URBAN ECOSYSTEM SERVICES

Abstract

Urban ecosystem services refer to the benefits that people obtain from natural ecosystems within urban areas. These services are essential for the well-being and quality of life of urban residents and can encompass a wide range of functions provided by natural or semi-natural systems in cities. Urbanization can significantly alter natural climate patterns, leading to phenomena such as the urban heat island effect, increased air pollution, and changes in precipitation patterns. Urban ecosystem services aim to mitigate these impacts and create more comfortable, healthier, and sustainable urban environments. This chapter discussed importance of urban ecosystem services and strategies to enhance various ecosystem services through regulation of microclimate, creation of multifunctional green spaces, uplifting cultural ecosystem services and afforestation of Urban cities. Efforts to protect and enhance urban ecosystem services are essential for creating sustainable, resilient cities. Urban planning and design strategies that prioritize green infrastructure, such as green roofs, rain gardens, multifunctional green spaces and urban forests, can help maximize the benefits provided by urban ecosystems while mitigating environmental impacts such as air and water pollution, urban heat island effects, and habitat loss. By prioritizing strategies that enhance environmental sustainability, resilience, and human well-being, cities can create more livable and climate-resilient urban environments for current and sustainable future.

Key Words: Urban cities, Ecosystem Services, Microclimate and Sustainability

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I. INTRODUCTION

Urban gardens are regarded as interconnected ecological and socioeconomic structures in which individuals play a fundamental and interactive role (e.g., Buchmann 2009; Barthel *et al*. 2010). They are predicted to house 68% of the human race by 2050 (United Nations 2014). Individual trees and shrubs, parks, and forests, as well as urban forests, are critical for improving the ecological state of societies and the quality of life for city dwellers (Roy *et al*. 2012; Shwartz *et al*. 2014). Ecosystem services are viewed as the result of a collaboration between biological mechanisms and human initiatives such as gardening. Urban allotments and community gardens provide numerous significant and diverse benefits to humans, involving agriculture (e.g., Buchmann *et al*. 2009; Barthel &Isendahl 2013), the pollination process (Andersson *et al*. 2007), climate oversight (Gómez-Baggethun and Barton 2013), recreation (e.g., Kaplan 1973), and social integration (e.g., Armstrong 2000). The ecosystem service concept is increasingly being applied in urban environments to characterize the flow of benefits provided to people by the planned network of greenery in cities (urban green infrastructure) (Guitart *et al*. 2012; Gómez- Baggethun *et al*. 2013). Urban gardens are currently being touted as a means to combat the growth of inner-city food crises (Corrigan 2011). Local regulating functions provided by urban gardens include improving soil quality, avoiding soil erosion, maintaining water, lowering runoff, moderating microclimates, and pollination (e.g., Cameron *et al*. 2012; Edmondson *et al*. 2014). Urban gardens are important for biodiversity protection because they provide different spaces for vegetation and animal species. They can also aid in the reproduction and upkeep of many different types of cultivated plants (cultivars). Urban gardens provide cultural ecosystem services such as nature experiences, aesthetic expertise, and establishment (Beilin& Hunter 2011; Guitart *et al*. 2012). The potential creation of artistic ecosystem benefits varies depending on the social and ecological aspects of the garden, its physical location, and the users' particular perspectives.

II. MICRO-CLIMATE REGULATION AT STREET AND CITY LEVEL

Microclimate (the ecology of a relatively small or restricted locale, notably it is distinct from the general environment of the surrounding area) is the suite of climatic factors seen in constrained locales. The change patterns entail the mimicking of natural phenomena in order to control the environment and get a range of advantages. To be effective, they are all interconnected in a manner with other systems. Its efficiency in alteration patterns is frequently dependent on an in- depth knowledge of the local environment and how various systems interact. It is feasible to accomplish specific targets such as enhanced harvest rates, lower utility bills, or the production of pleasant urban settings by carefully regulating these elements. Metropolitan roads and avenues are recognized to have a major influence in the construction and establishment of urban microclimates. Streets are common in urban settings, and studies have demonstrated that roadway design influences urban climatic conditions (Chen *et al*., 2012; Shishegar 2013). The form and direction of urban streets influence natural ventilation and sun radiation, as well as microclimates inside street canyons and the surroundings (Rajagopalan *et al*.,2014; Qaid *et al*.,2016). The impact of urban heat islands is the higher air temperature in urban regions compared to neighboring countryside, and it constitutes one of the most significant features associated with urban conditions (Voogt and oke 2003).

