing faith in plants, and the plants in turn get protection from wanton damage. There are sacred plants not only in Hindu mythology, but also in Muslim literature, Muslim cultures, in Christian literature, like the Christmas tree (*Araucaria excelsior*). In certain instances, whole forest areas, forest patches have been conserved as sacred forest or sacred grove.

The Adivasis living in forest areas believe in supernatural powers of various animate and inanimate objects. Adivasis have an intimate relationship with the plant wealth around them. Their material culture almost entirely depends not only on the forest products of their vicinity, but they also have deep faith in supernatural powers of certain plants. These plants are, therefore, associated with festive and auspicious days, riddance from disease, safeguards against animals and evil spirits, and weather and crop conditions.

It is observed that many tribals of West Bengal and Odisha have some traditional timetable of cutting the wood from trees even for fuel. They have some dates when there will be a festival which generally relates to the ripening of fruits of a particular species. It is after this festival that they can cut the branches of that species even for fuel. In general, in Hindu culture too, there are many festivals associated with the phenology of certain plant species. The harvest festival of Rabi crops is celebrated as Pongal in south India and Lohri in

Punjab and northern states. The fruits of ber (*Zizyphus jujuba*) are consumed during Holi when it is the fruiting time of the plant. Yellow bunch of flowers of *Cassia fistula* are considered sacred during the Onam festival of Kerala.

"Chirka" – tuber of one species of *Dioscorea* is attributed to the clan "Bhakta" inhabiting the Purulia district of West Bengal. Bhaktas never cut this particular species. There is a belief that taking of immature rhizome or tuber causes illness. Plants like *Dillenia aurea*, *Streblus asper*, etc. and abnormal trees are believed to be the abode of supernatural powers. It is also believed that any injury to these plants brings incurable diseases and death. As a result, some big tree species are found near tribal areas which indirectly help in regeneration of those taxa.

Beliefs in plants even go to the extent of forecasting in many rituals. Mahua (*Madhuca indica*) flowers are used in an elaborate ritual for forecast of rain in many places. Vanjing (*Oryza sativa*, rice) grains are used for the 'Jog-dekhna' ceremony i.e. forecast of mutual relationship between husband and wife. According to a study conducted by Pramod, Sivadasan and Anilkumar in 2003 in Kurichya, the largest tribal community of Wayanad district of Kerala, it revealed the use of 40 plant species for magico-religious beliefs belonging to 34 genera and 27 families. Among these, 23 species are used for religious functions, 14 for agricultural ceremonies, 7 for functions related to life cycle, 7 for ritual healing techniques and magical treatments and other 8 species are related to sacred or supernatural beliefs. For example, fruits of *Areca catechu* are given as offerings to Gods during their festivals Onam and Vishu. In a survey carried out by Vijay Sharma and B.D. Joshi (2010) in the Almora district of Uttarakhand state in India, it was observed that 19 plant species have high utility and importance in religious activities and traditional healing systems. Plants like *Ficus religiosa, Mangifera indica, Aegle marmelos, Cynodon dactylon, Piper betel,* etc. find lot of mention and use in the folk religious rituals to appease various Gods and Goddesses. Sprinkling of water containing tulsi leaves all over the house is believed to ward off 'impurities' and evil spirits. Its decoction is given as 'tirth' in many temples in south India to purify the internal systems. Neem leaves are eaten by the Hindus especially on New Year day (Gudhi-Padva) to ward off sickness. Many tribal priests always tie the neem twigs around his waist like a skirt to ward off evil spirits during religious ritual performances.

Prophet Muhammad chose green as the colour of His religion. He exhorted his followers not to cut green trees. He advised to plant such trees as provide fruits to man and fodder to cattle. He also advocated economy in the use of water. Some of the plants mentioned in the Holy Qur'an are: *Phoenix sylvestris* (khajoor), *Olea europea* (jaitun), *Vitis vinifera* (angoor), *Punica granatum* (anar), *Ficus carica* (anjir), *Zizyphus mauritiana* (ber), *Acacia nilotica* (babool). Prophet Muhammad advised his followers to eat pomegranate as a way to purge the spirit of envy.

The Parsis worship fire as one of the five life supporting elements. They burn fire in fire temples using wood of babool and offer sandalwood sticks while performing prayers. Some plants sacred to their religion are *Phoenix dactylifera* (dates), *Punica granatum* (Pomegranate), *Ephedra gerardiana* (somballi), *Santalum album* (chandan), etc. Leaves of pomegranate are given to chew at the time of Navjot and marriage ceremonies to impart purity to body and soul. Its twigs are used to make sacred broom and its juice is

squeezed into the mouth of a dying person. Home twigs are pounded in brass mortar while chanting sacred hymns of Avesta.

In Christianity, according to the Bible, God first created all vegetation in the Garden of Eden and then created man. Some of the plants described in Bible are *Populus alba* (Poplar), *Salix tetrasperma* (Willow), *Lawsonia inermis* (Mehndi), *Aloe vera* (Korphad), *Ricinus communis* (Castor), *Brassica nigra* (Kali mohari), etc.

Sikh religion recognizes only one source of primal energy in the Universe, which can neither be created nor destroyed. According to Shri Guru Granth Sahib, God, the creator of the world is compared to a tree. Sikh Gurus used to give sermons under the shade of trees around water bodies. Sikhs believe that trees planted in the names of Gurus thrive well. The trees associated with Sri Guru Nanak Dev Ji, the founder of Sikhism are *Ficus religiosa* (peepal), *Sapindus trifoliatus* (Ritha), *Dalbergia latifolia* (Talli), *Zizyphus mauritiana* (Ber) and *Bauhinia purpurea* (Kanchan).

Gautam Buddha, the founder of Buddhism, was himself born under an Ashoka tree in a sacred grove in Lumbini, Nepal. He spent almost 52 years out of 80 years of his life in close proximity to trees and forests. He always preached that forests and green trees should not be cut. He once remarked that the act of tree planting is as noble as the construction of a temple. According to Buddhism, man is entrusted with the sole responsibility of promoting environmental ethics. Man should utilize nature in the same way as a bee collects pollen from the flower, neither polluting its beauty nor depleting its fragrance. *Shorea robusta* (sal), *Ficus benghalensis* (vat), *Syzygium cuminii* (jamun), *Ficus infectoria* (pakad), etc are some of the trees associated with Buddha. Besides, some of the trees under which Buddha and his followers attained enlightenment are *Alstonia scholaris, Butea monosperma, Ficus obtusifolia, Messua ferrea, Terminalia tomentosa, Azadirachta indica, Bambusa arundinaceae,* etc.

