

The Value of Ecosystem Services by the Trees in the Cities of India: A Synthesis

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ABSTRACT

Indian cities are currently facing several challenges due to the abrupt increase in urbanization and global climate changes. Since human development is an inevitable part of civilization that is rapidly increasing at unprecedented rates; therefore, demands for natural resources have gone up many folds to ensure the survival of human beings. Among urban ecosystems, trees play a vital role in stabilizing nature and provide several essential ecosystem services such as water and air purification, noise reduction, carbon sequestration, climate regulation, food supply, wildlife habitat. At this time, we are moving toward a new urban period in which the ecology of our world as a whole is mainly influenced by both natural and anthropogenic activities with more outstanding contributions from the latter side. Therefore, urbanization presents fundamental challenges and provides new opportunities to boost the resilience and functioning of ecosystem. Through a review of several global works of literature concerning ecosystem services, this article highlights the ecosystem services values provided by the trees in some prominent cities of India. Various ecosystem services have been examined like air filtration, carbon sequestration, surface runoff mitigation, noise reduction, temperature regulation, climate regulation etc. We concluded that ecosystem services have a substantial impact on the quality of life in urban areas. The ecosystem services concept can play a crucial role in interconnecting cities globally.

Keywords: Urban ecosystem, ecosystem services, cities, trees, air filtration, carbon sequestration, climate regulation.

Mathematics Subject Classification: 62J12, 62G99

Journal of Economic Literature (JEL) Classification: Q12, D24

1. INTRODUCTION

According to the World Urbanization Prospects Report (WUPR), about 53.40 percent of the world's population lives in cities. The urban population is growing at a rate of 0.5 percent per year (K'Akumand & Olima, 2007). Urban areas constitute just 4% of the world's land area, but they would hold 121 billion trees if planted at the global average tree density (Endreny, 2018). A healthy ecosystem and biological diversity are essential for cities to work appropriately and deliver a varied range of ecosystem services. Ecosystem services are the benefits that humans obtained directly and indirectly from ecosystems for human well-being, such as provisioning, regulating, supporting, and cultural services (Millenium Ecosystem Assessment, 2005; The Economics of Ecosystem and Biodiversity, 2010). The provision of

ecosystem services in cities depends upon the quality and quantity of urban green structure. Green infrastructure includes parks, urban forests, gardens, wetlands, lakes and ponds, and natural areas such as forests, mountains, and wetlands close to urban areas. Ecosystem services are considered to value for the function they deliver to the people. These values can be different and can be categorized into monetary and non-monetary terms. Urbanization can have substantial impacts on biodiversity and ecosystem services. Table 1 shows multiple values that can be attributed to an urban ecosystem.

Table 1. Values and types of goods and services of an urban ecosystem.

Economic values	Direct or indirect monetary values provided by urban ecosystems, e.g., avoided costs for air pollution reduction or property damaged by natural activities.
Ecological values	Environmental outputs have good value for humans. For example: air purification, carbon sequestration, water filtration, genetic diversity, climate regulation.
Socio-cultural values	Different kinds of ecosystem services such as moral, spiritual, aesthetic, ethnic, and values are associated with urban biodiversity. In addition, emotional, sentimental and symbolic views are also attached to urban nature and local ecological knowledge promote more socio-ecological values.
Health values	Reduced air pollution, increased water quality, and enhanced mental health are some of the health benefits gained from urban green areas.

Furthermore, studies show that green spaces can improve city residents' physical and psychological well-being (Kuo, 2003). On the other hand, meeting the ecosystem services demand while also protecting human health and preserving natural resources in urban settings appears to be exceedingly challenging. Because Indian cities have significant levels of pollution, trees not only act as carbon sinks but also aid to improve the quality of urban life; as a result, urban trees are also recognized as the protectors of the urban environment.

Increased flooding is predicted to be one of India's most severe climate change consequences in the future decades. In 2019, India has faced extreme flood that occurred in nine states in the month of July and early August as a result of severe rains. At least 50 individuals died, and a million more were displaced. Kerala, Madhya Pradesh, Karnataka, Maharashtra, and Gujarat were among the states that were adversely impacted. Cities may be flooded after heavy rains if the water does not drain fast into the ground and the city's sewage infrastructure cannot handle the amount of water. Cities with more impermeable surfaces have more surface water runoff, which makes them more vulnerable to floods. Surface runoff is enhanced by utilizing urban green areas. Infiltration rates are further reduced by the underlying soil, which acts as a sponge by holding water in the pore spaces. Surface runoff can lose 40-83 percent of rainfall in urban environments with 50-90 percent impermeable cover, related to 13 percent in forest areas. Green roofs, for example, may retain 25-100 percent of rainwater, depending on rooting depth and rainfall intensity. (www.urbesproject.org).

The most difficult task for urban landscape management is to maintain urban green spaces as an effective and safe ecosystem service provider while following conservation policies to fulfill

sustainable millennium objectives. It is necessary to enhance our understanding of the multiple benefits ecosystem services in urban areas to integrate them into urban planning and move toward more sustainable and resilient cities. The present review provides a critical understanding of the potential of trees as an urban planning solution to improve human health and well-being through ecosystem services which are organized in four main sections: - 1) Classifying urban ecosystem services and benefits provided by urban vegetation. 2) Urbanization and green spaces in India. 3) Ecosystem services delivered by trees in major cities of India. 4) Key challenges and recommendations for future urban ecosystem service research.