A typical urban region lacks nature and is ruled by high-rise buildings and transportation infrastructure. The urban setting is marked by increasing consumption of energy and artificial heat from cooling devices and automobiles, as well as increased industrial waste dumps and pollution emissions (Giridharan *et al*., 2004). Anthropogenic heat, which is induced by human activity, is widely acknowledged as a key contributor to microclimate variance (Gartner 2008). Wong *et al*. (2016) reported empirical evidence that human activity concentration is a substantial source of urban heat due to crowding. To show physiological changes in humans and the repercussions of heat retention on an individual under crowded situations, Blows (1998) and Wong *et al*. (2013) coined the "Penguin effect" and "Herd effect," respectively. One of the most common Ecosystem-based adaptation methods is the design, installation, management, and upgrading of Metropolitan Green Facilities (UGI) to control microclimate and minimize summer heat. UGI can contribute to decreasing high temperatures in cities and the associated health risks because to its cooling capability, i.e. the ability to adjust temperature, humidity, and wind fields (Lafortezza *et al*. 2013; Escobedo *et al*. 2015). According to research, UGI can lower the summertime temperature by up to 6 Celsius degrees (Souch and Souch 1993; McPherson *et al*. 1997). The formation and regeneration of UGI, in addition to their optimum cooling potential, can help to cut summer energy expenses for air conditioning units while also assisting in the reduction of fatalities due to higher temperatures (Koomen and Diogo 2015). Because of their congestion and impermeability, cities require as much greenery as feasible. Green infrastructure in the urban setting includes whatever from parks to trees on streets, rooftop gardens to wetlands - in other words, anything that collects, slows, and processes rainwater, reducing floods and pollution downstream. Green infrastructure also contributes to the creation of oxygen, the collection of the element carbon, and the creation of wildlife habitat. Greenery in cities has also been shown to boost psychological health and happiness.

Suitable species for Micro climate regulation and improving air quality in the urban areas

Category	Species	Purpose	Reference
Trees	mango trees pongamia and umbrella trees, neem, gulmohar, silk cotton, pipal, Indian laburnum, Indian lilac, pagoda tree.	Improving Air quality	Shetye and Chaphekar 1989; Pokhriyal and Subba Rao 1986
Trees	*Alnus spaethi, Sophora japonicum, Pinus sylvestris, Fraxinus excelsior*.	Phyto remediation of airborne particulates.	Popek *et al*. 2013

Shrubs	Pinus mugo; taxus spp, Acer campestre, Sorbaria sorbifolia	Phytoremediation	Wang *et al*., 2015
Climbers	Parthenocissus spp, Hedera helix, and polygonum aubertii	Phytoremediation of dense habitat particulates	Borowski *et al*., 2009
Herbaceous plants	Achillea millefolium, Berteroa incana and Aster gymnocephalus	Phytoremediation	Weber *et al*., 2014
Houseplants	spider plant, snake plant, and golden pothos.	Reduce indoor ozone concentration	Papinchak, H. L *et al*. 2009

