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THE CITY 'GREENS': USHERING SUSTAINABLE URBANIZATION

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Abstract: Urban green spaces (parks, forests, green roofs, streams and community gardens) are public and private open spaces in urban areas, primarily covered by vegetation, which are directly (active or passive recreation) or indirectly (positive influence on the urban environment) available for the users. Most urban green spaces *represent novel ecosystems* providing critical ecosystem services. In fact, *urban areas can support endemic native species and others of conservation concern both at regional and global levels.* These species and the overall diversity in a city rely on the size, quantity, and quality of such spaces which facilitate citizens to connect with nature, witness ecological processes in action, and potentially become scientifically literate citizens, equipped to make informed decisions regarding conservation initiatives and policy.

Quality green spaces in the city act as carbon 'sinks' and affect climate change. Apart from supporting a variety of species and habitats, they contribute to essential services including water filtration and absorption, nutrient cycling, air filtration and noise buffering. Identifying the ecological role and conservation value provided by different types of urban green spaces is of particular importance, given the continued growth of urban areas and the development of new cities, along with the promotion of certain types of green spaces. The recent **Smart City** initiative by the Indian Government promoting development of urban green spaces can be coupled with **strategic landscaping** to optimize benefits of greening programs, thus ushering sustainable urbanization.

Index Terms- Urban Biodiversity, Urban green spaces, Sustainable development, Carbon sequestration, Urban ecosystem

I. INTRODUCTION

Urban areas house the majority of the world's population, and there has been a surge in interest in researching urban ecosystems. As urban areas expand, understanding how ecological processes function in cities has become increasingly important for conserving biodiversity. (Lepczyk *et al*. 2017)

Urban green space, such as parks, forests, green roofs, streams and community gardens provide critical ecosystem services. In fact, *urban areas can support endemic native species and others of conservation concern both at regional and global levels.* These species and the overall diversity in a city rely on the size, quantity, and quality of urban green spaces which facilitate citizens to connect with nature, witness ecological processes in action, and potentially become scientifically literate citizens, equipped to make informed decisions regarding conservation initiatives and policy. Green space also promotes physical activity, psychological well-being, and the general public health of urban residents besides greater environmental responsibility. Access to green space is therefore increasingly being recognized as an environmental justice issue.

II. Urban Green Spaces

Urban green spaces (parks, forests, green roofs, streams and community gardens) are public and private open spaces in urban areas, primarily covered by vegetation, which are directly (active or passive recreation) or indirectly (positive influence on the urban environment) available for the users. The three main components of urban forest and green spaces are:

1. **Patch** (urban domestic gardens, public and private parks, gardens, urban forest patches etc.),
2. **Corridor** (roadside avenues, walkways and urban greenways etc.), and
3. **Network structure** (layout of all the patches and the corridors connecting the patches).

Green spaces are often viewed in different lights because ecologists and other stakeholders have contrasting opinions on their role in biodiversity conservation and value to society. They comprise a range of habitat types that cross a continuum from intact remnant patches of native vegetation, gardens and yards, to essentially terraformed patches of vegetation that may or may not be representative of native community associations. ***Most urban green spaces represent novel ecosystems***. The variety of these supports different taxa on the basis of patch size, patch quality, quantity in the landscape, and heterogeneity both within and among green spaces. Urban green spaces may include heavily maintained terraformed patches, such as plantings in the city core, green roofs and community garden spaces that include both managed and unmanaged vegetation, such as city parks and home gardens, unmanaged vacant lots, brown fields and remnant natural areas.

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Most urban green spaces *represent original ecosystems* providing critical ecosystem services. In fact, *urban areas can support endemic native species and others of conservation concern both at regional and global levels.* These species and the overall diversity in a city rely on the size, quantity, and quality of such spaces which facilitate citizens to connect with nature, witness ecological processes in action, and potentially become scientifically literate citizens, equipped to make informed decisions regarding conservation initiatives and policy. They also promote physical activity, psychological well-being, and the general public health of urban residents besides greater environmental responsibility. **Access to green space is therefore increasingly being recognized as an environmental justice issue.**

III. Urban Biodiversity

Urban biodiversity is defined by the Convention on Biological Diversity (CBD) as: "The variety and richness of living organisms (including genetic variation) and habitat diversity found in and on the edge of human settlements. This biodiversity ranges from the rural fringe to the urban core (CBD 2012). Establishing a clear picture of biodiversity within an urban context is complex, as it requires the consideration of a range of attributes (Maruani and Cohen, 2007).