Lord Mahavir, the 24th Tirthankar and founder of Jainism, strongly advocated Ahimsa projecting it as a supreme religion. He realized that there is life in all animals, plants, water and air and that this life should not be destroyed. According to him, cutting and burning of forests was a great sin. In keeping with these principles, he exhorted his followers to become vegetarians. Various tree species are associated with different Tirthankars in Jainism. *Ficus benghalensis, Pinus roxburghii, Albizia lebbeck, Terminalia bellerica, Aegle marmelos, Diospyros melanoxylon,* etc. are some of the significant species associated with this religion.

Some trees are considered sacred for being the incarnation of a specific deity. For example, all trees, which have trifoliate leaves, like the varun (*Crataeva religiosa*), are believed to be associated with the Trimurti. The leaves of the bel, which are also trifoliate, represent Shiva's three eyes and are offered to Him in worship. Other trees are held sacred because they are believed to be the homes of certain Gods. A specific mention of the different varieties of Rudraksha (*Elaeocarpus ganitrus*) exists in Lakshmipuran and Shivapuran. Shiv-lingas made of rudraksha are found in many temples across the country.

The latex of *Pogostemon purpurascens*is used by many Muslims in north-east India to bathe a dead body before its burial. Selection of this plant is done with the belief that the fragrance of this plant will

suppress the bad smell of a dead body. Using of fragrance is also considered a *Sunnah* (a way of Prophet's life). After putting the dead body in the shroud, its head should be perfumed. Wet camphor of *Cinnamomum camphora* is rubbed on the head, nose, knees and feet. Dress of the dead is smoked with the gum extract of *Canarium strictum*.

There are frequent references to plants, particularly to flowers and fruits in folk songs, folk tales and folk proverbs. They refer to important characteristics or qualities of the plants, their uses and sometimes to express other associations and beliefs.

CASE STUDIES OF INDIAN METROPOLITAN CITIES

A metropolitan area is a region consisting of a populous urban core with an agglomeration of peripheral zones not themselves necessarily urban in character, but closely bound to the center socio-economically by employment or commerce. It is characterized by urbanization which is a process of human movement and centralization towards and into cities and urban areas with the associated industrialization, urban sprawl and lifestyle. Urbanization in India is more rapid around the major cities of India. The population growth has been mainly centered around cities. Increase in industrial activities, population (endemic as well as floating) and vehicular population etc. led to a rapid increase in environmental problems, the most common one being air pollution.

1. Mumbai: -

Air pollution in Mumbai

The air quality and pollution are represented in the form of AQI (Air Quality Index) as designated by the WHO. AQI factors in five categories of pollutants: ground-level ozone, sulphur dioxide, carbon monoxide, nitrogen dioxide and particular matter. The table given below shows the categories of AQI and their impact on the human health.

AQI	Air Pollution Level	Health Implications
0 - 50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk
51 -100	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
101-150	Unhealthy for Sensitive Groups	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects

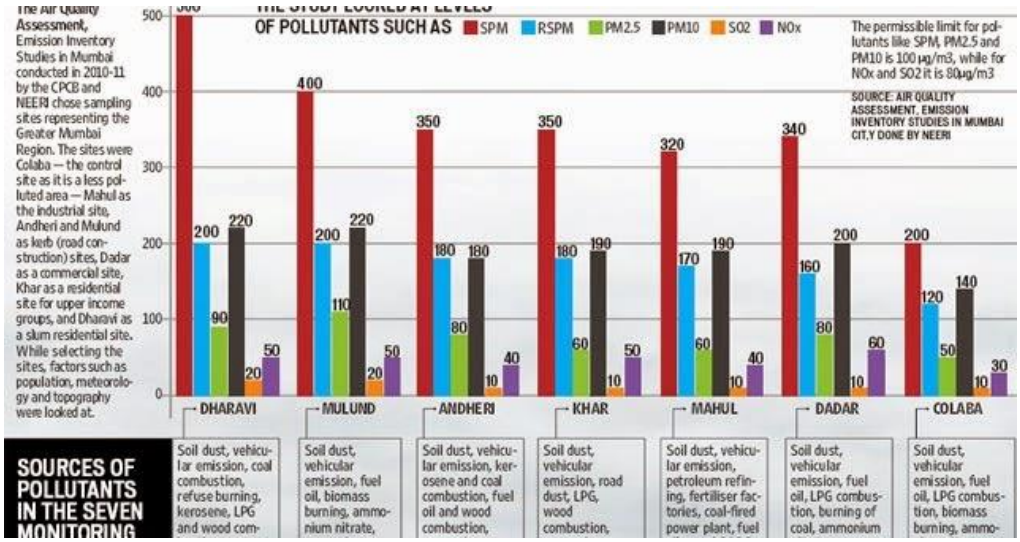
AQI	Air Pollution Level	Health Implications
201-300	Very Unhealthy	Health warnings of emergency conditions. The entire population is more likely to be affected.
300+	Hazardous	Health alert: everyone may experience more serious health effects

The present overall AQI of Mumbai (i.e. in December, 2018) is recorded at 183, which falls under the "Unhealthy" category. Air quality index (AQI) of 80 μg/m3 in Mumbai is considered as safe as per Ministry of Earth Science's System of Air Quality and Weather Forecasting and Research (SAFAR). In city it averages around 120 to 300. The city is breathing a cocktail of hazardous heavy metals like lead and cadmium, as well as noxious gases like sulphur dioxide, carbon monoxide and nitrogen dioxide. It also steadily worsened since 2014-15, when the average air quality index in Mumbai was 117, according to Maharashtra Pollution Control Board. According to the Central Pollution Control Board (CPCB) data of 2012, the analysis of nine-year air quality data with respect to PM_{10} showed an increasing trend till 2008 and slight decrease in 2009. NO_2 also showed an increasing trend but SO_2 showed a decreasing trend. In addition to criteria pollutants like SO2, NO2 and PM10, CPCB also collected data on four additional parameters such as ammonia, carbon monoxide, ozone and particulate matter with size less than or equal to 2.5 μm in the year 2010. Ammonia levels were measured with the help of National Environmental Engineering Research Institute (NEERI). With respect to ammonia, low levels were observed in industrial and residential areas of Mumbai. There was no improvement of air quality standards at all the monitored locations except Parel in Mumbai. Thus, ammonia was found to be within the National Ambient Air Quality Standards (NAAQS) in Mumbai along with some other metropolitan cities. A study released by the Centre for Science and Environment (CSE) in December 19, stated that Mumbai's air has the highest concentration of PM10 out of 24 cities in peninsular India. According to data from the CPCB the average annual PM 10 concentration in Mumbai 2007 was 90μg/m3.