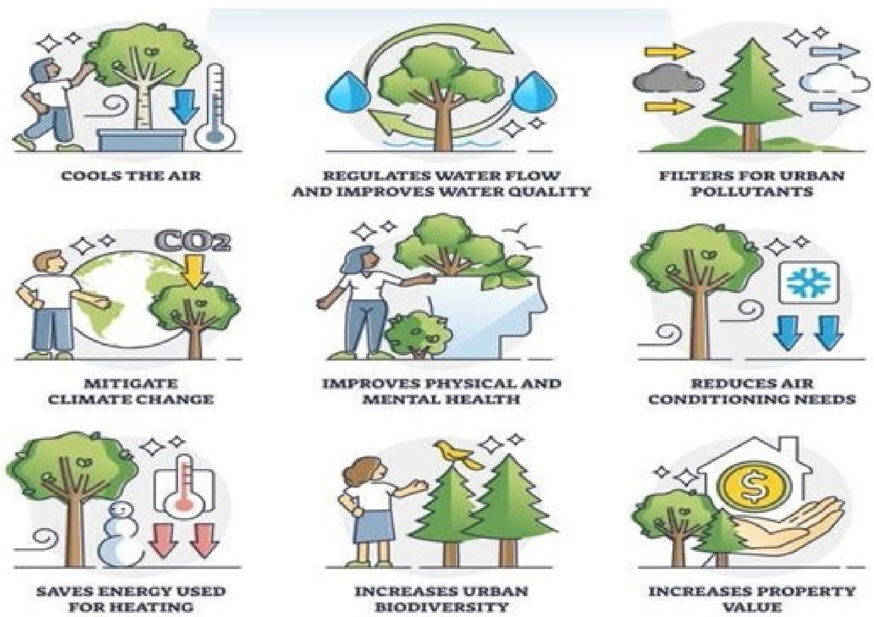

Figure 1: Sequential step-wise procedure for regulation of micro climate.

III. MULTI-FUNCTIONALITY OF URBAN GREEN SPACES

Urban green spaces are vital elements of cities that offer a host of advantages, including bettering the quality of the air and water, promoting social connections, boosting biodiversity, and aiding in physical and mental health. To create healthier, greener, and more pleasant urban settings, it is imperative to acknowledge the importance of these places and make investments in their upkeep and growth. The establishment and fair distribution of urban green areas should be a top priority for communities, legislators, and city planners in order to optimize their advantages. Regardless of socioeconomic background, investing in the upkeep and growth of these places may result in cities that are more sustainable, happier, and healthier for all of its citizens. The engineering solutions presented are often geared to handle one issue at a time, but green spaces have proven to tackle the problem cost effectively while also meeting the various criteria. Taking levees as an example, they are an engineering method used to protect cities from flooding, whereas increasing coastal wetland in the area can not only serve as good levees, but can also provide habitat for flora and fauna, act as an affluent filter, and have recreational uses (Costanza *et al*., 2006). The full potential of urban areas can be understood when seen holistically, demonstrating the multifunctional approach of urban green spaces as the foundation of diverse advantages received by humans (Langmeyer, 2015). Taking a holistic approach to urban planning that incorporates multifunctional green spaces alongside traditional engineering solutions can lead to more resilient, sustainable, and livable cities. By recognizing the various benefits that green spaces offer, cities can address multiple challenges simultaneously and improve the overall well-being of their residents while also safeguarding the environment.

In terms of agricultural operations, a green area can provide energy, compost, and goods like wood and fruit as a result of urban greening. These places can increase a city's economic worth and possibly create new jobs. Green spaces, bodies of water, open space, and visually appealing landscape types all contribute to an appealing metropolitan context. Attractive landscape types, in particular, can contribute significantly to rises in real estate values, for example, through hedonic price. The various uses of urban green spaces illustrate that green spaces are complex and multifaceted (Leeuwen *et al*., 2009).

Urban green spaces—whether public, semi-public, or private—contribute greatly to the standard of life in a number of ways because of their structure and multifunctionality. These spaces have a variety of purposes in cities, including enhancing the image and character of the city and addressing environmental, natural, monetary, cultural, and visual problems. Additionally, they have the feature of promoting an exceptional quality of life by acting as variables of connection between individuals and the environment because of their multifunctionality (Quintas and Curado, 2009). Therefore, in order to maximise the value of these green spaces in conjunction with other urban features in a coherent, comprehensive, and planned manner, it is imperative to have a feeling of and knowledge of the function that they play in the city. It is crucial to keep in mind that, in spite of the urban areas' continued growth and extension, as well as the growing gap between them and environment, the city depends on wilderness for its continued existence (Bolund and hunhammar, 1999).