2. CLASSIFYING URBAN ECOSYSTEM SERVICES AND PROVIDED BENEFITS BY URBAN VEGETATION

Based on previous categorizations of ecosystem services (Daily, 1997; de Groot et al., 2002; MEA, 2003), the TEEB report classifies 22 types of ecosystem services grouped in four main categories: Provisioning, Regulating, Supporting and Cultural Services (TEEB, 2011). Provisioning services include material or direct benefits from ecosystems, including food, water, medicinal plants, and other kind of resources. Regulating services maintain functions of an ecosystem, such as air filtration, soil erosion control, flood, stormwater and disease control. Habitat and supporting services support all other services. Finally, cultural services include the non-material and socio-ecological benefits, such as recreation and ecotourism, aesthetic, spiritual and psychological benefits. Because different habitats deliver different types of ecosystem services, so, general classification needs to be adapted to specific types of ecosystems (MEA, 2003). For example, if agroecosystems are critical for food production, wetlands for nutrient cycling and forest ecosystems for carbon sequestration. Nevertheless, the urban ecosystem can be significant in providing services directly impacting health and security, such as noise reduction, air purification, urban cooling and runoff mitigation to the human (Bolund & Hunhammar, 1999). In their 2011 'Manual for Cities', the TEEB report made one of the first successful efforts to directly reflect urban environments (Fig 1).

Changing climate, population aging, and natural resource loss are all significant issues challenging cities today. Ecosystems play a crucial role in promoting the transformations that are needed to solve these issues. So, in this section, we describe numerous benefits of urban trees that have been reported in the literature (Fig 2). The color of the vegetation, species and other qualitative factors contributes to the aesthetic, scenic, or cultural benefits of urban trees; however, most of the benefits are attributed to tree height. More giant trees can absorb and accumulate more carbon dioxide from the atmosphere, trap more contaminants in the air due to their larger leaf area, and intercept or slow down rainfall-runoff (Brack, 2002). Indirectly, trees can lower air temperatures in the summer by providing natural shade and evapotranspiration, eliminating air pollution from the process of producing energy for cooling. Reduced air temperature will also reduce chemical reactions in the urban atmosphere that emit secondary air pollutants (Nowak et al., 2000; Yang et al., 2005). Furthermore, before stormwater reaches water tables or river systems, tree root systems can serve as effective biofilters (Denman, 2006). Mature trees will continue to play an essential role in urban environments, and they must be cared for to ensure that they remain healthy and reach their maximum potential.

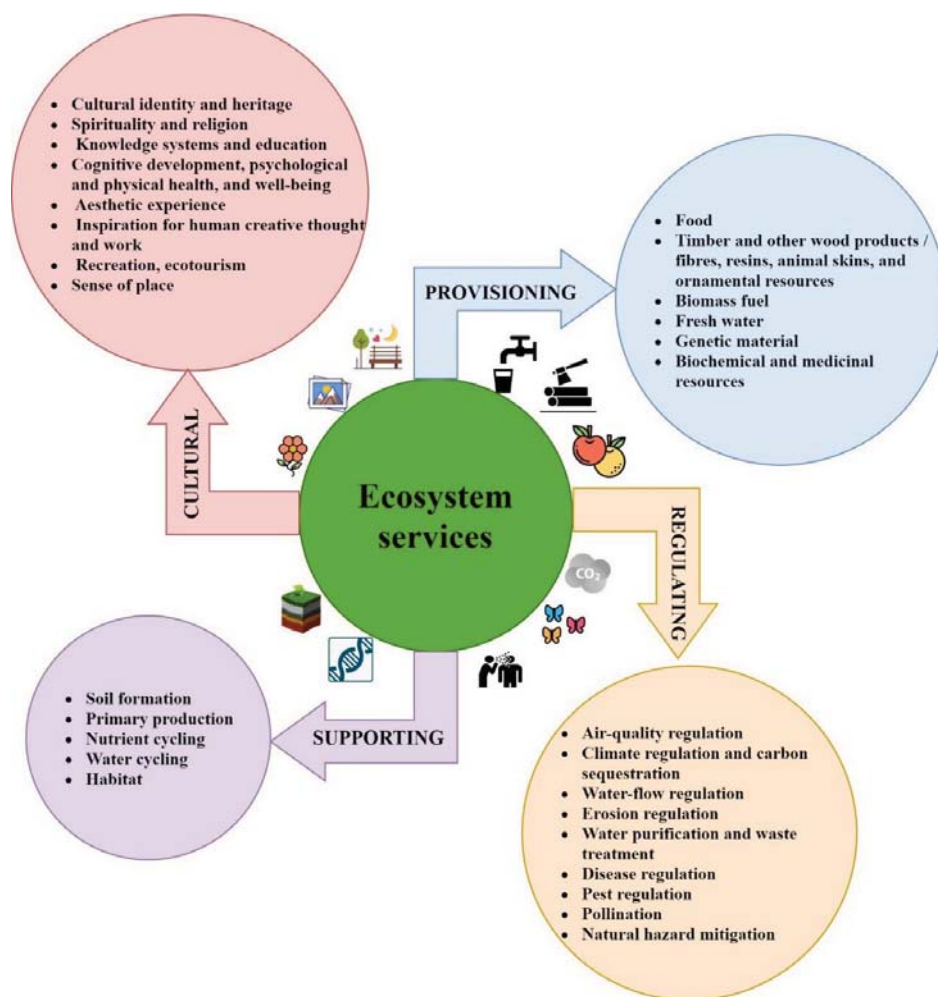


Figure 1. The topology of ecosystem services (topology used here is the combination of MEA (2005) and TEEB (2011)).