These defining factors are: (1) the diversity of urban areas in terms of the quantity and quality of green spaces; (2) the types of diversity desired to be measured (i.e. the number of individuals of a single species, or the total number of species present); and (3) the variation between groups of species in their ability to adapt to urban environments (Concepción and Diaz 2011).

IV. Initiatives for Urban 'Green Belts'

Urban areas house the majority of the world's population, and there has been a surge in interest in researching urban ecosystems. A range of challenges for city infrastructure, inhabitants and surrounding areas are projected to accompany this growth, such as finite resource availability, decreasing quality of urban environments, and mounting pressure on biodiversity. For many, urban areas are sometimes viewed as concrete jungles, with impoverished fauna and flora dominated by non-natives and homogenous taxa across regions. Although such views are understandable, in truth, urban areas house a great deal of species both native and nonnative to the surrounding region (Aronson et al. 2014, Ives *et al.* 2016). In fact, urban areas can support endemic native species and others of conservation concern both at regional and global scales (Ives *et al.* 2016).

These species and the overall diversity in a city rely on the size, quantity, and quality of urban green spaces, which are also features vital for human health and well-being (Barton and Pretty 2010). Urban green spaces provide opportunities for citizens to connect with nature, witness ecological processes in action, and potentially become scientifically literate citizens who make informed decisions regarding conservation initiatives and policy. The potential to utilize urban green infrastructure (planning) has emerged as a promising multifunctional tool by which to support both biodiversity and provide citizens with healthy and habitable conditions.

The National Forest Policy of India aims to ensure that a minimum of one-third of the total land area of the country remains under forest or tree cover. It encourages planting of trees alongside roads, railway lines, rivers, streams, and canals. Raising of **"green belts"** has been recommended in urban/industrial areas and in arid tracts (Ministry of Environment & Forests, India 1988). **Individual green assets** (plants on terrace, terrace garden, indoor plants, and private garden/lawns) must be encouraged and enhanced in a large scale in the built up city area. **Urban forestry** is to be planned and integrated and systematic approach to urban tree management should be stressed. The policy of "**right place, right tree**" provides technical support towards intelligent greening of cities. Identification of "**champion trees**", *i.e.* trees of ecological importance due to species richness or physical attributes, and policies for their preservation will help to sustain species variety and richness. **Tree census** should be initiated and must include a study of the physical attributes of trees, such as species variety, richness, health, age etc. (Imam and Banerjee, 2016). **Tree databank** providing detailed assessment of the physical, economical, and ecological value of city flora could promote afforestation of Indian cities. The recent **Smart City** initiative by the Indian Government promoting development of urban green spaces can be coupled with **strategic landscaping** to optimize benefits of greening programs, thus ushering sustainable urbanization (Imam and Banerjee 2016; Sen, 2016a).

V.A Ecosystem Services of Urban Green Spaces

Urban green spaces have been shown to improve health and well-being through conferring a number of ecosystem services including buffering noise pollution, air quality through absorbing and shielding from particulates, and preventing heat stress by providing shade. A further ecosystem service is the proposed ability of biodiverse urban green spaces to improve psychologicalwell-being. Such restorative ecosystem services provide one of many arguments for biodiversity conservation.

