Reduced Environmental Impact Of Cities & Sustainable Streetscapes

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Abstract

Cities are growing inexorably, causing many to think that inevitably their environmental impact will worsen. In this research, three approaches to understanding the environmental impact of cities are analyzed, namely population impact, Ecological Footprint and sustainability assessment. Although the population impact model provides some perspective on local impact, and the Ecological Footprint model on global impact, only the sustainability assessment approach allows us to see the positive benefits of urban growth and provides policy options that can help cities reduce their local and global impact while improving their live-ability and opportunity, which continue to drive their growth.
This Research looks into the evolution of Bengaluru: From Garden City to Silicon Valley and its resulting environmental impact on the city, its population and transformation of the streets.

In this context, the research aims to activate the role of sustainable streetscape as an approach to provide an attractive and safe sustainable urban environment, and to sustain the development process for the visual image of cities, especially in India. The research concludes the importance of developing urban environment visual image in India, through directing urban planners and designers to the important role of streetscape in achieving sustainable development.
Keywords: Environmental impact, Sustainable streetscapes, urban environment, urbanization

INTRODUCTION

Climate change is a global phenomenon that largely impacts urban life. Rising global temperatures causes sea levels to rise, increases the number of extreme weather events such as floods, droughts and storms, and increases the spread of tropical diseases. All these have costly impacts on cities' basic services, infrastructure, housing, human livelihoods and health. At the same time, cities are a key contributor to climate change, as urban activities are major sources of greenhouse gas emissions.

Estimates suggest that cities are responsible for 75 percent of global CO_2 emissions, with transport and buildings being among the largest contributors.

Only with a coordinated approach and action at the global, regional, national and local levels, can success be achieved. It is essential, therefore, to make cities an integral part of the solution in fighting climate change. Many cities are already doing a lot by using renewable energy sources, cleaner production techniques and regulations or incentives to limit industrial emissions. Cutting emissions will also reduce local pollution from industries and transport, thus improving urban air quality and the health of city dwellers.Due to economic boom in developing cities, there is a rapid growth of population and infrastructure which tends to negatively impact the environment. Sustainable materials in urban design arises from a combination of environmental, economic, and social concerns.

This research aims to measure and analyze the various changes in the city of Bengaluru due to expansion and its effects on the environment by studying the changes in ecosystem, the changes in land use patterns, the roadways, changes observed in the trees, and the encroachment of lakes. We also aim to study the changes in the climate, temperature and pollution of Bengaluru and its effects on the citizens of Bengaluru.

The paper aims to study the strategies implemented by other cities to combat the problems of expansion. The paper intends to develop strategies to resist the problems of urban expansion by suggesting methods and techniques to create sustainable streetscapes that would aid in reducing the environmental impact on cities.

In order to understand the effect of urban sprawl on the environment in the city of Bengaluru, the analysis has been carried out in various aspects like, effect of urban sprawl on the ecosystem, blue space, trees and humans. After few Studies about sustainable development at St marks Road, Gandhi bazaar, Seshadripuram. The framework for development of sustainable biophilic streets along with streetscapes.

SUSTAINABLE STREETSCAPE

Sustainability assessment enables us to understand and act upon both the local and global impact of cities. By applying the sustainability criteria, a city can address both sets of issues: the "natural resources" criterion promotes attention to global and local resource issues at every step of development, while the "environment" criterion calls for the same approach to include all the global and local impacts. The other criteria enable the questions of "livability" to be addressed at the same time – and the synergies between them to be found.

- Streets present a potential for green, lively and just cities by compensating for the lack of green spaces in the neighborhoods.
- Streets—especially those developed as green streets—can be "considered as a sustainable development approach, fulfilling a variety of environmental, social, and economic objectives"
- As large linear open spaces, the cities 'streets are almost completely under municipal responsibility and may form part of a connecting green grid. It is widely argued that such a greenery-based model can underpin improvements in environmental conditions and an increased quality of life.
- Areas shaded by trees were identified as the coolest spots in street canyons and street greenery forms a convenient adaptive strategy to create thermally comfortable living environments.
- Although there are many benefits to turning streets into green, everyday public spaces beyond mobility and traffic, in many places it is proving difficult to gain or redistribute the necessary space in the traditional streetscape and to undertake transformations.

    Based on these considerations, the paper elaborates on the questions of how streets can be designed as more sustainable in order to fulfill a wider range of functions and how to distribute the available space.

    The continued rapid growth of cities raises a number of persistent questions. Are they becoming so big that their negative impacts outweigh the opportunities that they provide? Is urbanization damaging the planet or helping save it? How do we assess the growth of population in a city? Can the concept of sustainability provide a better way of understanding the local and global environmental impact of cities? Is there a future for cities? These questions will be addressed using three approaches: population impact, Ecological Footprint and sustainability assessment.

    The study aims to quantify trends of urban growth in Bengaluru city using Geographical Information System. The study reveals an increasing trend in the entropy values for the city signifying urban sprawl or dispersed development of the city.

    This research also aims to develop guidelines for sustainable streetscape. This is achieved through a combination of sub-objectives as follows:
- Identify the main principles that should be considered to define sustainable streetscape.
- Formulate a set of recommendations for developing streetscape of one of the main streets in India to fit the criteria for sustainable Urban design.
- To reach sustainable urban design through the achievement of environmental efficiency and economic viability of streetscape.