Benefits	Uses	Source
Social benefits	Improvements to living and working conditions, effects on physical and mental health, cultural and historical aspects of the green environment	White M.P *et al.*, 2013
Aesthetic and architectural benefits	Variation in landscape through diverse plant colors, textures, and forms, defining open space, farming and filtering views, and landscape buildings	Tyrväinen, L *et al.*, 2005
Climaticand physical benefits	Wind control, cooling, the effects of temperature and humidity control on urban climate, air pollution reduction, sound control, flood prevention, and erosion control	Jim, C. Y., & Chen, W. Y 2009
Ecological benefits	Flora & wildlife biotopes in urban environments	Tyrväinen, L *et al.*, 2005
Economic benefits	Increased property values, value of market-priced amenities	Tyrväinen, L *et al.*, 2005

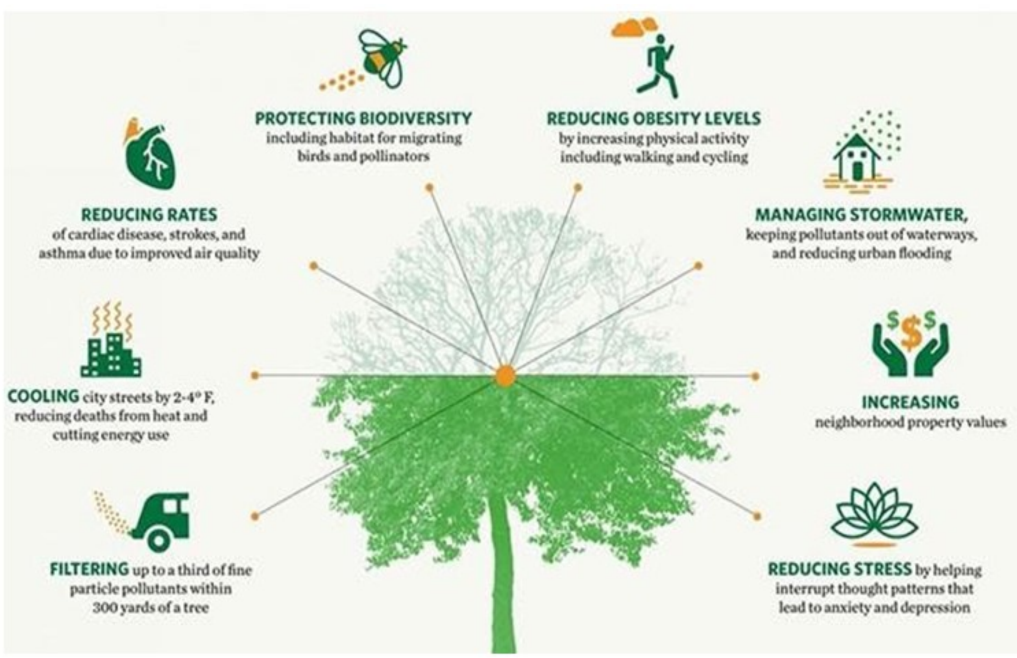

Figure 2: Various benefits of Urban forestry

IV. VALUE OF CULTURAL ECOSYSTEM SERVICES IN NEIGHBOURHOODS

Cultural ecosystem services are defined by the Millennium Ecosystem Assessment (Sarukhán *et al*. 2005) as "the intangible benefits mankind gain from landscapes via psychic enlightenment intellectual growth, reflection, recreation, and visual experiences." Cultural ecosystem services give emotional, physical, and mental advantages and are typically subtle and intuitive in character (Kenter *et al*. 2011) and implicitly expressed by indirect manifestations (Anthony *et al*. 2009). The value attributed to cultural ecosystem services is dictated by individual and cultural perceptions of their contribution to well-being.