- ***Most urban green spaces represent novel ecosystems.***
- Quality green spaces in the city act as **carbon 'sinks**' and affect **climate change**.
- **biodiversity conservation**,
- removal of atmospheric pollutants,
- oxygen generation,
- noise reduction,
- mitigation of **urban heat island effect**,
- **microclimate regulation**,
- stabilization of soil,
- groundwater recharge,
- prevention of soil erosion and
- **carbon sequestration**
- ***Such urban areas can support endemic native species and others of conservation concern both at regional and global levels.***

V.B Social Benefits

- Can offer a larger diversity of land uses & opportunities for a wide range of activities, help to foster **sustainable lifestyles**
- Contribute to **social justice** by creating opportunities for people of all ages to interact & enhance cultural life, creating environmental responsibility & awareness
- Provide safe play space for children, contribute to physical, mental and social development and an important role in education with respect to environment and nature, **inculcating pro-environmental behaviour** (Sen 2010; 2017a)
- Access to green space is therefore increasingly being recognized as an **environmental justice issue**.
- Flora and fauna preserve physical human health and psychological well being and prevent 'Nature Deficit Disorders' in urban children (Sen, 2018b, 2019a). Biodiversity Vision 2050 envisages "By 2050, biodiversity is valued, conserved, restored and widely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people." (CBD Decision X/2)

V.C Economic Benefits

- Property owners value the urban forest by the premium they pay to live in adjoining areas with urban green spaces and public parks.
- Study on effects of neighbourhood parks on the transaction price of high-rise private residential units in different cities indicated that **neighbourhood parks could lift prices significantly**
- Urban shade trees offer significant benefits in **reducing building air-conditioning demand** and improving **urban air quality by reducing smog**

V. Urban Heat Islands

The Urban Heat Island is a phenomenon whereby temperatures in urban areas are warmer than the surrounding rural countryside, often by several degrees. As urban green spaces and urban forests increase, evapotranspiration rate increases .Thus, a common measure to mitigate urban heat island effect is to increase urban green spaces. Studies on microclimate formation through built-up morphology and urban shade trees have clearly established the importance of urban trees in alleviating the heat island effect in a hot and humid summer (Shashua-Bar *et al*. 2010).

A team of researchers from IIT Kharagpur has found that most cities in the country are turning into "urban heat islands" in all seasons during day and night. In their study, researchers of IIT-KGP and its Architecture and Regional Planning department showed that most big cities in the country with population more than one million have recorded rise in mercury level during daytime while showing an increasing trend in the night hours. The study, 'Anthropogenic forcing exacerbating the urban heat islands in India', noted that the relatively warmer temperatures in urban areas, compared to suburbs, have potential health hazards due to heat waves apart from pollution (Outlook India, 2020)

Evidence from the study suggests that more green spaces within the city and its boundary could reduce the temperature in the city and its neighbourhood. Conservation of water bodies and expansion of green areas in and around cities could be an effective strategy to curb the effects of urban heat islands, he said. The construction of buildings and infrastructure with eco-friendly materials could also prove to be crucial to mitigate the effects of heat islands. (The Week, 2020)

VI. Types of Green Spaces

Urban green space is divided into eight types inspired by the classifications of green spaces by Bell *et al*. (2007). We believe that people relate to green space not as a uniform good with a continuum scale of quality but rather a hierarchy of distinct goods which provide a range of services that enable different recreational activity and in some cases no activity. Some types of green space provide amenity services where people go to have recreational experiences. Other types of green space are associated with disamenities, e.g. through negative visual effects, or where neighboring land use reduces the recreational value of the green space significantly. An example could be green space near noisy infrastructure.

The different types of green space can be characterized as follows:

1. **Parks**: Green space categorized as a park has a high maintenance level with well-kept vegetation and a wide range of recreational possibilities. Footpaths open the green area to the public and make it possible to walk in the area and enjoy different features such as small lakes, trees, lawns, flowers, and sport activities.
2. **Lakes**: Some green space in cities is characterized primarily by the presence of water bodies such as lakes. In cases where a lake is the dominant feature of the green space, this is treated as a distinct type of space as the access and maintenance features differ from that of a park or a natural area, suggesting that the services provided differ as well.
3. **Nature**: On the edge of the city, large areas of green space can be found which often contain open fields of grass, tree cover, and lakes. Most often these areas contain small gravel roads and nature paths, which enable people to move through the landscape. The area is less well kept than an urban park. Fields and pastures often border the natural area.
4. **Churchyards**: These are often open to the public during daytime and have a high level of maintenance with flowers and hedges. While footpaths provide internal accessibility, there is little space for other activities than walking, and more lively social activities are rarely socially acceptable.
5. **Sports fields**: Schools and institutions often have access to green space, which facilitates sport activities and playground for the pupils. These areas often form a square and are outlined by trees. Sports facilities connected to sports clubs often have similar characteristics, e.g. similar size. In some cases these facilities are fenced limiting access.
6. **Common areas**: Communities of houses or apartment buildings in Denmark often have shared "common green space" which is maintained by the property owner association or landlord. Well-kept lawns and small playgrounds often dominate such space. The users are mainly local residents and as such the areas are semi-public in terms of accessibility. Common areas are often relatively small, consisting of patches of green space connected by footpaths. We divided common areas into two separate types of space depending on whether the space is related to apartment buildings or houses. Given the semi-public character of common areas, they are mainly used by residents in the immediate vicinity.
7. **Agriculture fields**: These areas are usually relatively large and homogeneous in nature. Most often there are no footpaths or roads allowing access into the fields and often meadows are fenced.
8. **Green buffers**: Green space can be found in connection to infrastructure such as highway, larger roads, and railways. Often covered by trees, the main function of such areas is to reduce the negative impact of noise and air pollution coming from the neighboring infrastructure. Likewise, industrial areas often contain patches of green space. The latter areas often consist of a kept lawn potentially surrounded by trees and do not invite recreational activities. We grouped these areas together due to the unattractive character of the neighboring land use (Panduro and Veie, 2013).
9. **Roof Gardens**

Green roofs are vegetated layers that sit on top of the conventional waterproofed roof surfaces of a building. Green roofs are designed to be sustainable and have a number of benefits for the environment.

10**. Intensive roofs**

These are composed of deep substrates of over 20cm in depth and can support a wide range of plants and vegetation type. They are generally heavy and require a large amount of support from the building.

11. **Extensive roofs**

These are composed of lightweight layers of free-draining substrates that support drought tolerant plants. The depth can be only a few millimetres with a maximum of 10-15cm. These roofs have a potential for wide spread use due to needing a lack of support from the building.

12. Biodiverse roofs

These are designed to replicate a habitat for a specific species, or to create habitats that maximise the number of species that can inhabit and use the roof. (Forest Research, UK)

Roof gardens increase the proportion of green areas and ameliorate UHIs through thermal pacification.

- Minimize monetary expenditure on storm water runoff management by serving as readily available media for water retention
- They render **ecological utility by filtering airborne pollutants**, and enhance aesthetic appeal
- The soil medium insulates the roof while the vegetative layer intercepts radiation;**total system accounts for evaporative cooling.**
- **Reduction in building cooling load and consequent savings in energy depend on thickness of soil, & type and density of vegetative cover**.

13. Roadside avenues & greenways

- Vegetative growth ensures a pervious ground cover with potential for evaporative cooling.
- Trees shade pavements and building envelope besides reducing heat gain by maintaining lower surface temperatures.
- Since road networks occupy considerable land area, **avenue trees and roadside greening help to reduce ambient temperatures.**
- Trees render **direct cooling of the microclimate through shading, evapo-transpiration, and carbon sequestration**.

14. Green Walls

The lack of space required for accommodating a fully grown tree in densely developed Indian cities can be overcome by using **green walls**.

- **Plant cover on wall acts as layer of insulation & reduces transmission of heat to indoors**. This entails innovative strategies for ease of implementation & maintenance.
- **Energy conservation potential of a green wall is directly proportional to the amount of surface area covered—**reduction of 33% in surface absorption coefficient value of wall has been observed.