Roshni Udyavar Yehuda, president of the Institute of Environmental Architecture and Research, agrees. She identifies vehicular emissions and construction work as major sources of pollution and says that efficiently managed public transport and a development plan which allows for a staggering of infrastructure projects, are the need of the hour.

According to BMC officials, there are over 150 roads that are currently under construction, in addition to which roads are being dug to create new stormwater drains, lay sewage lines and wires, pipes and cables, and to repair existing footpaths not to mention six new metro rail lines covering 139 kms. While work on the BMC's ambitious coastal road project resumed last month, and the State Public Works Department is widening and concretizing the Sion-Panvel highway, construction is also actively underway on the Goregaon-Mulund Link Road, Bhandup Water complex and over 1000 commercial and residential buildings. This is a cause for concern because as environmental expert, advocate RB Mahabal, points out that ready-mix concrete plants spread a lot of fine sub-micron respirable particulate matter in the ambient air.

According to a study conducted in the city between 2010 and 2016 by the WHO, Mumbai had also been ranked the 63rd most polluted city among 859 cities around the world. In an alarming reflection of the city's air pollution levels, the WHO's air pollution database had ranked Mumbai as the fourth most polluted megacity in the world. the graph depicted below gives a clear idea of the air pollution levels in Mumbai around the year 2010.



The air quality in Mumbai has improved in the last three years, with the average levels of pollutants dipping significantly, according to the BMC's Environment Status Report (ESR) 2017-18 released recently. However, the levels of the air pollutants remain much above the Central Pollution Control Board's permissible limits. According to the report, the annual average PM 10 (particulate matter lesser than 10 microns) levels in 2017-18 for the nine locations monitored by System of Air Quality Weather Forecasting and Research (SAFAR) were above the permissible limit of 60 µg/m^3 (micrograms per cubic metre of air)—the overall average for Mumbai was 93 µg/m^3. The average levels of the more hazardous PM 2.5 (lesser than 2.5 microns) were between 38 and 68 µg/m^3 this year—the overall average for Mumbai was 54 µg/m^3. Only Worli recorded an annual average lesser than the permissible limit of 40 µg/m^3. Nitrogen dioxide levels at the four monitoring sites of the BMC were in the range of 62 to 76 g/m^3 (grams per cubic metre of air) in 2018, much above the permissible limit of 40 g/m^3.

One of the major causes of it is the unorganized industries sector. Unauthorized burning takes place at many of these industries which goes unchecked. Besides, the dust generated from the Ready-Mix Concrete (RMC) plants is also very dangerous and these still continue to operate within the city limits, according to Godfrey Pimenta from the NGO Watchdog Foundation. According to Khar-based environmental activist Zoru Bathena, the three locations where PM levels are above prescribed levels have heavy traffic. People generally prefer private vehicles instead of public transport, which is a major reason for excessive traffic in Mumbai. Another source of pollution is heavy construction; there is fine dust seen coming from construction sites, which only worsens the air quality. Industrial areas are mainly concentrated in some pockets of the city like in Airoli, Turbhe, Ghansoli, Vikroli, Kalyan – Dombivli (MIDC), Navi Mumbai, etc. where the air pollution can be felt in the form of an obnoxious smell of all types of gases in the air throughout.