3. URBANIZATION AND GREEN SPACES IN INDIA

Since 1970, India has been rapidly urbanising, with the urban population rising from 109 million in 1971 to 377 million in 2011. Meanwhile, the number of cities with populations of one million or more has gradually grown across the country, from 23 in 1991 to 35 in 2001 to 53 in 2011 (<http://www.censusindia.gov.in>). The transportation sector of Indian cities contributes to over 7% of total GHG productions in India. In many cities, high automobile emissions have pushed air pollution to dangerously high levels (Ghose et al., 2004).

Green spaces across many cities in India have significantly decreased and are further decrease with growing urbanization and population growth. Table 2 shows that many Indian cities have insufficient green space per capita, which is much below the WHO suggested criteria of 9sq.m/capita. Bangalore is among one of India's fastest-growing cities, with rising levels of air pollution. Once regarded as India's "Garden City", Bangalore is increasingly losing tree cover in community areas, including parks

(Nagendra & Gopal, 2010). Gandhinagar and Chandigarh, both planned cities in India after independence, provide greater incorporation of urban greenery in their city master plans. Gandhinagar, Gujarat's capital, has the highest tree density (152/ha) and tree cover (53.9 % of city area) of any major Indian city (Singh, 2013; Chaudhry et al., 2011). *Peltroforum ferruginieum*, *Azadirachta indica*, *Cassia fistula*, *Polyalthia longifolia*, *Cassia siamea*, *Delonix regia*, *Acacia nilotica*, *Albizia lebbeck*, *Alastonia scholaris*, *Ailanthus excelsa* and *Mangifera indica* are some of the city's major tree species. Chandigarh is one of the top Indian cities, with forest and tree cover covering more than 35% of its land area and per capita green space available of about 55 m² (Chaturvedi et al., 2013) provided one of the greenest cities in India.

Table 2. Major Indian cities with per capita green space.

City	Geographical area(km ²)	Population in millions (census, 2011)	Forest and tree cover (km ²)	Per capita green space (m ² /inhabitant)
Delhi	435	16.31	90.74	5.5
Bangalore	226	8.43	150	17.79
Mumbai	735	18.48	122	2.01
Hyderabad	172	7.74	3.87	0.5
Ahmedabad	469	6.35	21.8	3.9
Chennai	174	8.69	9	1.03
Kolkata	186.23	14.11	0	0
Jaipur	484.64	3.07	61.4	20
Gandhinagar	75	0.20	30.75	147.6
Chandigarh	114	1.05	16.78	54.45

Source: Population of cities from the census of India (2011), the geographical area is taken from urban India.nic.in, and green cover of cities taken from Forest Survey of India Report (2011). The per capita green space for Jaipur is taken from Singh et al., (2010).

4. ECOSYSTEM SERVICES PROVIDED BY TREES IN MAJOR CITIES OF INDIA

Urban trees generally offer multiple services and environmental benefits to society. These trees are distributed into different land uses, ranging from forest environments and gardens to densely built areas or polluted urban environments. Urbanization, on the other hand, has negative environmental effects such as increased temperatures, increased air pollution, increased stormwater quantity, and decreased stormwater quality, all of which pose serious environmental and public health issues in cities (Seto & Shephard, 2009). Increased tree cover has been shown to offer numerous ecosystem services and benefits, including a decrease in temperature (Salmond et al., 2016), air pollution removal (Nowak et al., 2014), carbon sequestration (Nowak et al., 2013), and climate control (Salmond et al., 2016). Ecosystem services are the factors and processes that allow natural ecosystems to preserve and accomplish human existence (Daily, 1997), whereas benefits are the ecosystem's outputs that directly influence human well-being (Haines-Young & Potschin, 2012).

Ecosystem services are vital to sustainable development because they underlie the capacity for well-being and must be maintained in terms of both quality and quantity for future generations to satisfy their requirements.