VII. The Indian Scenario

The government appears to have in mind a “green wall of India", a 1,400km-long and 5km-wide green corridor all the way from Panipat in Haryana to Porbandar in Gujarat. It would be modelled on the so-called Great Green Wall of Africa that was envisioned to run from Djibouti in the continent’s east to Senegal in its west. This African green belt, proposed about a decade ago, was meant to act as a defensive flank against climate change, desertification and other forms of land degradation, but has fallen short of its targets for lack of coordination among the countries involved. In contrast, the Indian project is likely to face far fewer hurdles. (Livemint, 2019)

A. Urban Forestry

The term 'urban forestry' was initially coined by Professor Erik Jorgensen at the University of Toronto in Canada. In brief, urban forestry comprises the planning, design, establishment and management of trees and associated vegetation in and near urban areas. (Bosch *et al.* 2006) According to the Society of American Foresters’ Dictionary of Forestry (1998 edition), urban forestry is defined as ‘the art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physiological, sociological, economic, and aesthetic benefits trees provide society.

The need for urban forestry to be a ***planned, integrated,*** **and *systematic* approach** to urban tree management should be stressed. Planning is important because trees are very often considered as an afterthought once development has taken place, rather than being incorporated at the original design phase. An integrated approach implies the participation of many different organizations - local councils, municipal and national planning bodies, departments, etc. Systematic management entails regulated tree management; operations such as planting, pruning, and felling must all be conducted in an organized manner, at the appropriate time (Saphores and Li 2012; Sen, 2019b).

B. Guidelines to designing an urban forest

All urban forest design processes should start with the identification of **suitable spaces**. There are **three main types of location** for forests and trees in urban and peri-urban settings:
1) Trees in streets, squares, parking areas and other “grey spaces” with sealed surfaces;
2) Trees in parks and other green spaces such as continuous soil strips, yards, gardens and commercial areas; and
3) Stands, patches and other groups of trees, which may be referred to as “woodlands”, “woods” or “forests”.

All potential constituencies in a community should be consulted in urban forest design so that it fully reflects their needs, requirements and demands; the design process should be sufficiently flexible to accommodate the outcomes of the consultation process. It is also crucial to ensure that any urban forest design:
• Promotes the social comfort of users by meeting the needs of the community;
• Is compatible with the specific characteristics of the site;
• Creates places in which trees can thrive and deliver their full range of benefits without causing nuisance; and
• Helps meet the SDGs. (Salbitano *et al.* 2016)
In West Bengal, the State Government agency, Housing Infrastructure Corporation (HIDCO) has decided to create, in collaboration with a private organization, the country’s first urban forest in Kolkata. This will form an effective effort to combat pollution in the city. The two organizations together have come up with the campaign, ‘Heal the Earth, clean is our birthright’ to popularize the effort.

The urban forest, which will be spread over 4 acres of land, will come up in Rajarhat, on the outskirts of the city. At least 8,500 trees will be planted in this man-made urban forest, which will produce 9,54,500 kg oxygen and will absorb 5,27,000 kg carbon dioxide (UNI, 2018).

Apart from maintaining the balance of our environment, there will be opportunities to buy trees.