BACKGROUND OF STUDY

Bengaluru (or Bengaluru) is at 13 degrees north latitude, on a plateau at 920 meters (3,000 feet) above sea level. The climate of Bengaluru is tropical, tempered by the altitude, with a rainy season from June to October, due to the monsoon, and a dry season from December to April. In May, before the monsoon, and more rarely in March and April, showers and thunderstorms occur, which gradually become more frequent. In the first part of the monsoon (June-July), the rains are not abundant, because most of them are discharged on the western Ghats, the mountain range near the southwestern coast of India. From mid-October, the north-east wind begins to blow, which in the first period, until November, still brings a bit of rain. This is the so-called retreating monsoon, which generally does not bring heavy rains to Bengaluru, except during some years, such as in November 2015, when 290 mm (11.4 in) of rain fell in a month and widespread flooding occurred. In winter, from November to February, nights are cool. Occasionally, the temperature can drop to 10/12 °C (50/54 °F). At the airport, the coldest record is 8.8 °C (47.8 °F), set in January 1993. From March to May, before the monsoon, it is very hot. The record is 39.2 °C (102.6 °F), set in late April 2016.
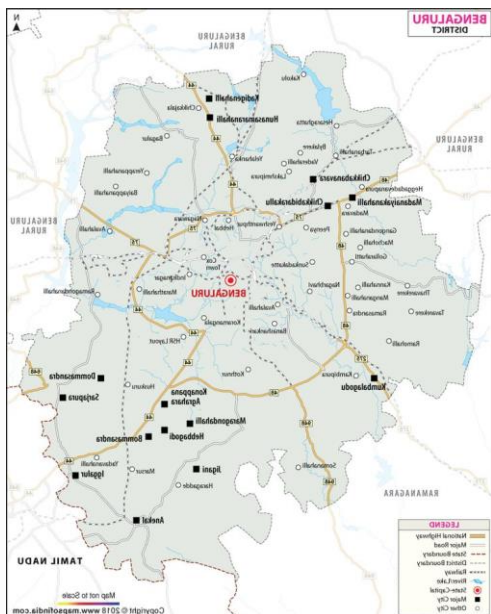
Map of Bengaluru

Source: mapsofindia.com
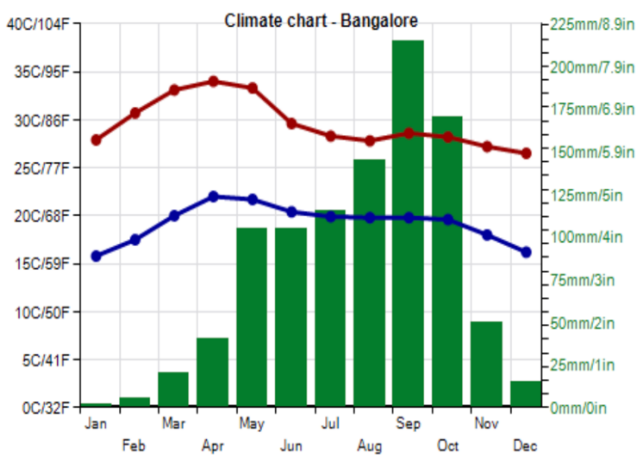
Climate Chart of Bengaluru

The capital and largest city of the Indian state of Karnataka is Bengaluru, often known as Bengaluru. It is the third most populous city and fifth most populated urban agglomeration in India, the largest city in South India, and the 27th largest city in the world with a population of over 8 million and almost 11 million in the metropolitan area.

Bengaluru's prominence as a center of trade and commerce was established during the early nineteenth century, when the city supported a flourishing trade and commerce. In the past two decades, Bengaluru's economic growth, due to information and communication technology (ICT) industrial expansion, has placed the city on the global map. Bengaluru's economic growth is powered by the presence of numerous higher education institutions, public sector companies and knowledge-based industries. Consequently, patterns of change in green areas appear to be similarly constrained, with increased loss in vegetation and fragmentation in the city periphery compared to the city core.

Urban expansion has also greatly transformed the land-use patterns and institutional forms of governance of many ecosystems located in former agricultural hinterland areas. The consequences of these combined changes in ecosystems, land use and governance have been manifold, with deterioration of biodiversity and soil quality, aggravation of urban heat island effects, increased pollution, flooding, water scarcity and epidemics, and consequent impacts on human health and well-being.

A number of small neighborhood parks have also come up in the core of Bengaluru in the last two decades. Their size and focus on exotic, landscaped features does appear to provide limitations in terms of the range ecological services they can provide. Yet, even these parks provide important recreational services for local neighborhoods, and field surveys indicate that these constitute important habitats for migratory birds and other local biodiversity.

Need to understand the Environmental Impact of cities

- Urbanization is considered as a significant driver of land use and land cover change which is closely associated with the growth of population and economy. In order to avoid unwanted impact of urban growth at the local and regional level, planning for expected future growth is essential. Bengaluru, in Karnataka, India, is a city of economic success, challenges, opportunities, hopes and above all, a city of dreams for immigrants.

- Urban sprawl is the uncontrolled and uncoordinated outgrowth of towns and cities. The process of urban sprawl can be described by a change in the pattern over time, like a proportional increase in built-up surface to population leading to rapid urban spatial expansion. Landsat satellite imageries of five different periods, i.e., Landsat MSS of 1973, TM of 1991, 2001, 2011, and 2016 from Global Land Cover Facility (GLCF), quantify the changes in the Bengaluru town from over 40 years.

- It also indicates spatial shifting of growth centers within the city. The process and the findings have a high utility to comprehend the land use changes and forecast expansion patterns to develop a future scenario, which may be further used to prepare planning and management strategies at regional as well as local levels. Civil society also significantly shapes the environmental agenda in Bengaluru, taking an active and vibrant role in respect of environmental issues.

- In the coming decades, climate change and scarcity of access to clean water are likely to pose significant challenges for the city, exacerbated by the loss of lakes, wetlands and green spaces.

- The disappearance of lakes has curtailed access to water-evident in the relative absence of gardens and parks. Moreover, the remaining lakes are Increasing y subject to pollution trom untreated sewage.

- The consequences of these combined changes in ecosystems, land use and governance have been manifold, with deterioration of biodiversity and soil quality, aggravation of urban heat island effects, increased pollution, flooding, water scarcity and epidemics, and consequent impacts on human health and well-being.
  The need for sustainable materials in urban design arises from a combination of environmental, economic, and social concerns.

Environmental assessment of Bengaluru City:

In rapidly growing Indian cities, change seems like the only constant. Heritage buildings are torn down, roads widened, lakes and wetlands drained, and parks erased to make way for urban growth. Bengaluru was known as a tiny village in the twelfth century and has grown through the intervening centuries, to emerge as the fifth largest city in India today. The results indicate that during the last four decades, the Bengaluru town area's built-up area and the vacant area increased, there is proportional increase in built-up surface to population leading to rapid urban spatial expansion.