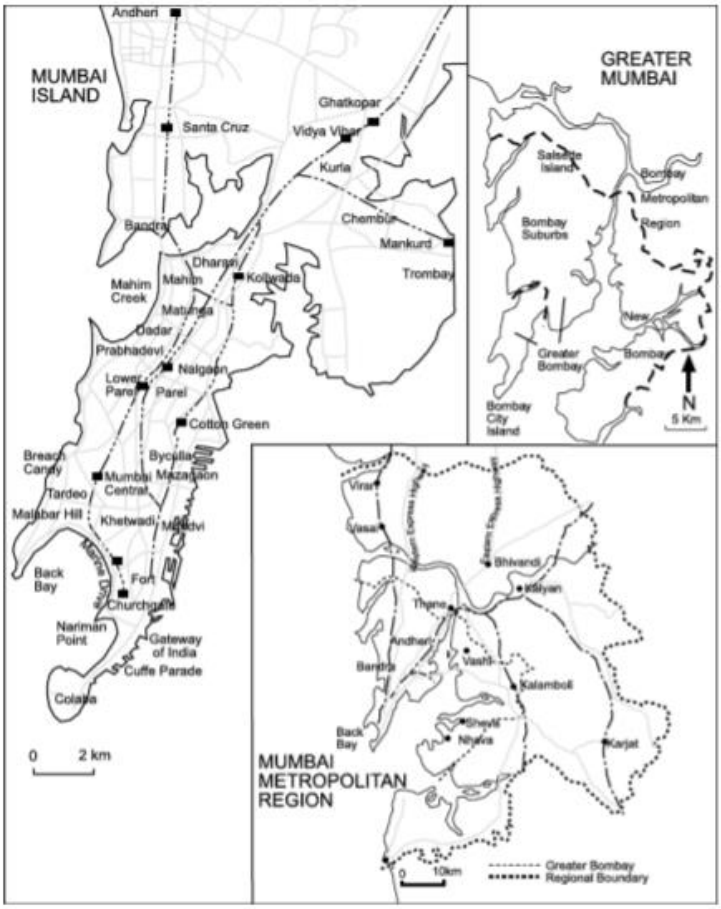
Water pollution in Mumbai

Lakes and rivers are abundant in the huge metropolitan city like Mumbai. The city of Mumbai gets its supply of water from seven major lakes located around it – Modak Sagar, Tansa, Tulsi, Vihar, Bhatsa, Middle Vaitarna and Lower Vaitarna. Tansa and Vaitarna dams supply to the south Mumbai while the rest supply to the suburbs. The rivers include Poisar river, Dahisar, Oshiwara and the Mithi river. Besides, there are various creeks in and around Mumbai that meet the Arabian sea at many places. The Thane creek, Mahim creek, Kalyan creek, etc. are some of them. The Western Ghats located near Mumbai trap most of the monsoon clouds and feed these water bodies during the monsoons. But unfortunately, due to the uncivilized attitude and careless disposal of garbage, industrial effluents and all other types of waste directly into the water bodies have badly choked these waters and rendered them unfit for primary uses. Mindless disposing of all types of garbage directly into the stagnant waters of small and big drains, rivers and creeks have made them offensive with a persistent smell lingering in the air throughout in these areas. Religious wastes produced mainly during festivals are dumped directly into these water bodies which adversely affect the BOD and aquatic life. Small and big industries discharge toxic effluents into the waters. Small agricultural fields along the railway tracks sometime use such dangerous waters to grow crops like spinach, which poses a grave health hazard.

According to The Energy and Resources Institute (TERI), the number of monitoring units for such a big city is not enough. When there should be one water quality monitoring station for every 5 km, the present ratio is 1:43 km. The Vaitarna river, which supplies nearly 30% of Mumbai's water, has WQI monitors only upstream, and none downstream, near to Mumbai. The 122-km Ulhas river, which has 10 tributaries, is monitored by only three stations. Around 8 rivers and about 17 tributaries are not at all monitored. The only monitoring station is located at Bhandup in Mumbai, which is the BMC's sole lab. It carries out pollution tests in the form of turbidity, residual chlorine, colour, toxic heavy metals, coliform bacteria, etc.

The pollution levels of water bodies are measured by a parameter called WQI (Water Quality Index). It is measured by calculating the various parameters like DO, faecal coliform levels, pH, BOD, temperature, total phosphate, nitrates, turbidity and total solids. Though the average WQI of west-flowing rivers across the five nearby districts of Mumbai, Thane, Raigad, Ratnagiri and Palghar has shown a slight improvement in annual average of 2017-18, Mumbai alone is consistently recording a poor WQI, according to the report 'Water Quality Status of Maharashtra. The Mithi river in Mahim region recorded a WQI of 2168, according to the NWMP (National Water Monitoring Programme), which falls under the 'bad to very bad' category. WQI less than 50 is considered to be 'excellent'. According to the MPCB, one persistent problem is the discharge of untreated effluents. Maharashtra Water Resources Regulatory Authority has recently applied to the Centre to approve a river rejuvenation programme, which will ensure diversion of all sewage water from cities like Mumbai to treatment plants before released into the rivers. The existing STPs will be upgraded and new ones will be set up. Maharashtra will be the first state to take up such a plan and it should greatly improve the water quality of small and big water bodies in Mumbai in the near future.

Urban planning and infrastructure of Mumbai



- Mumbai island, Greater Mumbai and the Mumbai Metropolitan Region (Pacione, 2006)

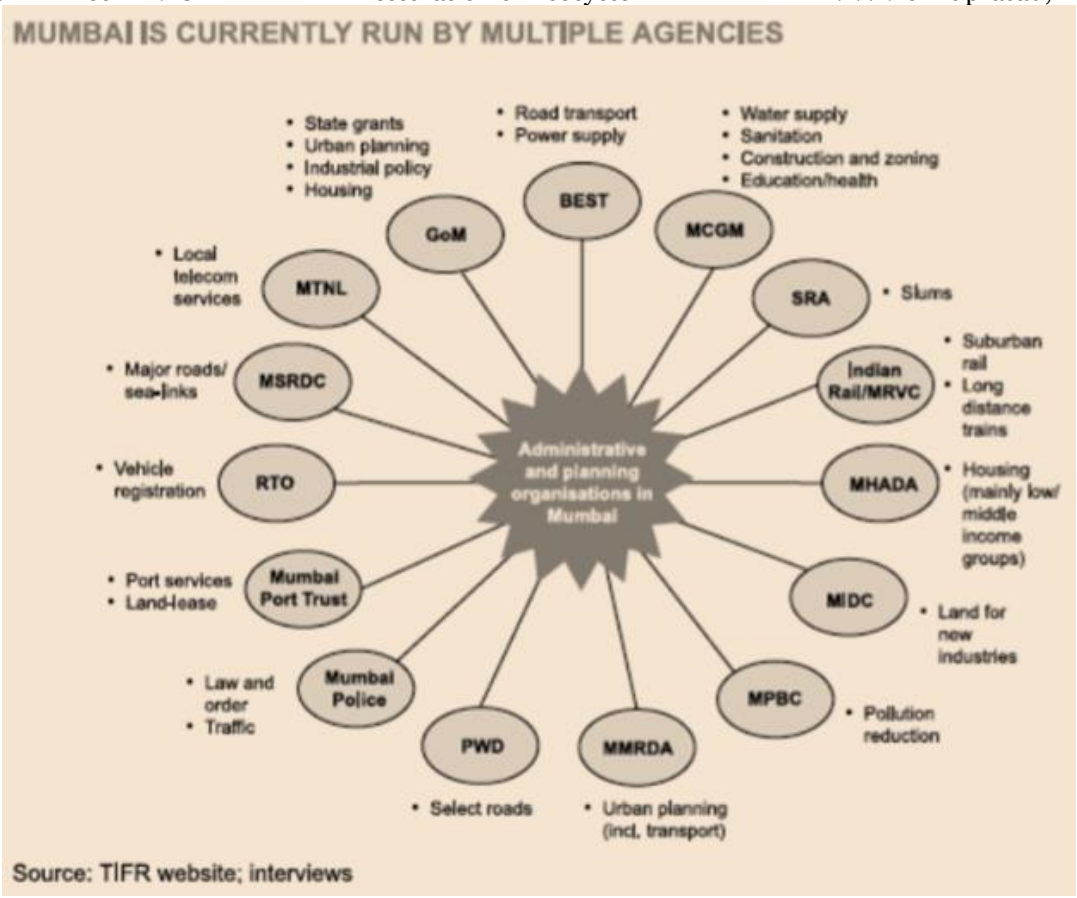
Mumbai/Bombay is the capital of the State of Maharashtra, the second largest city of India after Delhi and one of the largest metropolitan areas in the world. The same name is actually used to define at least three different territorial units (Patel, 2007; Zérah, 2008): -

- the original colonial city - also called the 'island city' - that covers an area of sixty-eight sq km with a population of around three million inhabitants (Census 2001);
- the area created through the extension of the boundaries of the island city in 1950 and again in 1957, officially called 'Greater Mumbai'. It covers an area of 437.71 sq km and is populated by almost fourteen million inhabitants (Census 2011); -
- the 'Mumbai Metropolitan Region', an area of 4355 sq km populated by more than twenty-one million inhabitants (Census 2011).