Leisure, appreciation of beauty, meditation, an awareness of place, and a sense of community boost and contribute to everyday life by providing meaning and emotions that improve the physical and mental well-being of city dwellers (Altman and Low, 1992; Chiesura, 2004; Gómez-Baggethun *et al*. 2011, Mader, A. *et al*., 2011). Understanding the worth of ecosystem services in cultures is one approach to highlight the relevance of voluntary perks from nature that humans value, and may thus be used to influence green infrastructure development (Chan *et al*., 2012). Residents attribute different meanings to biological terms, and many techniques and strategies for valuing ecological services in urban environments have been used, ranging from monetary valuation methodologies such as Hedonic pricing, contingent pricing, and other monetary valuation methodologies, Valuation choice trials, and travel cost approaches (Teknomo, 2005), to non financial approaches centred around qualitative data, self-reported happiness, claimed well-being, physiological well-being, time management, and time management.

The employment of economic and non-economic methodologies to estimate the value of cultural ecosystem services results in a variety of inconsistencies. The technique, survey design, issues answered, and metrics employed can all have an influence on which specific values are to be recorded. Ecosystem service value, whether monetary or non-monetary, is intended to give beneficial data for urban development and oversight. When assessing green infrastructure efforts, ignoring essential value aspects of ecosystem services can lead to inaccurate making choices and, as a result, ineffective planning and management. Parallel appraisal methodologies alongside combined evaluations assist to lessen vulnerability to specific approach biases and shortcomings.

The advantages associated with diverse ecologically conscious infrastructure forms can be determined by merging the concepts of the cultural ecosystem's services into design and management. As a result, it could offer more data for green infrastructure in cities programmes and concrete planning. By enhancing place recognition and connection, urban green infrastructure can serve to foster social cohesion (Altman & Low, 1992; Peters *et al*., 2010; Stedman *et al*., 2006). Accessible public green space with little operational intensity may foster social activities, hence increasing social cohesiveness. Less-managed green spaces may allow for greater biodiversity and animal observation, leading to a better knowledge of biological processes such as plant growth.

A rigorous estimation of the worth of ecosystem services associated with culture with regard to existing land use and administration levels, plus prospective strategies, may satisfy the policy demand for data on trade-offs and synergies between ecosystem services offered by various sorts of green infrastructure (De Groot *et al*., 2010). Green infrastructure designs may also be evaluated by urban policymakers and practitioners (Andersson *et al*., 2007; Barthel *et al*., 2010; Potschin & Haines-Young, 2012). On the one hand, establishing links between ideals and land uses gives insight into the biological makeup of urban green areas that promote cultural advantages. In contrast, ecosystem service values connected with use and management regimes enable legislators in figuring out how to actively modify cultural advantages and boost the city's flexibility to satisfy social requirements thru green infrastructure plans.

General agreement on standardized methodological techniques is required to enable comparability across different evaluations and to give reliable recommendations to urban authorities. By spatially explicating the advantages of cultural ecosystem services, green infrastructure investments may be appraised in the context of compromises and opportunities in the supply of ecosystem services (Langemeyer, 2015)

V. FUTURE PERSPECTIVE STEPS TO REDUCE TEMPERATURE LEVELS IN URBAN AREAS

The landscape of urban areas changes as they grow. Open space and vegetation are being displaced by structures, roads, and other infrastructure. Surfaces that are permeable and damp eventually turn impervious upon drying (U.H.I. 2011). As the climate of the planet changes over the next few decades, urban areas will be especially hard hit as buildings and pavements effortlessly soak up daylight and boost the ambient temperature, triggering a rise of metropolis heat islands—the scenario wherein suburban domains endure warmer temperatures than their rural surroundings. As a result, cities are more prone to experience dangerously hot times (Hoag, 2015). This raises energy costs (such as air conditioning), dust in the air, and heat-related diseases and fatalities. The summertime heat waves are expected to become more frequent, more intense, and endure longer as an outcome of climate change.