While the city was once known for its wide tree-lined avenues, historic parks, and expansive water bodies, this influx of growth has led to the encroachment and pollution of water bodies, the felling of thousands of trees, and large-scale conversion of open areas and parks into commercial, industrial and residential settlements.

URBAN EXPANSION'S EFFECTS ON BIODIVERSITY:

- Bengaluru contains a diversity of green spaces located within multiple land use categories including in parks, home gardens, office complexes, wooded streets, wetlands, and remnant forests.
- Vegetation in the city core tends to harbor greater heterogeneity and species richness as well as a larger proportion of exotic species compared to rural and forested areas
- Within the central, older parts of the city, few patches of remnant natural vegetation exist, and most ecosystems have been significantly modified by human influence, responding to social preferences that vary across location and time
- Bengaluru has a relatively high tree diversity but relatively low tree density compared to many other cities.
- As with other parts of the world, home gardens in Bengaluru are rich in plant diversity but in contrast to cities in Europe and the USA, these tend to contain a large proportion of plants selected for their cultural, medicinal and culinary properties.
- The city flora contains a large proportion of exotic species, with three out of four park trees coming from introduced species. Many of these species have however been planted for well over a century, with the view to creating a spectacular, scenic urban landscape with a succession of species flowering across all seasons. Many of the introduced species thus support a wide diversity of birds, insects and other fauna.
- There is high insect diversity, with reports of rare species in the campuses of Bengaluru University, the Indian Institute of Science and University of Agricultural Science in Bengaluru, as well as in the city's two botanical gardens – Lal Bagh and Cubbon Park. There has even been a report of the discovery of a new ant species in an Indian educational institution campus.
- Urban expansion has led to the disappearance of some patches of the city's iconic oldest botanical gardens even as far back as the early nineteenth century, but the scale of impact has exploded in recent decades.
- A number of small neighborhood parks have also come up in the core of Bengaluru in the last two decades. These parks provide important recreational services for local neighborhoods', and field surveys indicate that these constitute important habitats for migratory birds and other local biodiversity. In these and other human-impacted urban habitats in Bengaluru, some taxa such as ants and earthworms are able to persist because of the availability of specialized microhabitats, leaf litter and soil organic matter, while other taxa such as lichens indicate patterns of species turnover and replacement by species more tolerant to pollution. Yet, worryingly, fragmentation of vegetation connectivity has increased over time, within the city core as well as the periphery.

EFFECTS OF URBAN SPRAWL ON ECOSYSTEM:

- Bengaluru's ecological history of growth can be roughly divided into three broad periods: pre-colonial (pre-1799), colonial (1799-1945), and post-colonial (after 1945).
- This historical signature determined the pattern of urban growth, and is still visible in the structure and species selection of trees in the 21st century city. The former British Cantonment was designed with trees forming an integral part of the colonial landscape. Bengaluru was known as a tiny village in the twelfth century and has grown through the intervening centuries, to emerge as the fifth largest city in India today.
- For decades in urban areas of Jayanagar and Basavangudi, it was not buildings but street trees that dominated the skyline, dwarfing the shops and bungalows that lined the streets. Even now, traces of such a past can be seen on several streets.

The Effect of Urban sprawl in Bengaluru:

- Population growth is the key driver of urban sprawl, and spatial distribution of the population is concentrated around city center, but randomly at sub-urban areas. This random spatial growth of built-up land (generally housing) refers to urban sprawl

- Accurate temporal information about the state of urbanization, the rate of urban expansion, the patterns and extent of sprawl is often not available in an adequate manner for a suitable analysis.
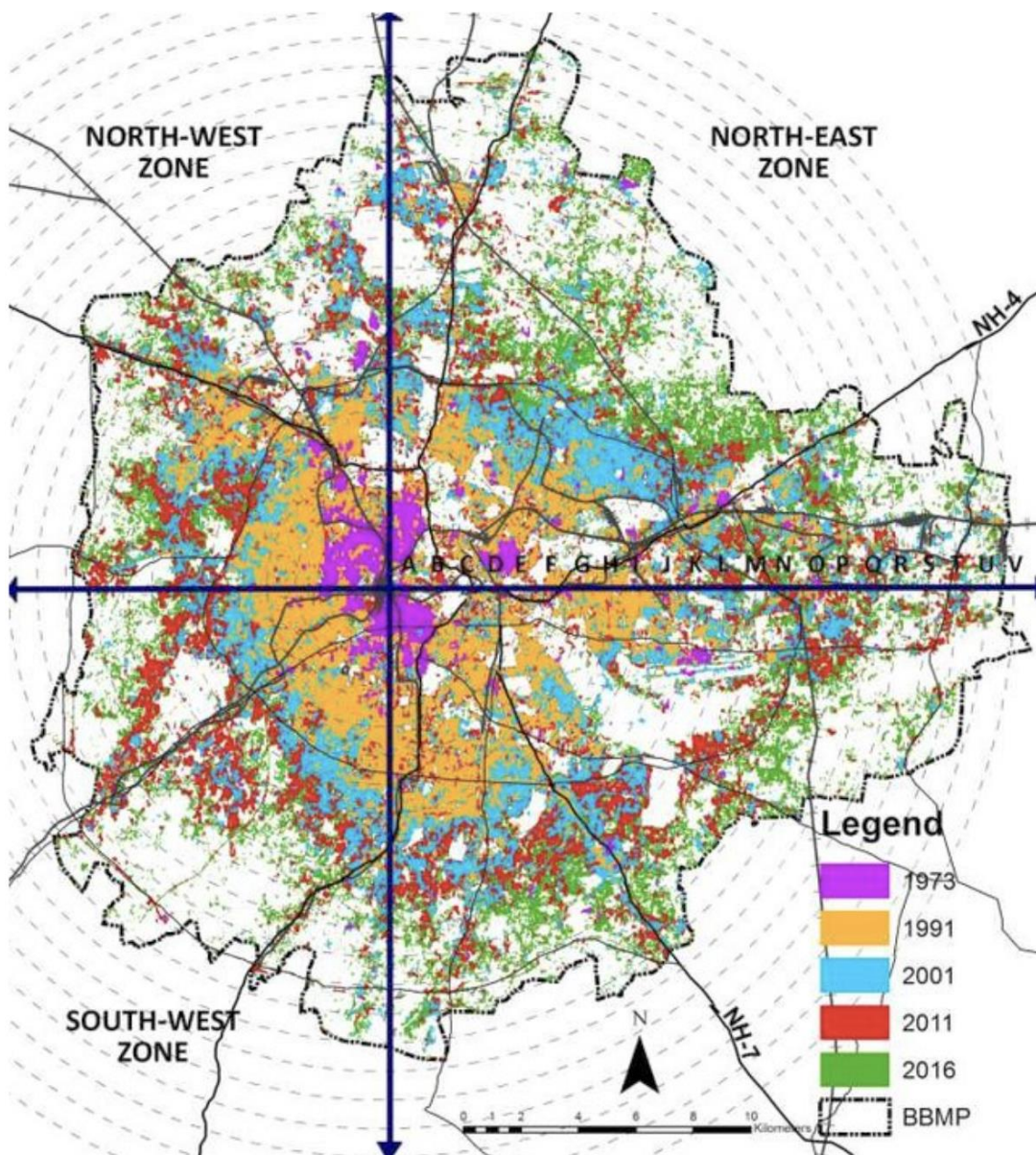
Diminished water bodies:

Source: H.S. Sudhira 2013,chapter 10,springer.com

The expansion and intensification of Bengaluru has transformed the land-use patterns and institutional forms of governance of the city's wetlands and water bodies. There were once thousands of reservoirs in the area surrounding Bengaluru, used for a number of purposes including agriculture, fishing, cattle washing, drinking, and domestic uses. These water bodies were largely created and maintained by human effort, through damming rainfed streams to create networks of freshwater reservoirs topographically distributed throughout the region.
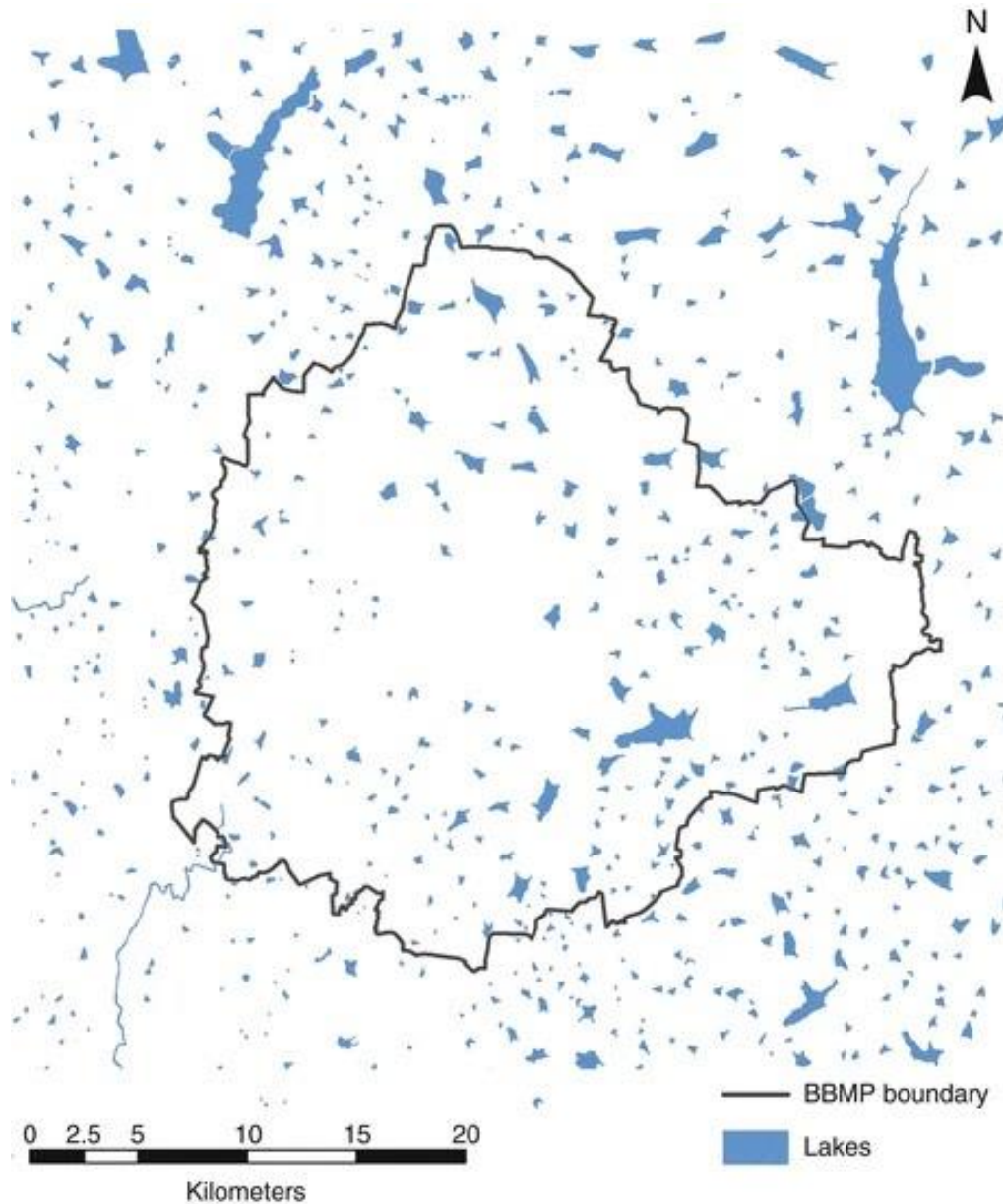
Lakes present in Bengaluru

Source: Harini Nagendra (2012), chapter 1o, springer.com

- These wetlands supported an impressive diversity of birds, fish, amphibians, reptiles, insects, and micro-organisms until quite recently. Originally managed by adjacent village communities, lakes in Bengaluru are now managed by a large number of government departments with overlapping jurisdictions and responsibilities.

- Public perceptions and uses of lakes have also transformed as a consequence of urbanization, from community spaces valued for water and cultural services, to urban recreational spaces used largely by joggers and walkers.