The metropolitan city of Mumbai located adjacent to the Arabian Sea in Maharashtra has a unique topography. The city has a vast area and is ever increasing due to the increasing population owing to excessive migration from different parts of the country. Mumbai is popular mainly for its huge crowd everywhere, seen clearly in the local trains (the lifeline of the city), on roads (everlasting traffic), markets, malls, etc. The city is widely cosmopolitan in nature. The southern part of the city is an old area dotted with British era buildings and offices. Colaba located in the southernmost tip of the city to Bandra, Sion and Wadala comprises of the

Urban Mumbai. Beyond this region is the Sub-urban Mumbai, extending all the way up to Borivli, Thane and Chembur-Mankhurd. Since the past few decades, areas even beyond these regions, which actually fall in the Thane and Palghar districts, are also virtually considered as a part of Mumbai. Human settlements have increased in areas as far as Badlapur, Panvel, Ulwe and Palghar and people are known to travel daily for work all the way to the main city every day. Mills were present in the Parel – Elphinstone area before independence but have been closed since many decades. Those areas are making way for developed posh office and commercial complexes, providing large scale employment to the people. The sudden increase in peak-hour rush in that area is an evidence of this. Bandra – Kurla Complex (BKC) near the Mithi river is another commercially splurged area located in the heart of the city, where people go in large numbers for daily work. Generally, the celebrities and the rich-class category reside in the Western suburbs from Bandra to Andheri besides the main urban area like Malabar hill, Napean Sea, etc. The rest of the city consist of mainly upper and lower middle-class people. Navi Mumbai area from Vashi onwards to Panvel and Uran is a recently developed area which is characterized by residential complexes, educational institutes, industries and an upcoming new airport is quite well-planned part of the city. The city gets its drinking water supply from seven lakes – Lower Vaitarna, Middle Vaitarna, Upper Vaitarna, Modak Sagar, Tansa, Tulsi and Vihar. There are other small fresh-water bodies in and around the city too. Mumbai is the only metropolitan city in the world to have a big natural forest area around it, popularly demarcated as the Sanjay Gandhi National Park, bordered by Borivli, Dahisar, Thane, Mulund and Bhandup on all sides. There are huge mangrove areas near the coastal regions like in Vikroli, Thane, Bhayander, Dahisar, Naigaon and Navi Mumbai.

The first Development Plan for Greater Mumbai (1964-1981) focused mainly on the provision of amenities and on the decongestion of the island city through the promotion of development in the suburbs and the shift of industries outside of the city core. In 1970 the first Regional Plan for 1970 – 1991 was published. It envisioned the creation of Navi Mumbai, a new city on a 344 km area opposite to the island city. The city was planned to host 2 million inhabitants, but had only reached 200,000 units in the Nineties and ad scarce public service (Pacione, 2006). A new Development Plan was promoted at the level of Greater Mumbai for the period 1981-2001. The next Regional Plan (1996-2011), created after the liberalization, reflects a different approach: it amended rent control act to promote urban renewal, land use zoning was relaxed to develop new offices at Nariman Point and business centre at Bandra Kurla (Pacione, 2006). The traditional planning system in Mumbai has undergone severe critiques since the beginning of the 21st century. It is interesting to notice that the 'visions', defined as a form of strategic planning by their promoters, are substantially overlapping with the traditional forms of planning both in terms of scale and of duration. The first vision was presented in 2003 for the area of Greater Mumbai and was intended to last until 2013, that is to say exactly the same moment in which the Development Plan for Greater Mumbai would have expired. The most recent vision is targeting the whole region and has been presented in 2011, that is to say when the Regional Plan has expired. It is intended to be valid until 2052, more than any other traditional plan. In 2005 the Mumbai Transformation Support Unit (MTSU) was formed to act as an umbrella initiative within which all projects selected inside the shortlisted focus areas have been integrated. It aims to achieve the status of a world class city for Mumbai.



Vision Mumbai's intention about making Mumbai a liveable city is clear, but the questionable aspect is if this agenda of large-scale development is deemed successful over the debris of thousands of slums, which are the homes of the voiceless poor making up of major part of the city's population and work force. The salt pans of Mumbai, which have till now been earmarked as NDZs (No Development Zones) not only because they are eco-sensitive, but also because the 1991 Development Plan states that these areas are not suitable for construction. The policy of providing incentives in the form of tax breaks to private developers for building low cost housing is a direct import of planning policies from the USA (Healey, Upton 2010). The case of the current planning innovations in Mumbai raises several reflections on strategic planning, especially in contexts that are different from the Western countries. Nowadays, while the Government of Maharashtra has entrusted a Singapore-based consultancy (Surbana Ldt.) to develop a further vision (Vision Mumbai 2032 and 2052), a group of academics from the Rachna Sansad's Academy of Architecture, researchers from UDRI (Urban Design Research Institute) and NGOs are preparing a brief based on the perceptions and needs of a large number of citizens that should work as a base for the next Development Plan of the Greater Mumbai area (promoted by the Greater Mumbai Municipal Corporation).