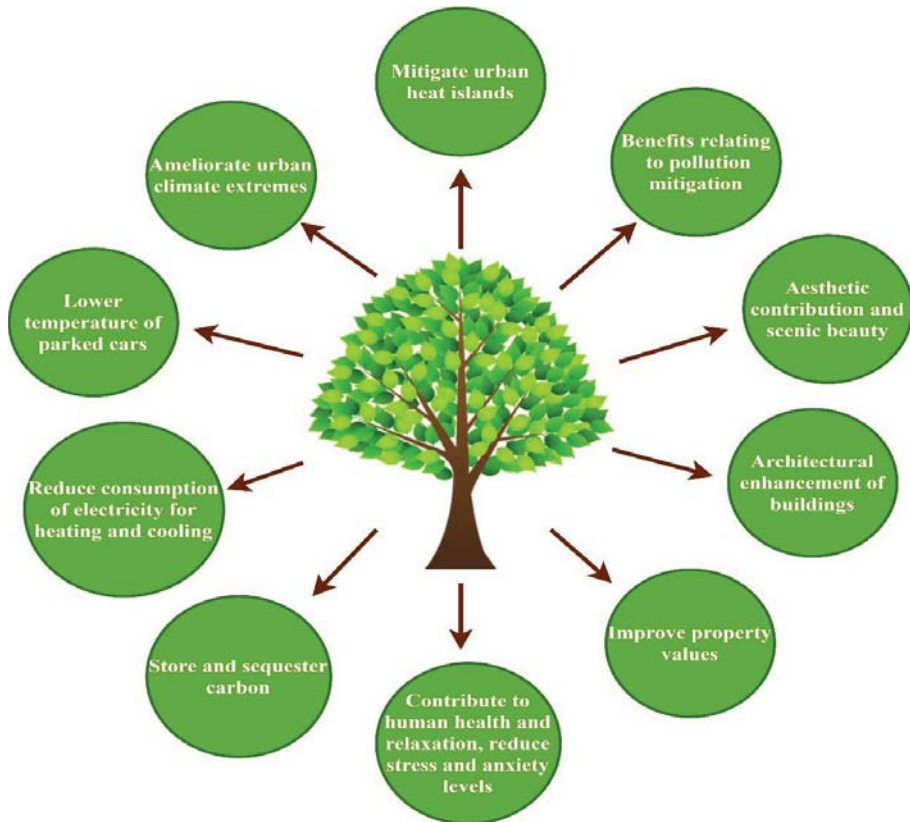


Figure 2. Benefits provided by urban trees.

Some essential services in an urban ecosystem:

a) Air filtration: Air quality in the urban environment continues to be a primary health concern (54% in 2014), and this is expected to increase to 66% by 2050 (UN, 2014). Traffic emissions are the primary source of air pollution in cities (Kumar et al., 2015). Green infrastructure in the urban environment has been considered one potential of urban planning solutions for improving air quality in the growing urban population. Urban trees may improve air quality by gaseous deposition, dispersion, particulate matter deposition, and the risks of many diseases (Fig 3).

The top-rated tree species for improving air quality in India are: *Grevillea robusta*, *Juglans regia*, *Ficus carica*, *Toona ciliata*, *Caesalpinia sappan*, *Dalbergia sissoo*, *Delonix regia*, *Albizia lebbeck*, *Azadirachta indica*, *Polyalthia longifolia*, *Mangifera indica*.

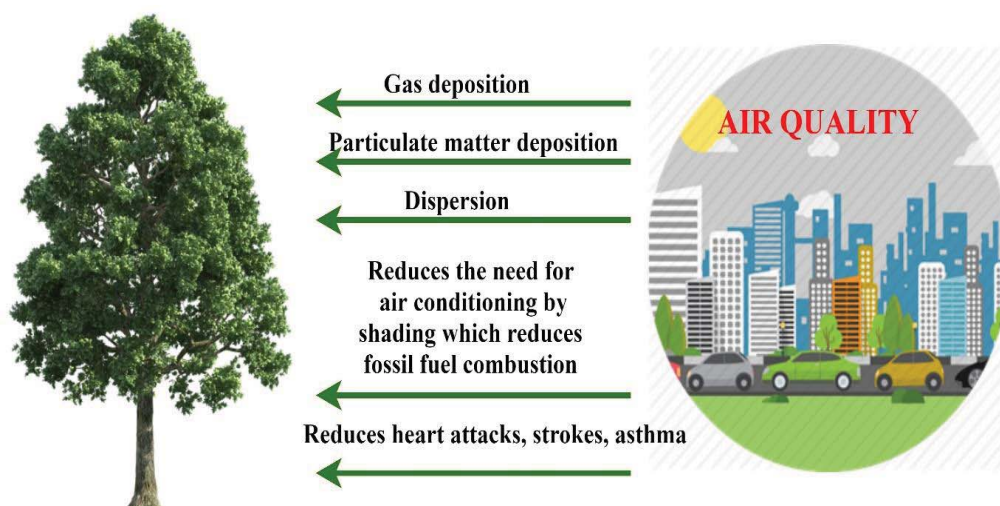


Figure 3. The link between urban trees and air quality.

b) Carbon sequestration: Carbon sequestration is a natural method for removing carbon from the atmosphere by storing it in the environment (Chavan & Rasal, 2010). A carbon sink absorbs CO₂ from the atmosphere and stores it as carbon. By fixing carbon during photosynthesis and storing excess carbon as biomass, trees act as a CO₂ sink. More CO₂ is transformed into biomass as photosynthesis increases, lowering carbon in the atmosphere and sequestering it in plant tissues above and below ground (Gorte, 2009). Trees with higher biomass have more carbon sequestration potential, and teak has the highest carbon sequestration potential in India.