URBAN SPRAWL IMPACT IN BLUE SPACE:
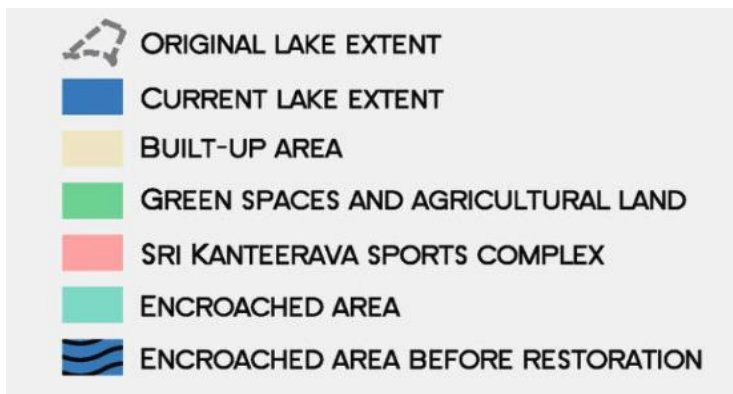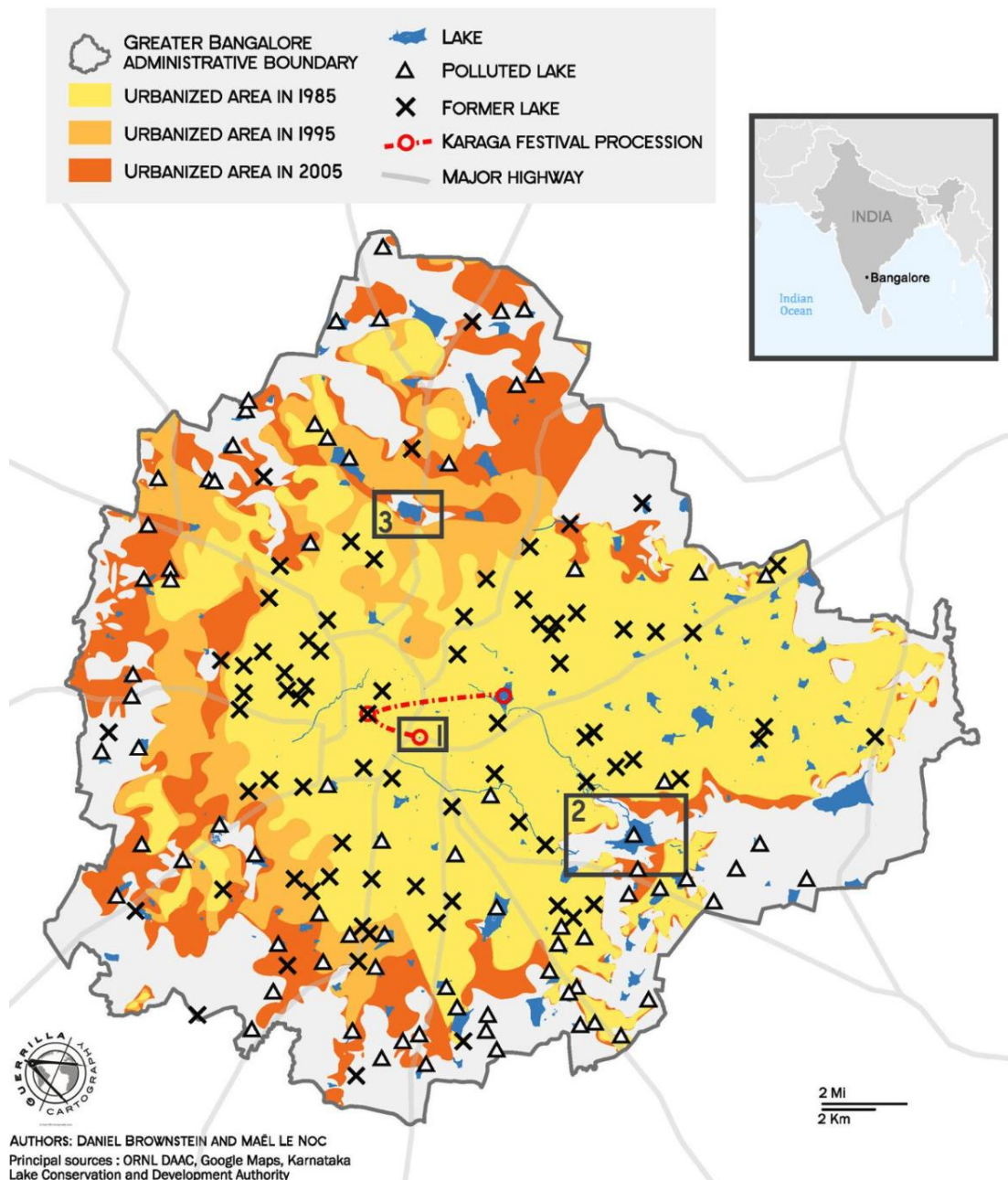

1. SAMPANGI LAKE
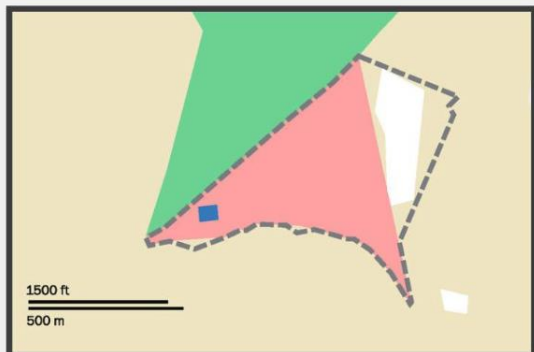
2. BELLANDUR LAKE

3. HEBBAL LAKE

The urbanization of Bengaluru, India, took off in the 1950s and led to drastic reduction in the number of lakes in hilltop city, once known as "the necklace of lakes." Seasonal rains during monsoons were originally captured in over 200 man-made lakes, ponds, and tanks. The water in these lakes was used for domestic drinking, agriculture including irrigation and livestock washing, and religious practices. Today, the disappearance of lakes has curtailed access to water-evident in the relative absence of gardens and parks. Moreover, the remaining lakes are Increasing y subject to pollution from untreated sewage water.