C. Towards Green Indian Cities: Recommendations

- The National Forest Policy of India aims to ensure that a minimum of one-third of the total land area of the country remains under forest or tree cover.
- It encourages planting of trees alongside roads, railway lines, rivers, streams, and canals. Raising of **"green belts"** has been recommended in urban/industrial areas and in arid tracts (Ministry of Environment & Forests, India 1988).
- **Individual green assets** (plants on terrace, terrace garden, indoor plants, and private garden/lawns) must be encouraged and enhanced in a large scale in the built up city area.
- Urban Structure of Kolkata City: A Geographical Analysis environmental policy must be formulated and implemented for the household level.
- Apart from residents, students from educational institutions in the neighbourhood may be truly encouraged to play a active role in the maintenance of the green space (Sen, 2014a; 2016b).
- The need for **urban forestry is to be planned & integrated** and **systematic approach** to urban tree management should be stressed.
- **Planning** is important because trees are very often considered as an afterthought once development has taken place rather than being incorporated as original design phase.
- An **integrated approach** implies the participation of many different organizations, local council, municipal and national planning bodies, department etc.
- **Systematic management** entails regulated tree management, operations such as planting, pruning and felling must be conducted in an organized manner at the appropriate time.
- **Lack of afforestation** programs is a major drawback of Indian cities. Urbanization should be complemented with afforestation targeting specific increment in tree count.
- **Performance-based incentive programs** encourage competition and result in better output (Sen, 2015a, b).
- Since low-income residents tend to live in dense neighbourhoods, special care should be taken to ensure **provision of green walls and green/cool roofs**. Such measures will prove crucial in the cooling of microclimate and compensating for dearth of material resources (Sen, 2011; 2014b).
- The plants for vertical gardens are the ferns for their adaptability and humidity resistance, bromeliads, Bird Nest fern, Pothos, golden pothos, devil's ivy, Lipstick plant, succulents, Dracaena, crotons and the likes.
- **Tree databank providing detailed assessment of the physical, economical, and ecological value of city flora** could promote afforestation of Indian cities.
- **Tree census should be initiated** and must include a study of the physical attributes of trees, such as species variety, richness, health, age etc
- Study on **increase in property value due to the vegetation** will provide an assessment of the economic value of city flora, & convince residents about monetary benefits from maintenance & development of green areas (Troy, 2008).
- A **sacred grove** is an excellent example of an **autonomous community effort** initiated by communities for conservation and management of biological resources and existing urban sacred groves may serve this purpose excellently (Sen 2015c, 2017b).
- The policy of "**right place, right tree**" provides technical support towards intelligent greening of cities.
- **Evergreens should be selected for roadways** to minimize accidents due to leaf shedding from deciduous varieties.
- Road traffic is a major source of pollution in India. Impetus should be given to **greening of transport corridors** to reduce atmospheric pollution
- Identification of "**champion trees**", i.e. trees of ecological importance **due to species richness or physical attributes**, and policies for their preservation will help to **sustain species variety and richness**. For example importance of cultivating *Ficus* sp to provide food for birds (Chowdhury and Sen, 2019)
- **Incorporation of permeable pavements such as grassed footpaths and greening of parking lots** will help to decrease the proportion of paved areas, aid in storm water retention, and reduce surface heating.
- **The high percentage of flat-roofed buildings in India provides ample scope for development of roof gardens**. The added benefit of rain water harvesting and storm water runoff collection could be amalgamated to **solve acute water shortage in cities**.
- Since people remain more amenable to monetary benefits, tax abatements can be provided for maintenance of roof gardens, box plantations, and green terraces.
- **Public participation *i.e.* community involvement** is a prerequisite for the success of any biodiversity conservation and urban development program but is sadly significantly missing in India (Sen, 2014c, d; 2018c).
- The recent **Smart City** initiative by the Indian Government promoting **development of urban green spaces** can be coupled with **strategic landscaping** to optimize benefits of greening programs.

VIII. Conclusion

During the United Nations Sustainable Development Summit in September 2015, the relationship between cities, sustainable development, socio-economic factors, human settlement and natural resources was finally recognised. It was also clear that, without transforming our approach to how we design, build and manage our urban space, sustainable development cannot be achieved. The world leaders' recognition of this materialised in the inclusion of SDG11: 'Make cities and human settlements inclusive, safe, resilient and sustainable', to strengthen resilience and the capacity to adapt to climate-related hazards and impact on natural resources (UN). This goal is a remarkable success for urbanists and local stakeholders worldwide and puts urbanisation and territorial development at the heart of sustainable development. SDG11 and its 10 targets require action from sub-national urban governments. SDG11 targets address a wide range of unique urban challenges, such as the upgrading of slums and the provision of affordable housing, public transportation systems, planning and governance, cultural heritage, disaster management, air quality, waste management and public and green spaces.

In 2018, The Government of India, AFD and the European Union launched the City Investments To Innovate, Integrate and Sustain (CITIIS) program, a challenge process that called on cities around India to submit their proposals of how they would

become the country's next smart cities. As current projections indicate that the majority of the world's future population will live in urban areas, cities play a central role in the pursuit of sustainable development. This recognition materialised through the inclusion of Sustainable Development Goal 11 (SDG11): 'Make cities and human settlements inclusive, safe, resilient and sustainable' in the post-2015 goals. Hence, **the term "sustainable living" has gone through a variety of definitions and concepts and currently can be assigned as the common area to flourishing environment, equitable economy and vibrant community.**

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