List of top-rated tree species for carbon sequestration in India:

Tectona grandis, *Terminalia chebula*, *Ficus bengalensis*, *Morus alba*, *Moringa olifera*, *Delonix regia*, *Azadirachta indica*, *Bombax ceiba*, *Terminalia bellerica*, *Neolamarckia cadamba*, *Mangifera indica*, *Ficus religiosa*.

c) Climate regulation and Indian cities: As a tropical country, India is particularly vulnerable to catastrophic phenomena like cyclones and floods. According to the IPCC's fifth assessment report, such risks are expected to rise in the future (IPCC, 2013). In many Indian cities, temperatures have risen over the years. Kumar & Hingane (1988) have noted a marked rise in temperatures in three cities, Kolkata, Mumbai, Bangalore, while Ramachandra & Kumar (2010) observed a temperature rise of 2°C in Bangalore city due to an urban heat island effect. Due to severe rains and flooding in 2005, Mumbai, one of India's most populous cities, was totally shut down. Though the city is susceptible to frequent floods as a result of its position in a tropical region with extensive monsoon rains. Ranger et al., (2010) stated that the city's flooding risks are exacerbated by human-made interventions in its topography, primarily owing to the suppression of natural runoff surface water and the loss of a network of rivers, creeks, and ponds that flow directly into the city. That's why, there is a clear need for adaptation to future climate changes in Indian cities (Revi, 2008). Urbanization is dynamic for India's economic growth

and the Indian government has recently highlighted the need for producing innovative and sustainable cities. Climate resilience should be an essential component for future and existing cities in the country. Therefore, increased vegetation density is considered an effective option for climate change (Fig 4).

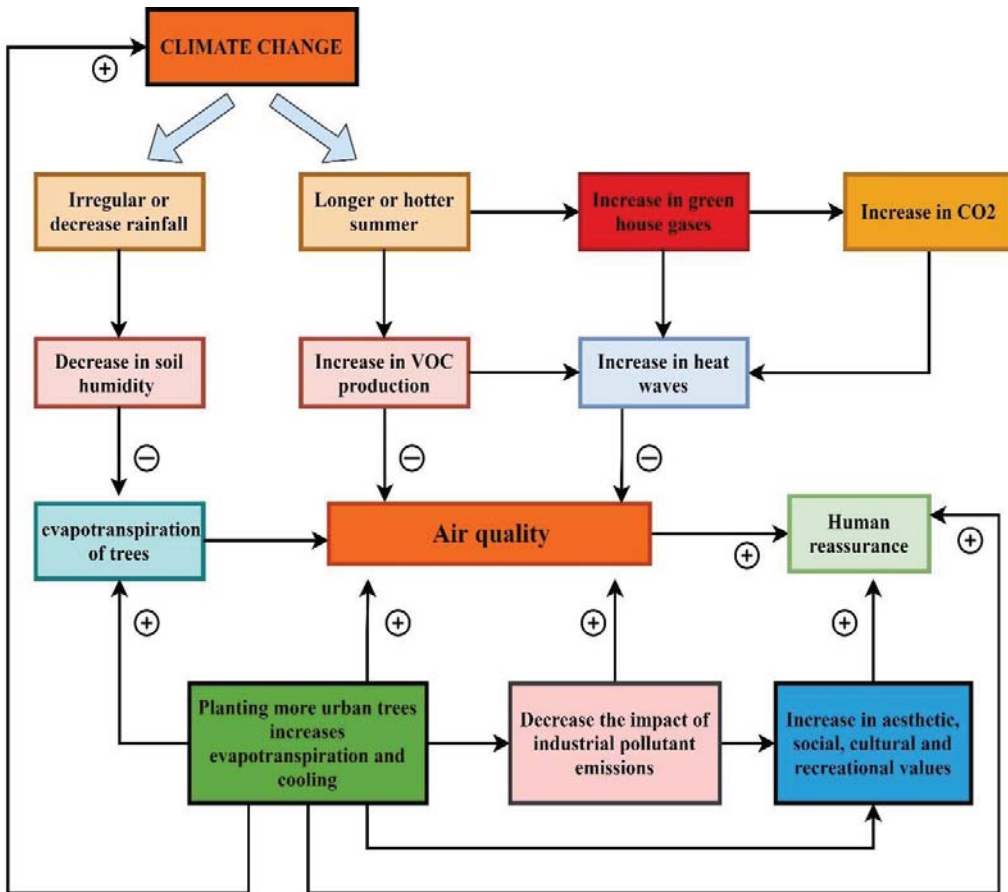


Figure 4. Possible outcomes of climate change on the urban ecosystem.

d) Noise reduction: In most towns and cities, noise pollution is considered a critical environmental factor was directly affecting the quality of life of their inhabitants. This pollution derives directly from the activities carried out by humans in the city, such as transport, the construction of buildings, industry or certain leisure activities, which can cause an irritating noise capable of having harmful physiological and psychological effects on people. These harmful effects include sleep disorders, tiredness, hearing loss, stress, anxiety and other disorders that disturb people's health.

According to World Health Organization (WHO), the desirable noise limit, measured in decibels (dB), outside the house should be 55 dB in the daytime and 45 dB at night. However, this value is exceeded in many areas and at numerous points in the cities of India, as shown below (Table 3).

Table 3. Noise limit in certain major cities of India (Recommended by WHO) (Source: Central pollution control board report).

City	Day time (dB)	Night time (dB)
Bangalore	70	66
Chennai	77	74
Delhi	72	70
Hyderabad	72	74
Kolkata	75	76
Lucknow	73	72
Mumbai	75	76

Trees in general affect noise attenuation in different ways: through absorption (eliminating the noise), deviation (altering the direction of the noise), reflection (returning the noise to its origin), refraction (when the sound waves circulate the vegetation) and occultation (when an irritating noise is changed into a pleasant sound) (CONAMA 2002). According to Aylor (1972), with an increase in leaf density and the breadth and thickness of leaves, the effect of foliage is increased. According to Mailliet & Bourgerly (1993), broad-leaved trees are better at reducing noise than conifers. The most effective trees are those with large, leathery leaves, even more so when they are orientated perpendicularly to the noise source. In addition to this, Aylor (1972) agrees that plants absorb high frequencies more than low ones. This fact is an advantage for human beings, as the highest frequencies are the ones that affect people and cause the most stress.