Despite the lost landscape of water, some former lakes still survive in the collective memory, and their religious functions are commemorated in annual rituals such as the Karaga festival. whose procession route visits the former Sampangi Lake (now a sports stadium) and Dharmabudi Tank (now a bus terminal). While severe pollution and encroachment issues have been occasionally addressed through restoration projects, the disappearance of lakes in Bengaluru, south Asia's high-tech capital. remains a major issue.

- ORIGINAL LAKE EXTENT
- CURRENT LAKE EXTENT
- BUILT-UP AREA
- GREEN SPACES AND AGRICULTURAL LAND
- SRI KANTEERAVA SPORTS COMPLEX
- ENCROACHED AREA
- ENCROACHED AREA BEFORE RESTORATION

Impact of urban sprawl on lakes
SOURCE: ORNL DAAC, Google Maps, Karnataka Lake Conservation and Development Authority

IMPACT OF TREES IN THE URBAN GROWTH OF BENGALURU:

- In rapidly growing Indian cities, change seems like the only constant. Yet the street tree stubbornly survives across Indian cities – beleaguered by gasoline fumes, besieged by construction, but still tenaciously gripping the sidewalk. These trees play an important role in the daily lives of Indian cities, a role that is often hidden from our awareness.

- Trees were prized according to a secular colonial aesthetic that favored the ornamental over the fruiting, and the exotic over the native. Trees were thickly planted along streets, and in wooded campuses, but otherwise kept under strict control. Areas of the footpath were demarcated for plantation, an even spacing was maintained between trees, and the flowering colors of trees were selected in a careful mix, so that every part of the colonial city was bound to have some flowers in season at all times of the year.

- Trees serve an important civic need. Despite the constant churn of old heritage buildings being torn down to make way for tall multi-storey offices, these trees are much prized by residents and office-goers, giving the colonial neighborhood its integral character of a "Garden City", as it is often termed.

Trees planted at pre-determined spacing, and neatly confined to defined areas on a street near Mahatma Gandhi Road in the Bengaluru Cantonment.
SOURCE: Suri Venkatachalam(2018), Photo essay: If you look closely, you can still find the 'Garden City' in Bengaluru, scroll.in

At Mayo Hall (a heritage colonial building housing the City Civil Court), an irregular, sprawling Ficus elastica is contained within a cemented square, a bench placed neatly parallel to the square, and its hanging roots well-trimmed so as not to interfere with the asphalt.
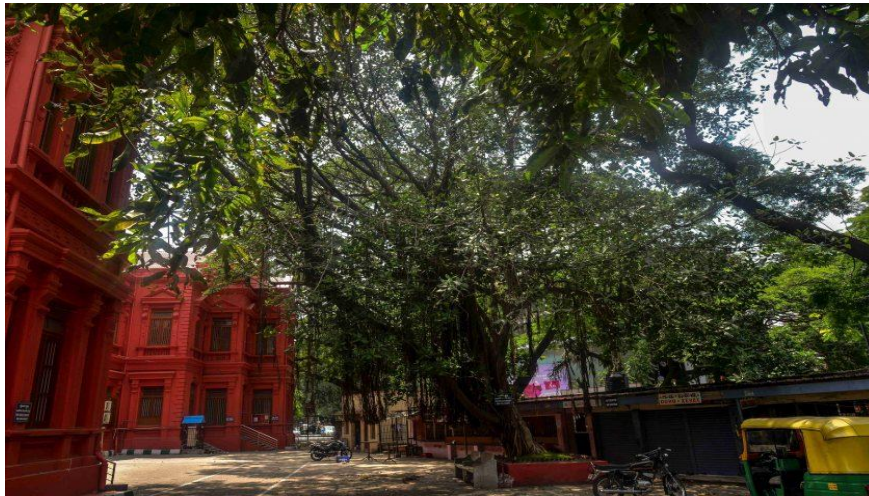
Mayo hall-irregular ficus
SOURCE: : Suri Venkatachalam(2018), Photo essay: If you look closely, you can still find the 'Garden City' in Bengaluru, scroll.in
Yet adjacent to this ornamental aesthetic, a very different pre-colonial aesthetic emerges – that of the sacred. The Maha Muniswara temple, on the same road as the well contained street trees in Photo 2, is built around a sprawling Ficus. Unfettered, the tree controls the urban landscape, not the other way round. Despite its location in an area surrounded by

trees, owing their existence to a colonial landscape ethic, the sacred tree, and its associated temple intrude on the road, asserting their right by pre-existence to appropriate urban space, and reclaim the city for their own.

The Maha Muniswara temple from above – surrounded by Ficus trees – the temple pagoda appears to be floating in a green sky. Venkatachalam
SOURCE: Suri Venkatachalam(2018), Photo essay: If you look closely, you can still find the 'Garden City' in Bengaluru, scroll.in
In contrast to the central parts of the city Cantonment – areas of south Bengaluru between the neighborhoods of Basavanagudi and Jayanagar – display a different street tree aesthetic. These areas constitute a well-planned mix of commercial and residential neighborhoods, distinguished from each other by the size of the roads.

THE IMPACT OF ENVIRONMENTAL DAMAGE ON HUMANS

- The unplanned city became hub for dumping garbage.
- The population of city was finding deficiency in clean water and the entire city now relay on bore well or Kaveri River water, since pollution was more directed towards soil through polluted water, the poor infrastructure in waste management forced to flow the water in the lakes of Bengaluru. The continuous process of this treatment of water was driving the contaminated particles from the waste to settle on ground water and Kaveri River water.
- The consumption of Kaveri River water and bore well has been increased tremendously in last few years. The deterioration of ground water and other sources has been affected the quality of life and studies says that most of the water in Bengaluru is unsafe to use because of the concentration of chemicals in water. Chemicals like Nitrate, Mercury Calcium, Magnesium, Sulphates, and Fluorides makes chemical imbalances in the body. Since the pollution has increased in other hand the number of health issues have been increased both physical and mental cases. The rapid growth in urbanization and the poor planning became perfect spot to settle waste. The waste was created by various stakeholders in the city.
- The use and throw culture that has been a part of city life in long time is now turning into an environmental and public health hazard. People are unmindful when it comes to disposal of waste. The waste generated by city is 4500 tons per day, the waste use to transport to the neighbor district for more than 10 years now, most of the garbage use to burn in landfills or compress in soil also poising environment and the natural resources in soil are contaminated due to these activities. The resistance from neighbor district blocked the movement of waste and generated wastes are being dumped in any corner of city, mind set of people in Bengaluru blinded with the growth of city and capitalist culture became common norm among people who spend their life in Bengaluru,
- consequences of these activities are faced by the same people through the reaction of nature, change in climate, spreading of disease, reports of miscarriages and mental cases has increased in past few years. Empirical studies suggest that Bengaluru will become the unsafe city within 5 years down the line.
- Bengaluru is also known as the city of two wheelers, the density of the two wheelers and no-restriction for honking making the city noisy throughout the day. Noise pollution increases the level of irritability, sleeping disturbance and decrease in hearing ability. Continuous exposure to noise of 85-90dBA, probably leads to the breakage of both mental and physical health threshold related to hearing. Bengaluru city holds 95lakh people, most reported problem among the people in the city is noise annoyance, and it is the most documented subjective response to noise pollution

