**URBAN ECOSYSTEM SERVICES**

**Indu kale1, NasamMidhun Kumar2, Himanshi Singh3, Ali Syed4, DK Yadav1, Alok Kumar Singh2**

1Indira Gandhi Krishi Vishwavidhyala, Raipur, Chhattisgarh

2 *Department Silviculture and Agroforestry, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh- 173230*

3Banaras Hindu University, Varanasi, Uttar pradesh

4College of Forestry, Ponnampet, Karnataka.

Corresponding author: [indukale562@gmail.com](mailto:indukale562@gmail.com)

**Introduction**

Urban gardens are viewed as connected socio-ecological systems in which humans function as an integral and interacting component (e.g. Buchmann 2009; Barthel et al. 2010). By 2050, urban regions are expected to hold 68% of the world's population (United Nations 2014). Urban forests, which include individual trees and bushes, parks, and forests, are essential for enhancing the environment of cities and the quality of life for city people (Roy et al. 2012; Shwartz et al. 2014). Ecosystem services are seen as a joint creation of biological processes and human endeavors like gardening. Humans gain numerous significant and diverse benefits from urban allotments and community gardens, including food production (e.g., Buchmann et al. 2009; Barthel & Isendahl 2013), pollination (Andersson et al. 2007), local climate regulation (Gómez-Baggethun and Barton 2013), recreation (e.g., Kaplan 1973), and social cohesion (e.g., Armstrong 2000). In urban contexts the ecosystem service approach is increasingly used to describe the flow of benefits that the planned network of urban green spaces (urban green infrastructure) provides to humans (Guitart et al. 2012; Gómez-Baggethun et al. 2013). Currently, urban gardens have been described as a way to tackle the emergence of inner city food deserts (Corrigan 2011). Urban gardens can offer crucial local regulating services, such as enhancing soil quality, preventing soil erosion, retaining water, reducing runoff, controlling microclimates, and pollination (e.g. Cameron et al. 2012; Edmondson et al. 2014). Urban gardens provide many habitats for plant and animal species and may be critical for biodiversity conservation. They can also help with the reproduction and maintenance of a wide range of cultivated plant kinds (cultivars). Nature experiences, aesthetic knowledge, and place-making are among the cultural ecosystem services provided by urban gardens (Beilin & Hunter 2011; Guitart et al. 2012). The potential generation of cultural ecosystem services differs among different types of urban gardens, based on social and ecological garden qualities, geographical location, and the recipients' individual views.

**MICRO-CLIMATE REGULATION AT STREET AND CITY LEVEL**

The suite of climatic variables observed in limited locations is known as microclimate (the climate of a relatively small or restricted area, especially when it differs from the climate of the surrounding area). Microclimate alteration patterns involve the imitation of natural processes in order to manage the environment and obtain a variety of benefits. They are all linked in some way with other systems to make them successful. The effectiveness of microclimate modification patterns often relies on a deep understanding of the local conditions and how different systems interact. By carefully manipulating these factors, it is possible to achieve specific goals such as improved crop yields, energy efficiency, or the creation of comfortable urban environments.

Urban streets and roads are known to have an important role in the establishment and formation of urban microclimates. Streets are ubiquitous in urban areas, and street design has been shown to influence urban microclimates (Chen et al., 2012; Shishegar 2013). Natural ventilation and solar radiation, as well as microclimates within street canyons and the surrounding environment, are affected by the design and orientation of urban streets (Rajagopalan et al.,2014; Qaid et al.,2016).The urban heat island effect is the greater air temperature within urban areas relative to nearby rural areas, and it is one of the most important features of urban microclimates (Voogt and oke 2003). A typical urban area is devoid of vegetation and dominated by high-rise structures and traffic infrastructure. The urban environment is characterized by increasing energy consumption and anthropogenic heat from air conditioners and autos, as well as increased disposal of industrial waste and emission of dangerous pollutants (Giridharan et al., 2004).Anthropogenic heat, caused by human activities and humans, is well recognized as a significant contributor to microclimate variation (Gartner 2008). Wong et al. (2016) presented empirical evidence pointing to anthropogenic activity concentration as a significant source of urban heat as a result of crowding. Blows (1998) and Wong et al. (2013) defined the "Penguin effect" and "Herd effect," respectively, to demonstrate physiological changes in people and the consequences of heat retention on an individual in congested conditions. The design, establishment, administration, and enhancement of Urban Green Infrastructures (UGI) to regulate microclimate and reduce summer heat is one of the most prevalent Ecosystem-based adaptation measures. By virtue of its cooling capacity, i.e. the ability to change temperature, humidity, and wind fields, UGI can contribute to lowering high temperatures in cities and the accompanying health concerns (Lafortezza et al. 2013; Escobedo et al. 2015). As per studies, UGI has been shown in trials to reduce summer temperatures by up to 6 degrees Celsius (Souch and Souch 1993; McPherson et al. 1997). The creation and restoration of UGI, as well as their maximum cooling capability, can help to minimize summer energy costs for air conditioning while also helping to reduce mortality due to higher temperatures (Koomen and Diogo 2015).