For optimum noise reduction, the trees and shrubs would have to be planted near the origin of the noise and not near the receiving area, which is almost the same in the case of street trees. In addition, it would be desirable diversity of high-density evergreen trees and shrubs species with dense foliage (Chaparro & Terradas, 2009). Table 4 describes ecosystem services provided by dominant woody species in major cities of India.

Table 4. Dominant woody species in major cities of India with their ecosystem services.

City	Dominant woody species	Major ecosystem services
Delhi	<i>Tabernaemontana divaricata</i>	Air filtration, medicinal value
	<i>Plumeria rubra</i>	Forage and fodder, medicinal value
	<i>Streblus asper</i>	Forage and fodder, high medicinal value
	<i>Manilkara hexandra</i>	Forage and fodder, high medicinal value
	<i>Madhuca longifolia</i>	Forage and fodder, shelter for birds, climate regulation, medicinal value
	<i>Alstonia scholaris</i>	Forage and fodder, air filtration, carbon sequestration, medicinal value

	<i>Artocarpus heterophyllus</i>	Air filtration, medicinal value
	<i>Barringtonia acutangula</i>	high medicinal value
	<i>Dillenia indica</i>	medicinal value
	<i>Ixora pavetta</i>	medicinal value
	<i>Mitragyna parvifolia</i>	medicinal value
	<i>Terminalia bellirica</i>	Forage and fodder, air filtration, carbon sequestration, medicinal value
	<i>Tectona grandis</i>	Timber, carbon sequestration, medicinal value, cultural value
	<i>Casuarina equisetifolia</i>	Shade, Fix atmospheric nitrogen
	<i>Dalbergia sissoo</i>	Timber, fodder, shading, fuelwood, medicinal value, controls soil erosion, improves soil fertility
	<i>Syzygium cumini</i>	Food, timber, ornamental value, fruit source of tannin, medicinal value, cultural value
	<i>Azadirachta indica</i>	Air filtration, carbon sequestration, medicinal value
	<i>Tamarindus indica</i>	Food, fodder, shade, carbon sequestration, medicinal value, cultural value,
Bengaluru	<i>Albizia saman</i>	Shading, medicinal value, carbon sequestration
	<i>Peltophorum pterocarpum</i>	Wood for furniture, Shading, medicinal value, ornamental, fix atmospheric nitrogen
	<i>Spathodea campanulata</i>	Ornamental, medicinal value
	<i>Pongamia pinnata</i>	Forage and fodder, wood as fuel, medicinal value, controls soil erosion, soil reclamation
	<i>Bauhinia variegata</i>	Food, medicinal value
	<i>Polyalthia longifolia</i>	Ornamental, medicinal value
	<i>Swietenia macrophylla</i>	Medicinal value
	<i>Delonix regia</i>	Wood as fuel, shade, ornamental value
	<i>Markhamia lutea</i>	Shading, controls soil erosion, soil conservation, medicinal value
	<i>Millingtonia hortensis</i>	Medicinal value, phytochemical properties
Mumbai	<i>Peltophorum pterocarpum</i>	Shading, Wood for furniture, ornamental value, medicinal value, fix atmospheric nitrogen
	<i>Samanea saman</i>	Fruit, shading, medicinal value, ornamental, fix atmospheric nitrogen
	<i>Delonix regia</i>	Wood as fuel, shading, ornamental, medicinal use, controls soil erosion,
	<i>Thespesia populnea</i>	Food, medicinal value, Ornamental, produce secondary metabolite, Cultural value
	<i>Erythrina indica</i>	Food, medicinal value, ornamental, fix atmospheric nitrogen
	<i>Casuarina equisetifolia</i>	Medicinal value, controls soil erosion
	<i>Cassia siamea</i>	Fodder, shelter for birds, ornamental, Medicinal and phytochemical properties,

	<i>Ficus religiosa</i>	Best for high oxygen production, controls soil erosion, improve soil structure and fertility, sound absorbent, climate regulation, cultural value
Hyderabad	<i>Careya arborea</i>	Food, medicinal value, secondary metabolite production
	<i>Chloroxylon swietenia</i>	Food as fuel, medicinal value, cultural value
	<i>Dalbergia paniculata</i>	Wood as fuel, timber, fodder, controls soil erosion, improves soil fertility
	<i>Diospyros melanoxylon</i>	Food, wood as fuel, medicinal value
	<i>Garuga pinnata</i>	Food, medicinal value
	<i>Gmelina arborea</i>	Food, medicinal value, ornamental, drought tolerant
	<i>Haldina cordifolia</i>	Wood for furniture, medicinal value, secondary metabolite production, drought tolerant
	<i>Lannea coromandelica</i>	Food, medicinal value, ornamental
	<i>Pterocarpus marsupium</i>	Food, medicinal value, secondary metabolite production, ornamental, improves soil fertility, fixes atmospheric nitrogen
	<i>Semecarpus anacardium</i>	Food, ornamental, medicinal value, phytochemical properties, secondary metabolite production
	<i>Strychnos potatorum</i>	Food, medicinal value, drought tolerant
	<i>Tectona grandis</i>	Timber, carbon sequestration, medicinal value, cultural value
	<i>Terminalia arjuna</i>	Bark used in dyeing and tannin, medicinal value, controls soil erosion
	<i>Terminalia elliptica</i>	Food, timber, wood as fuel, medicinal value, secondary metabolite production
Kolkata	<i>Ficus religiosa</i>	Best for high oxygen production, controls soil erosion, improve soil structure and fertility, sound absorbent, climate regulation, cultural value
	<i>Ficus benghalensis</i>	Food, wood for furniture, shade, shelter for birds, medicinal value, controls soil erosion, carbon sequestration, air filtration
	<i>Cocos nucifera</i>	Food, fiber, wood for furniture, medicinal value, ornamental, control soil erosion
	<i>Delonix regia</i>	Food, ornamental, medicinal value, secondary metabolite production, controls soil erosion, soil rehabilitation, fixes atmospheric nitrogen
	<i>Eucalyptus globulus</i>	Food, wood as timber, firewood, medicinal value, ornamental, phytochemical production, soil reclamation
	<i>Acacia auriculiformis</i>	Shade, wood as firewood, medicinal value, secondary metabolite production, fixes atmospheric nitrogen, improve soil physio-