2. Delhi: -

Air pollution in Delhi

[Write in brief about AQI here also when writing this answer separately]

Air pollution causes severe environmental problems and has become a major health risk for livelihood in Delhi. With increase in population, there is an increase in emissions from various utilities as well. The main source of air pollution is crop residue burning followed by vehicular and industrial emission. Crop residue burning during winter produces a thick cloud of smoke and causes major threats to human health by deterioration in air quality. This crucial matter was also discussed in the Indian parliament. The National Green Tribunal and various Courts of India have directed to the Delhi government and various concerned agencies to resolve the air pollution problem. WHO has conducted a survey of 1600 cities in the world, and reported that air quality in Delhi is the worst among major cities of the world. The main gaseous pollutants are oxides of carbon, oxides of nitrogen, oxides of sulphur, hydrocarbon and suspended particulate matter emitted by different sources, including transport, electricity generation, incineration, burning of domestic and industrial fuel. It is observed that due to industrial revolution, CO2 concentration level has increased by 28% in the atmosphere. The pollution problem becomes severe in Delhi, especially in winter, when the neighbouring states of Haryana, Punjab and Uttar Pradesh start burning large amounts of unused crop residues to quickly clean the fields after harvesting. Due to burning of crop residues, a thick cloud of smoke is formed which causes atmospheric pollution and results in major threats to human health by deterioration in air quality. This calls for suitable environmental policies, and awareness regarding proper utilization and management of crop residues to deal with the problems. The pollution level of Delhi is reported to be six times above normal. Breathing the Delhi air is as harmful as smoking 40 cigarettes in a day.

Various sources like industries, vehicles, construction, open biomass burning and dust from roads are responsible for air pollution in Delhi. The Supreme Court of India banned the use of fuels like furnace oil, coke and petroleum in Delhi, National Capital Region (NCR), Uttar Pradesh and Rajasthan on 24 October 2017. Vehicular emission mainly contributes carbon monoxide, hydrocarbon, HC and dust particulate matter, which are a threat to human health. On 29 March 2017 the Supreme Court of India banned the sale of BS-III vehicles; now only BS-IV vehicles will be registered by the RTO of India. Dust is responsible for 30–40% of PM pollution in Delhi and causes health risk. Dust is emitted due to friction of tyres during application of brakes. Construction activities like excavation, block cutting, demolition, road construction, mixing, drilling, loading and unloading of debris, etc. also emit dust particles. It is observed that around 93 Mt of agriculture residues is burnt in open fields in India33, of which Punjab produces around 20 Mt of wheat straw and 19–20 Mt of paddy straw. This is due to shortage of time between harvesting and sowing of two crops; about 85–90% of paddy and wheat straw is burnt in open farm areas. The Ministry of New and Renewable Energy, GoI has estimated that every year approximately 500 Mt agriculture residues are produced as by-product – Uttar Pradesh (60 Mt), Punjab (51 Mt) and Maharashtra (46 Mt). Cereals crops produce maximum residues (352 Mt), followed by fibres (66 Mt), oilseeds (29 Mt), pulses (13 Mt) and sugarcane (12 Mt). The cereal crops (rice, wheat, maize, millets) contribute about 70%, whereas rice crop alone contributes approximate 53% to crop residues. Presently, around 70–80 Mt of rice residue is burnt in open fields.

In India during winter, wind blows from the north and northwest towards the east. This results in heavy smog formation over Delhi. In winter, the AQI falls in the hazardous range due to biomass burning in the neighbouring agricultural states like Haryana, Uttar Pradesh and Punjab during October and November. In summer, the high value of AQI is because of the augmented concentration of PM10 and PM2.5, which is due to road dust. However, in the rainy season, pollution level goes down due to precipitation of suspended dust, although AQI value is in the sensitive category.

The residents of Delhi face serious problem of air pollution during winter due to the burning of crop residues in the neighbouring states. There is an urgent need to manage or completely stop crop residue burning to detect any significant improvement in air quality in Delhi. The problem of air pollution cannot be handled by regulations alone; their strict execution, enforcement and collaboration of general public are also important. Several actions recommended by various authorities/courts/tribunals to control crop residue burning may have some short-term, long-term and permanent solution to save Delhi from air pollution. In addition, there is need to adopt an effective strategy. Government should also motivate the R&D activities for advance pollution control mechanism and development of standards for abatement of pollution.

Delhi records poorest air quality in three yrs

Of the 37 air monitoring stations, 21 register Air Quality Index between 490 and 500; city's overall AQI touches 708 around 5 pm, which was 14 times the safe air quality level of 0-50

#NEW DELHI

Pollution levels in Delhi peaked to a three-year high on Sunday as hundreds of distraught people took to social media to say they wanted to leave the city due to poor air quality.

According to the Central Pollution Control Board (CPCB), the national capital's 24-hour average air quality index (AQI) stood at 494 at 4 pm on Sunday, the highest since November 6, 2016 when it was 497.

Twenty-one of the 37 air quality monitoring stations recorded the AQI between 490 and 500 with air quality sensors at Aya Nagar, Ashok Vihar, Anand Vihar and Aurobindo Marg peaked out at 7 pm.

In the National Capital Region (NCR), Faridabad with AQI 493, Noida (494), Ghaziabad (499) and Greater Noida (488), Gurugram (479), also breathed extremely polluted air.

The Ministry of Earth Sciences' air quality monitor, SAFAR, said the city's overall AQI reached as high as 708 around 5 pm, which is 14 times the safe level of 0-50.

An AQI between 0-50 is considered 'good', 51-100 'satisfactory', 101-200 'moderate', 201-300 'poor', 301-400 'very poor' and 401-500 'severe'. An AQI above 500 falls in the 'severe plus' category.

The apocalyptic haze stiffened its choke on Delhi and satellite towns as scattered rains on Saturday increased humidity, leading to smog and a cloud cover preventing sun rays from warming the ground.

Schools closed till Nov 5

The spurt in pollution levels also prompted the administrations in Ghaziabad, Noida, Greater Noida, Gurgaon and Faridabad to shut all government and private schools till November 5. The Delhi government on Friday directed closure of schools till November 5.