To lessen the urban heat island effect, take the following steps:

- Incorporate environmentally friendly enhancements into routine highway restorations and renovation projects to ensure ongoing investment in heat-reducing solutions across your community.
- Planting trees and other types of plants, Despite the fact that space is limited in crowded destinations, insignificant green infrastructure efforts may be swiftly incorporated into verdant or parched areas, abandoned lots, and highway rights-of-way.
- A foliage canopy taxation can assist the city in using trees to tackle problems such as heat island cities, drainage issues, and other challenges recognizing where we need canopy,

even to the pavement and roof level, would greatly enhance our efforts," Mayor Greg Fischer said."

- By planting trees near or within wayside pitchers along with other green infiltration-based projects to increase roadside cooling and shade, established water quality approaches can serve double duty.
- Wherever practical, grow native, adaptable to drought trees for shade and smaller perennials that include shrubs, grasses, and groundcover to improve the vicinity one project at a time.
- Install green roofs—Because they deliver both passive and active cooling, green roofs are an effective heat island reduction option. Green roofs enhance air quality by reducing heat islands and absorbing pollutants. Many municipalities provide tax rebates for green roofs. Look for employment vacancies on your local government's website. The United States District of Columbia's River Smart Rooftops Green Roof Rebate Programme and Philadelphia's Green Roof Tax Credit Programme are two existing programmes.
- Studies have indicated that energy-colored asphalt and white roofs reflect as much as fifty percent more light and lower ambient temperature. These techniques have been demonstrated to be beneficial in mitigating the effects of the health of the urban archipelago. Colours like black and dreary capture a lot of the sun's heat, scorching up the surface. Light-colored concrete with white roofs can significantly reduce the demand for air conditioning.
- Green Roofing and Crop Coverage-Green roofs are an effective method of reducing the impacts of urban heat islands. Green covering is the growing of greenery on a roof inside the same way as plants are grown in gardens. Rooftop plants are great summer insulators and help to reduce the impact of urban heat islands. Plants also assist to keep the environment cool, lowering the need for air conditioning. Furthermore, since the plants capture CO2 and generate oxygen-rich air, the air's cleanliness improves. Landscape establishing, trees on streets, and curbside planting are some more options. All of these solutions have a cooling impact in cities and minimize the cost of cooling.
- **Tree Planting in Cities** - Growing vegetation near or within cities is a great way to reflect solar radiation while reducing the influence of urban heat islands. Trees give shade, absorb cO2, exhale breathable and clean air, and provide cooling. Deciduous trees are appropriate for urban locations because they give shade in the hottest months and do not obstruct heat transfer in the winter.
- Natural parking lots make use of environmentally friendly structures to reduce the impacts of city heat islands. It prevents tarmac warming, which can significantly reduce thermal pollution generated by rainfall runoff. With new technology in place, the threat to waterways has decreased.
- Environmental legislation such as the Clean Air Act, low carbon fuel standards, renewable energy use, and clean automobile rule norms, when implemented by the state, can effectively manage the anthropogenic inducers of the urban heat island effect.
- Lowering the level of atmospheric greenhouse gases in the atmosphere can reduce the

effects of climate change as well as global warming. Society can also be instructed and educated on the financial and social advantages of forestry and eco-roofing through education and outreach.

The most effective ways for reducing noon outdoor heat stress are increased building density, more street trees, and urban forests/parks. Improvements in surface albedo, which thermal enrollment, and breathability have little influence on outer ambient temperatures but have a significant impact on surface-level heat retention and, as a result, internal climate (Erell *et al*., 2014).

There are several tools available to assist you in calculating the benefits of lowering heat-related tension within your community. Impact Infrastructure recently collaborated with the Institute for Sustainable Infrastructure (ISI) to create its Business Case Evaluator (BCE) for Stormwater, a risk-based systems worksheet statistical associate application to ISI's Envision Sustainable Infrastructure Rating System. The program calculates the worth of a wide range of advantages, including decreased heat-related morality rates (Oliveira, S., H. Andrade, and T. Vaz. 2011).

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