		chemical properties such as water-holding capacity, organic carbon, nitrogen and potassium through litterfall
	<i>Bombax ceiba</i>	Medicinal value, umbrella tree for animals
	<i>Psidium guajava</i>	Food, wood as firewood, medicinal value, ornamental, act as bio-indication and bio-accumulator
	<i>Peltophorum pterocarpum</i>	Shading, Wood for furniture, ornamental value, medicinal value, fix atmospheric nitrogen
	<i>Mangifera indica</i>	Food, medicinal value, air filtration, noise reduction
	<i>Polyalthia longifolia</i>	Shading, ornamental value, air filtration
	<i>Azadirachta indica</i>	medicinal value, air filtration, noise reduction, carbon sequestration
	<i>Terminalia arjuna</i>	Bark used in dyeing and tannin, medicinal value, controls soil erosion
	<i>Artocarpus heterophyllus</i>	medicinal value, air filtration
	<i>Aegle marmelos</i>	Food, medicinal value, air filtration, noise reduction
Jaipur	<i>Azadirachta indica</i>	Air filtration, noise reduction, carbon sequestration, medicinal value
	<i>Bauhinia variegata</i>	Wood as fuel, medicinal value, secondary metabolites production, air filtration
	<i>Tamarindus indica</i>	Food, shading, medicinal value, ornamental, fix atmospheric nitrogen, Air filtration, aesthetic value
	<i>Ziziphus mauritiana</i>	Food, medicinal value, air filtration
	<i>Aegle marmelos</i>	Food, medicinal value, air filtration, noise reduction
	<i>Polyalthia longifolia</i>	Shading, ornamental value, air filtration
	<i>Ficus glomerata</i>	Wood as fuel, food, medicinal value, ornamental, secondary metabolite production, air filtration, noise reduction
	<i>Acacia nilotica</i>	Timber, fuel and fodder, medicinal value, Air filtration
	<i>Mangifera indica</i>	Food, medicinal value, air filtration, noise reduction
Gandhinagar	<i>Peltophorum ferrugineum</i>	Medicinal value, ornamental, phytochemical production
	<i>Azadirachta indica</i>	Air filtration, carbon sequestration, medicinal value
	<i>Cassia fistula</i>	Food, ornamental, Wood as fuel, timber for furniture, secondary metabolite production, medicinal value
	<i>Polyalthia longifolia</i>	ornamental, medicinal value

	<i>Cassia siamea</i>	Food, medicinal value, secondary metabolite production, wood as fuel, ornamental, shading
	<i>Delonix regia</i>	Food, ornamental, medicinal value, secondary metabolite production, controls soil erosion, soil rehabilitation, fixes atmospheric nitrogen
	<i>Acacia nilotica</i>	Food, shade, Wood as fuel, timber, fodder, ornamental, secondary metabolite production, medicinal use, fixes atmospheric nitrogen
	<i>Albizia lebbeck</i>	Wood as fuel, medicinal value, secondary metabolite production, fixes atmospheric nitrogen, improves soil fertility
	<i>Alstonia scholaris</i>	Food, timber, medicinal value, ornamental, secondary metabolite production
	<i>Ailanthus excelsa</i>	Wood as fuel, medicinal value, controls soil erosion
	<i>Mangifera indica</i>	Food, medicinal value, air filtration, noise reduction
Chandigarh	<i>Ficus infectoria</i>	Ornamental, shade, cultural value, control soil erosion, climate regulation, sound absorbent
	<i>Alstonia scholaris</i>	Medicinal value, timber
	<i>Schleichera trijuga</i>	Seeds are source of Macassar oil, food
	<i>Terminalia arjuna</i>	Bark used in dyeing and tannin, medicinal value, controls soil erosion
	<i>Terminalia bellirica</i>	Timber, fruit source of tannin, medicinal value
	<i>Swietenia mahagoni</i>	Timber, controls soil erosion
	<i>Cassia fistula</i>	Ornamental, bark used for dye
	<i>Chukrasia tabularis</i>	Wood for furniture, flowers yield dye
	<i>Delonix regia</i>	Ornamental, controls soil erosion, host for lac-insect
	<i>Bauhinia purpurea</i>	Forage and fodder
	<i>Bombax ceiba</i>	Medicinal value, umbrella tree for animals
	<i>Tecoma argentea</i>	Ornamental, medicinal value

4.1 ECOSYSTEM SERVICES AS A PART OF GREEN ECONOMY

"By 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people."