AFP

AQI of 497 was registered on November 6, 2016

37 Delhi-bound flights diverted

Pollution caused a major disruption at Delhi airport on Sunday as 37 flights were diverted to other airports like Jaipur, Amritsar, Lucknow and Mumbai due to heavy smog, officials said. While Air India said it diverted 12 flights since 9 am, Vistara said it diverted five flights after 10 am. An Air India spokesperson said, "Bad weather affected flight operations since morning 9 am in T3 airport (Delhi). Twelve flights diverted to Jaipur, Amritsar and Lucknow." PTI

Please Lord Indra to check pollution: BJP leader

A BJP leader in Uttar Pradesh on Sunday advised the government to perform yajnas to please rain god Lord Indra and control pollution. Sunil Bharala, the chairman of the state Labour Welfare Council, said stubble burning is an "age-old practice". To back his argument, Bharala said, "It was around 1991-92, when there were no rains in Meerut and nearby areas, a community yajna of 40-50 villages was held and as soon as it was over, rains started". PTI

40 per cent of Delhiites ready to move out

Over 40 per cent residents of Delhi and NCR want to move to another city because of bad air quality while 16 per cent want to travel during the period, according to a new survey. The survey done by an online platform with over 17,000 respondents from Delhi and NCR region has found that 13 per cent resident believe that they have no option but to cope with rising pollution levels. PTI

Don't politicise pollution: Kejriwal

Delhi Chief Minister Arvind Kejriwal on Sunday said the issue of pollution should not be "politicised" and called on all neighbouring states and the Centre to "sit together" and deliberate on how to prevent stubble burning as the air quality in the national capital dipped to alarming levels. Kejriwal said his government was not indulging in "blame game" but looking for solutions to pollution caused by stubble burning. PTI

ber 5.

NASA satellite imagery showed vast swathes of the northern plains, covering Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, and parts of Jharkhand and West Bengal, blanketed under a smoky haze.

Weather experts said any significant improvement in the situation is highly unlikely unless there's a rainfall, which may on November 7 and 8 under the influence of Cyclone Maha and a western disturbance, wash away the pollutants.

On Twitter, hashtags 'DelhiBacho' and 'DelhiAirEmergency' trended for a major part of the day as hundreds of people expressed their willingness to leave the NCR till the situation ameliorates.

"Delhi ppl should leave at least for 1-2 weeks. It is painful to live," a Delhi resident tweeted. "I think it's time to leave Delhi. Went out for groceries and came back with eyes burning," another said. PTI

- Mumbai Mirror dated 5th November, 2019

Air pollution: Enlarge the focus from Delhi

The NCAP cannot drive change in cities unless data and reporting issues are fixed

Two-thirds of the world's most polluted cities are in India, and Delhi has the worst air among all capitals, the 2019 *World Air Quality Report* by IQAir AirVisual, which takes readings from 98 countries, said on Tuesday. The study was based on average yearly levels of PM2.5 concentration. While the media focus of the IQAir AirVisual report, which comes a year after the Centre rolled out the National Clean Air Programme (NCAP), has been on the Delhi-NCR, this is an opportune moment to look at how other cities are faring on the NCAP, the five-year action plan with a target of 20-30% reduction in concentrations of PM10 and PM2.5 in 102 non-attainment cities, by 2024, with 2017 as the base year. This is important because the IQAir AirVisual says India has 14 of the 20 most polluted cities in the world.

While air quality monitoring has begun to expand under the NCAP to address the data deficit, without a methodical system for reporting, the data cannot drive change in cities. For example, manual monitors require at least 104 days of monitoring, which is 28.5% of the days in a year. But an assessment by the Centre for Science and Environment of the manual data for all cities shows that as much as 73% of monitoring stations do not meet this requirement. The cities are expected to begin reporting on their progress; but for that, they must know the methods and standard operating procedures. These issues need to be redressed without delay to ensure that cities are enabled to opt for the right path for clean air.

- Mint, dated 28th February, 2020

Water pollution in Delhi

Water pollution is a major environmental issue in India. Across India, an estimated 62,000 million litres per day (MLD) sewage is generated in urban areas while there is treatment capacity for only 23,277 MLD. At least 70% of sewage generated in urban India is being dumped in rivers, seas, lakes and wells, polluting water bodies and contaminating fresh water sources.

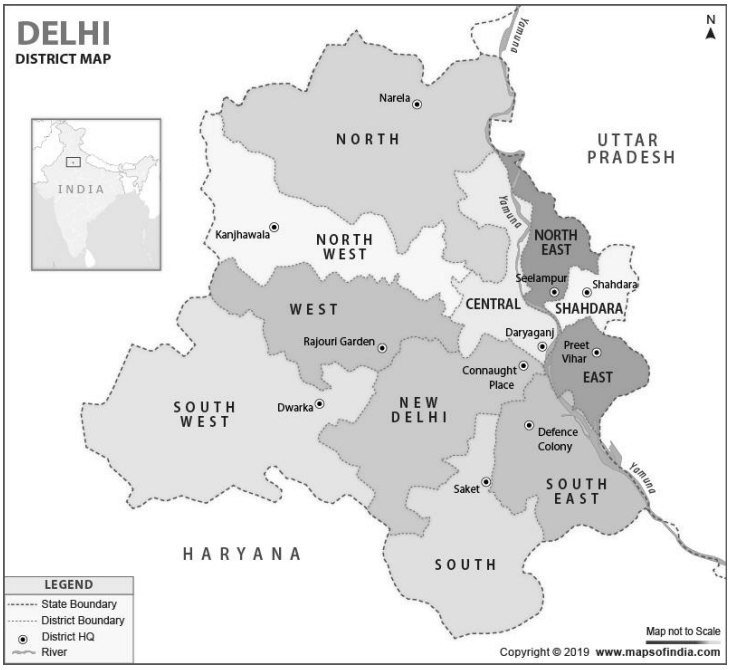
Water pollution and a lack of solid waste treatment facilities have caused serious damage to the river on whose banks Delhi grew, the Yamuna. Water in Delhi has been contaminated by various sources viz domestic and industrial. Sewage treatment plants could not keep pace with rising population and waste generation. Yamuna, which is the lifeline of Delhi and provides 70% of the city's water, is also among the world's most polluted rivers. It literally turns into a toxic sewage drain during its 22-kilometer journey through the city with 21 drains emptying 850 million gallons of sewage into the river every day (Chaudhary, 2015). As per SANDRP (2016), Delhi generates 3,800 MLD of waste and has a present installed treatment capacity of 2,693.7 MLD of which the actual utilization is 1,575.8 MLD. Thus, only 41% of wastewater is treated and the remaining 2,225 MLD of untreated water is either seeping into the ground or being discharged into Yamuna. It is evident from the abysmal state of Yamuna.