Case Study of sustainable development: St marks Road, Gandhi bazaar, Seshadripuram

Before, and especially during the pandemic, Bengaluru had some significant initiatives to promote walking:

- Motorized traffic was banned on Church Street and opened to pedestrians, cycles, and e-scooters on weekends for five months, starting November 2020, under the 'Clean Air Street' initiative. An IISc study found significant reduction in air pollution and an increase in pedestrian and transit activity on the street over this period.

- To comply with lockdown and physical distancing protocols, the Centre's Ministry of Housing and Urban Affairs (MoHUA) issued an advisory recommending holistic planning to make busy marketplaces pedestrian and cycling friendly. Bengaluru proposed implementing this in three streets - Gandhi Bazaar, Commercial Street and Malleswaram 8th Cross.

- Pedestrianisation of Gandhi Bazaar had been abandoned a decade ago due to opposition from residents and street vendors. The plan was revived in 2020 by the Directorate of Urban Land Transportation (DULT) and Bruhat Bengaluru Mahanagara Palike (BBMP), to design this street similar to Church Street.

- Under the Smart City Project, Commercial Street was to be made a pedestrian-friendly cobblestone street. The street design is complete, but it is yet to be completely pedestrianised.

- There are also citizen-led initiatives such as 'Eega Footpath Nammade' (Footpath is ours now) led by Sheshadripuram residents to bring attention to damaged footpaths, 'Malleshwaram Hogona' (Let's go to Malleshwaram) by Geechu Galu and Bengaluru Moving that involves 13 artists painting murals on 12 walls to make walking the "new normal", and 'Footpath beku' (Need footpaths) led by Malleshwaram Social.

Complete Pedestrianization of commercial street

- Sheshadripuram: Launching a campaign for better footpaths in Bengaluru, a group of residents in the city's Seshadripuram area held a 1.6 km loop walk negotiating the pits dug up and left open, dumping of debris and indiscriminate parking of vehicles on footpaths along the way.

- The walk, held from Seshadripuram Main Road to Mantri Mall and back on Saturday evening, was attended by residents who called for measures to be taken for the safety of pedestrians. It was coordinated by Citizens for Bengaluru, a civic organization working for citizen's rights.

S.no.	Aspect	Intention	Mitigation strategies
	Methods of Sustainable streets scapes to reduce environmental impact of cities		
1	Biodiversity and ecosystem function	1. Reserve core biodiversity values and enhance natural ecosystem of the bioregion with corridors and natural areas retained.	1.Incorporating new plant species. 2.Natural dispersal of seeds into restored areas. 3.Planting of native trees and bromeliads in dense patches. 4.Nucleation techniques
2	Air quality	1. To Reduce Ground-level concentrations of urban air pollutants.	1.Permeable linear barrier or hedge design heterogeneity into the urban canopy to exploit edge effects and maximise deposition. 2.Large areas of green walls in street canyons
3	Water quality	1. Mitigation strategies to avoid untreated stormwater runoff, containing raw sewage entering the streets.	1.Green roofs 2. Downspout disconnection:practice of redirecting rooftop runoff from storm drains to a permeable surface, such as a lawn, or to rain barrels or cisterns, which capture and hold the water for later use
4	Waste	1. Zero waste management strategies. 2. Managing garbage and keeping it from landfills.	1. Generate energy from waste 2. Pay as you throw- Make individuals accountable for their trash. 3. Hazardous waste.
5	Access	1. To provide sustainable accessibility between homes, jobs, services and recreation.	1.Ensure all knowledge-intensive centres and corridors have quality public transport at their core. 2. 2.Facilitate short trips by sustainable modes for local accessibility.
6	Governance	To establish effective, fair and efficient planning and decision making	1.Planning governance: Ensure that appropriate institutional support with local government is available for the implementation and review of plans 2.Create funding opportunities for each of the planning functions required to deliver Transparent and engaging processes: Ensure each planning step is transparent 3.Transparent and engaging processes: Ensure each planning step is transparent

Methods of sustainable streets to reduce environmental impact of cities

STRATEGIES FOR SUSTAINABLE STREETS:

1. Biophilic streets: a design framework for creating multiple urban benefits

- Biophilic design attempts to achieve the benefits of contact between people and nature within the modern built environment by integrating nature, internally and externally, into buildings, built infrastructure and across the urban space.
- In addition to anthropocentric goals and benefits, biophilic design is a recognized solution to a spectrum of environmental challenges including urban heat island effect, particulate matter filtration and carbon dioxide sequestration, rehabilitation and restoration of lost habitats and increase of urban biodiversity.
- It promotes ecologically interrelated design solutions at multiple scales and enables regeneration of natural systems in the urban environment.

DEVELOPING A FRAMEWORK FOR BIOPHILIC STREETS DESIGN:

Energy management

- Energy management in urban streets serves multiple functions: helping to cool a city where urban heat island effect is leading to ill health; making walkability easier and hence improving urban economics in the area; and helping to cool the buildings next to the street.
- The cooling capacity of a tree canopy depends on its characteristics, as well as the characteristics of the street such as surface materials, geometry, building height and how densely the street is built up. However, at night time the air temperature under the canopy, where the radiating heat is captured, can be 0.5 degrees Celsius higher than in an open space reference point
- Biophilic structures installed directly onto buildings include green walls and roofs. By introducing such structures, the air temperature in street canyons can be reduced as well as the demand for cooling and heating of buildings.