– Vision of the Strategic Plan for Biodiversity 2011- 2020
and the Aichi Biodiversity Targets 2010.

The link between ecosystem goods and services and the green economy is evident. A green economy or sustainable green growth is a part of sustainable development. Ecosystem services also stated to as "GDP of poor people", are the free services provided by the environment to the human race. These services are absent in the traditional System of National Accounts (SNA) of India. Chopra & Adhikari

(2004) claimed that ecosystem services should be valued to improve human health regardless of their marketability. This could only be possible by identifying physical and environmental linkages followed by economic linkages to assign a value. India had failed to meet the green GDP goals which were set by 2015. After that, the central government launched a five-year project to develop a metric that will measure the 'green GDP' of Indian states. In this direction, The Green Skill Development Programme (GSDP), under the Environmental Information System (ENVIS) Scheme of the MoEF&CC, Government of India, has started some training courses in the country. One of the courses, titled 'valuation of ecosystem goods and services includes valuation of ecosystem services, carbon stock and green GDP. ENVIS hubs facilitate this course and resource centers at the Indian Institute of Science (IISc) Bengaluru, Environment Protection Training and Research Institute (EPTRI) in Hyderabad, and Environmental Management & Policy Research Institute (EMPRI), Bengaluru.

5. KEY CHALLENGES AND RECOMMENDATIONS FOR FUTURE URBAN ECOSYSTEM SERVICE RESEARCH

The concept of ecosystem service is a transition between human-environment interaction and management practice (Bateman et al., 2013). It emphasizes how urban ecosystem service research is undertaken and linked to practice. In this context, here are some key challenges and recommendations for future urban ecosystem service research:

- Environmental and socio-economic factors are varying with urban areas. It makes it very difficult to understand for policymakers and stakeholders the extent to which the range of cities' climate conditions over which ecosystem service needs to be managed. So, research that considers a clear description of urban context should be conducted, including population sizes and densities, economic and political conditions, socio-cultural environments, and critical environmental variables that effect the ecological structures and functions providing urban ecosystem services.
- Sometimes the stakeholders are not enthusiastically involved in urban ecosystem services research. This creates mismanagement in the whole process. If the concept of urban ecosystem service is a beneficial tool for sustainable urban planning, stakeholder's perceptions should be considered more carefully in research. By doing so, the research process will enhance the identification, valuation and management of ecosystem services.
- Urban ecosystem services research aims to holistically cover all the stages of ecosystem services, like how to identify different ecosystem services and what methods should be employed for the valuation process.

In addition to this, the options mentioned below could help to improve some essential ecosystem services of urban ecosystems (air quality, carbon sequestration, noise pollution, etc.).

1. Maintain tree plant cover to maintain the carbon currently stored by the urban vegetation and the levels of pollutants absorbed.

2. Water trees and shrubs appropriately, which would increase the pollution extracted by vegetation and tree growth, and therefore carbon storage even further.
3. Minimize the use of fossil fuels in the city and maintain urban vegetation to reduce pollution emissions.
4. Plant pollution-resistant trees in the areas with the worst air quality to maximize air purification and the health of the people who live in those areas.
5. Plant evergreen species to reduce levels of particulate material throughout the year.
6. Plant new deciduous trees, correctly oriented, around buildings to promote energy conservation in homes and reduce the carbon emissions associated with the production of the electricity consumed.
7. Plant trees with broad leathery leaves and dense foliage, with a high density of shrubs and conifers, absorb noise pollution.
8. Increase the permeable area immediately under the tree to increase rainwater soak away and reduce runoff.

6. CONCLUSION

Ecosystem services delivered by trees include pollution removal, carbon sequestration, urban heat island reduction, stormwater runoff reduction, and other socioeconomic advantages. In many cities, large-scale tree plantings are taking place to improve tree canopy coverage and the health, economic, and environmental advantages that trees provide. The values of sustainable development endorse that a balance should be maintained between environment and development to ensure a sustainable future. Sustainable development cannot be attained without a proper knowledge of ecosystem services by trees in cities. The central insight that can be extracted from our review is that there is a piece of growing indication on the positive impacts of urban ecosystem services by the trees on the quality of life in cities. The present study emphasizes the importance of ecosystem services provided by trees in urban environment. Provisioning and regulating services, including medicinal property, air filtration, climate regulation, and noise reduction, have been of particular importance in urban contexts. Interestingly, suppose the urban ecosystem provides only a part of the total ecosystem services used in cities, in that case, the high density of benefits related to current green infrastructure indicates that the social and economic value of urban ecosystem services can be surprisingly high. However, to obtain other information such as which species best filter polluted air or which species is best for climate regulation, it would have to be completed with eco-physiological studies, at least of the most abundant plant varieties in the city. So, the choice of species through research and genetic selection could improve the state of the city's tree and ensure more extraordinary biodiversity, which might increase the Green GDP of the nation. So, the ecosystem services concept will also help the stakeholders and policy-makers in making urban areas ecologically sustainable. The idea of sustainable urban planning can only be achieved with the help of the ecosystem services concept, which will ultimately help in interconnecting cities globally.

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