According to Mishra (2010), several reasons of water pollution in Delhi includes sewage and wastewater, dumping of solid wastes and litters in water bodies, industrial waste, acid rain, global warming, eutrophication, etc. along the banks of rivers flowing through the cities in India. The quantity of waste generation is one of the biggest sources of environmental degradation in Delhi, India's capital. It contributes

to river pollution in a significant way through landfill leachate and runoff, especially during the rainy season. All the landfill sites except Tilak Nagar, Hastal and Chattarpur are located close (0-6 km) to the river Yamuna. The leachate produced by landfills finally percolates to the porous ground surface at the landfills or finds its way to nearby drains. A large portion of landfill leachate and runoff produced by these landfill sites finally reaches the Yamuna through ground water flow or surface water flow through the drains. They indicate that river water quality is affected by the presence of landfill locations. Kaur et al., (2013) study on assessment of idol immersion on physic-chemical characteristics of river Yamuna in Delhi stretch revealed that idol immersion activity has negative impact on water quality of river Yamuna. The composed data was analyzed for the year 2011, to understand deterioration in the water quality of the river due to idol immersion practices. According to the results, the value of DO, BOD, Total Solids and COD were found to vary from 6.0-7.5 mg/L; 3.3-38 mg/L; 430-1268 mg/L; 28- 136 mg/L respectively. The low levels of DO and high BOD and Total solids levels at different sites indicate the poor water quality due to idol immersions.

Social and behavioural change of Citizens and Strict Enforcement of Environment and Water pollution related Laws is the pre-requisite for an improvement in the environment. Awareness campaigns involving citizens and strict enforcement of environmental laws by concerned agencies is one appropriate solution to control environmental degradation. It is recommended that there should be proper waste disposal system and waste should be treated before entering in to river. Educational and awareness programs should be organized to control the pollution.

Urban planning and infrastructure of Delhi



- Map of Delhi, only for reference

The national capital territory of Delhi is the most important economic & cultural hub of Indian subcontinent and is known for its centralized distance from the major geographical features of Indian

subcontinent namely Himalayan Ranges & Aravalli range. The city has always been a favourable case from the geographical & political point of view.

Delhi is bound by the Indo-Gangetic alluvial plains in the North and East, by Thar Desert in the West and by Aravalli hill ranges in the South. The ridge area is predominantly visible in the south side of city extending up to the Okhla area & disappearing below the Yamuna floodplains which belongs to the North east side of the city. Ecologically the ridge is beneficial as it acts as a physical barrier between the extremities of Thar dessert and the plains of Delhi by restricting the inflow of dust and wind from the desert side. The ridge covers a 35km stretch from southern parts of city all the way till western parts occupied by Yamuna River and offers a uniformly distributed drainage pattern due to its topography across the city. It also contains a number of perennial tanks & pits which act as ground water collection & recharging points throughout its stretch while helping in sustenance of green areas bearing natural forests which in turn affects the surrounding air temperatures and act as breathing lung areas to the city. The river Yamuna is such located that the city falls towards its west side and is considered as the major source for drinking water and other sacred rituals in the city. Apart from Yamuna as a major source for water, Delhi has 3 canal systems working within its peripheries namely Agra canal, Hindan canal & western Yamuna canal serving as secondary water bodies. Apart from river & canal water sources the city rely heavily on the ground water sources whose availability is governed by the hydrogeological conditions of Delhi characterized by the alluvial formations and quartzitic hard rocks. The areas other than Yamuna flood plains and the ridge area, falls under the fertile plains also known as Bangar which consists major areas of Delhi city including old Delhi, New Delhi & Delhi cantonment.

The historic Delhi evolved through centuries present a mosaic of a distinct capitals & villages with a topographical /geographical context. The character of planning was primarily of introvert nature to compete with the hostile climate & the political insecurity. The capital has elaborated water harvesting systems, tanks, walled landscaped areas, orchards, water gardens, agricultural surrounding, etc. which defined its historic fabric. The sitting of the development was based on ecological parameters and thus the interventions made were optimum & sustainable. (Jain, 2009).

Delhi regional landscape shows an interrelationship between natural ecology & cultural ecology. The new city was planned in strict accordance to the geographical feasibility that the terrain of Delhi has to offer. It was located at the (then available) highest point on the Delhi ridge known as Raisina Hill's for physical domination in comparison to the previous settlements of Delhi. This was a deliberate planning attempt to utilize the existing natural boundaries offered by the ridge on the west and by river Yamuna offering limitations of extension towards the eastern periphery. The city was essentially planned with sightlines, view axis, avenues & lush landscape using geometric symmetry through triangles & hexagons. In order to connect with natural & historic remnants of the city three visual corridors were planned for visually connecting the new settlement complex with Jama Masjid, Indraprastha & Safdarjung Tombs respectively.

Table 1 Comparison of Master Plans for Delhi (DDA)		
Master plan 1962	Master plan 2001	Master plan 2012
Initiation of modern planning which aimed towards the integrated development of the city. Envisage development of Urbanisable area of 448 square kilometre by 1981	Prepared with a perspective of 20years (upto1981) and was aimed to cater increasing population & changing requirements of the city. This envisaged expanding the Urbanisable area of Delhi to 688 square kilometre	Extensive modifications with a futuristic perspective to 2021 with increasing population density and addition of 5 new cities along with existing urban areas, about 978 square kilometre of total area
Urban population of 4.6millions.	Accommodate 12.2 million urban populations by the year 2001	It projected population growth of 23million by the year 2021

As per the current scenario New Delhi today is an amalgamation of historically traditional &contemporary urban space, including organic settlements of Shahjahanabad, Bungalow Zone of Lutyen's Delhi and the Post-Independence growth with respect to Delhi's Master Plan. The urban morphology of Delhi depicts an irregular grid pattern around centre and grid patterns around it, whereas the functional zoning includes recreational zones, political area and a residential zone close to the Central Business District. The city has evolved over the ages going through several phases of growth. Owing to its ever-increasing pressure of urban growth hassled to its current form demarcating the present-day metropolitan area of Delhi, while exhibiting vast expansion on built-up space within and even beyond its boundaries. The expansion within the premises of Delhi city is demarcated by the proposed development of million plus sub-cities suggested by Master plan 2021 including cities like Rohini & Dwarka. While the outside boundary expansions are referred to the adjoining cities of Faridabad, Gurgaon, Ghaziabad and Noida as the second set of development under the segment of million plus cities. Delhi and its NCR are now connected well by the Delhi Metro Rail Corporation, which is also expanding with its Rapid Metro services now for efficient connectivity.

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