Stormwater management

- In recent years, biophilic designers have transformed one of the largest impervious areas—roof tops—into intensive and extensive gardens and meadows, creating efficient stormwater management systems. Tested green-roof stormwater retention on a small-scale trial and found that the retention capacity was on average 34, and 57% of peak flow run-off.

- Rainfall was shown to have little or no impact on the green wall. Most of the rainfall was blocked by the gutters integrated into the system. In order to improve the efficiency of the green roof and wall systems, the run-off from the roof was collected into cisterns and then used to irrigate the green walls with drip irrigation.

- Thus, a green roof can be considered an alternative to a conventional stormwater management system and become integrated into the concept of a biophilic street.

Masterplan and section of street design integrating greeneries and multiple functions
SOURCE: Chester Harvey et al.
The Professional Geographer
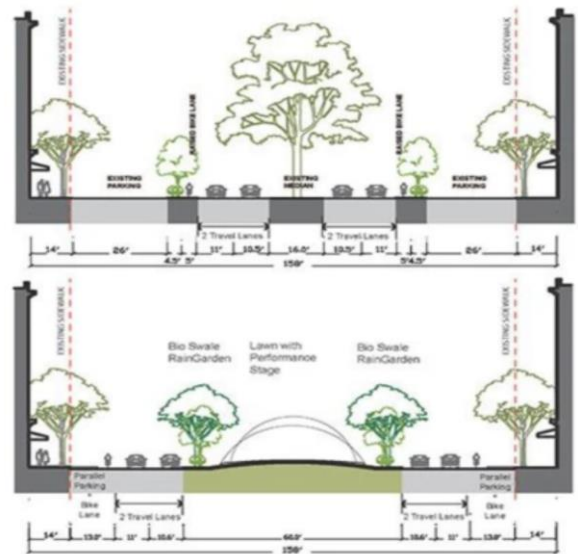
2. SUSTAINABLE STREETSCAPE MATERIALS

- Materials that produce less pollution and waste during manufacturing, utilization, transportation, and demolition process as well as economically feasible are being considered as sustainable materials. Most conventional construction materials are nonrecyclable, consume high energy, are environmentally unfriendly, and require high cost. When such material enters the environment, it will remain there for many years

- If the perception of using cement as construction materials is not changed globally, then 3.5 billion metric tons of cement could be produced in the world by the year 2050 Among all building materials, cement is the most widely used, plays a crucial role in the construction sector, and attains special features in the construction activities due to its durability, high compressive strength, and resistance to chemical and weathering actions.

3. FUNGAL MYCELIUM AND CARBON SEQUESTRATION

- Mycelium has been used for a long period in medicinal industries and molecular compounds.
Beyond bioremediation and medicinal application, nowadays mycelium is applied in biomaterial production such as bio cement, bio block, and bio enzyme.

- Mycelium is a dense network of thin strands called hyphae that grow and fuse together into a solid material. Mycelium growth forms self-assembling bonds and miles of tiny white fibers which invade and degrade the organic substrate, gradually colonize the organic matter, and bind them into strong and 3D structure materials

- While degrading lignocellulose substrate, the mycelium can assemble together and form a block-like structure. This self-assembling property of mycelium makes fungi unique in the production of noble bioproducts

- As mycelium can grow easily on organic wastes, its derivative materials have the potential to become the material of choice for a wide variety of applications because they are emission-free, recyclable, and of low cost. Mycelium-based materials (MBm) are recyclable and renewable and can substitute other conventional materials. These materials are fully biological so that they can be selected by different designers and architects to be used for packaging and building industries with little or no cost and environmental damage

- Mycorrhizal fungi are the main organisms driving carbon storage — we can test how different proportions and types of these fungi affect sequestration both in the soil and above ground.
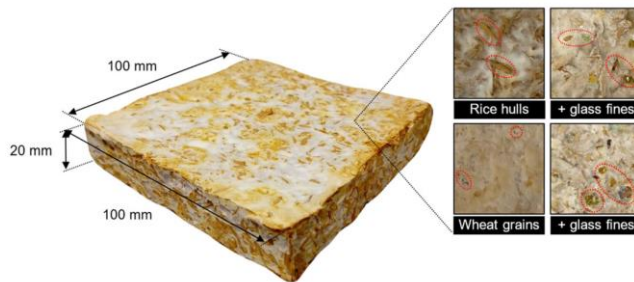
Representative mycelium composite as a dehydrated square tile with surface profiles for each composite sample produced, ie, rice hulls, rice hulls + glass fines, wheat grains, and wheat grains + glass fines

Structures like Arches and fences built out of mycelium tubes.

SOURCE: Arnold R. Spokane et al. Architectural Science Review

3. URBAN GREEN STRATEGIES

- As part of the initiative 'Urban Green, 'the employees can now indulge in some gardening or farming within the compound of their office, an exercise aimed at helping them de-stress.
- Nearly 70 employees own their own vegetable gardens, with over 400 more waiting for their turn. The initiative, spread over three large plots in the park, makes everything available – including manure.
- While some employees have been enjoying their stint with farming and are even sharing their produce with family and friends, for some, the initiative has had a deeper impact.
- There are plans to allot one plot for every building in the coming months.

TITLE: Employees own their own vegetable garden
SOURCE: shwetha sharma(2017), The better india

CONCLUSION:

The sudden expansion of population, infrastructure development has due to migration and industrial developments has led to urban sprawl in Bengaluru. There is a considerable toll on the environment and the health of the citizens due to urban sprawl.

It is also observed that the dirt and pollution in the city has a negative impact on not just the health but also the mindsets and behavior of its citizens leading to further pollution and destruction of infrastructure.

In order to reduce the environmental impact due to urban sprawl there needs to be planned growth of the city incorporated with sustainable materials in streets and infrastructure.

Sustainable streetscapes can lead to healthy environments, increase the efficiency of the neighborhood and boost productivity. Application of Biophilic concepts in street design can make the streets energy efficient and lead to lesser waste accumulation and lesser pollution.

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