Cities necessitate as much green infrastructure as possible due to their density and impermeability. In the urban context, green infrastructure comprises anything from parks to street trees, green roofs to bioswales - in other words, everything that absorbs, delays, and treats stormwater, minimizing flooding and pollution downstream. Green infrastructure also aids in the production of oxygen, the capture of carbon, and the provision of habitat for wildlife. City greenery has also been proved to improve mental 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 |

****

**Fig: Sequential step-wise procedure for regulation of micro climate.**

**MULTI-FUNCTIONALITY OF URBAN GREEN SPACES**

Urban green spaces are essential components of cities that provide numerous benefits, from improving air and water quality to supporting physical and mental health, enhancing biodiversity, and fostering social interactions. Recognizing the value of these spaces and investing in their maintenance and development is crucial for creating healthier, more sustainable, and more livable urban environments. To maximize the benefits of urban green spaces, city planners, policymakers, and communities should prioritize their creation and equitable distribution. Investing in the maintenance and expansion of these areas can lead to healthier, happier, and more sustainable cities for all residents, regardless of their socioeconomic status. 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).

Because of their structure and multi-functionality, urban green spaces (whether public, semi-public, or private) contribute significantly to the quality of life in a variety of ways. In cities, these places serve a range of functions, including environmental, ecological, social, economic, cultural, and aesthetic aspects, as well as promoting a city's image and character. They are also features that, due to their multifunctionality, act as factors of interaction between human activities and the environment, supporting outstanding quality of life (Quintas and Curado, 2009). As a result, having a sense and awareness of the role that these green places play in the city is vital in order to maximize their value in an articulated, complete, and planned manner, alongside other urban characteristics. It is important to remember that, despite the expansion and growth of urban areas, as well as the increasing distance between the city and nature, the city requires nature for survival (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 |
| Climatic and 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 and 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 |

t should be noted that urban green spaces provide a range of benefits in various forms and

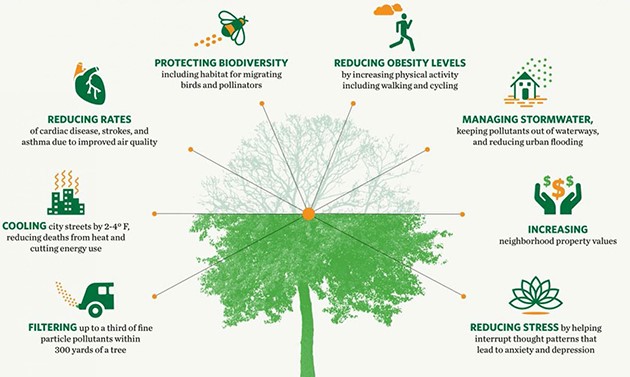
offer a variety of opportunities to people. They reinforce the identity of towns and cities, which

can enhance their attractiveness for living, working, investment and tourism, and therefore these

spaces can contribute positively to both the quality of life and the competitiveness of cities. In

addition, urban green spaces moderate the impact of the negative consequences of human

activities

****

**Fig: Various benefits of Urban forestry**

**Contrasting values of cultural ecosystem services in urban areas**

The Millennium Ecosystem Assessment (Sarukhán et al. 2005) defines cultural ecosystem services as "the non-material advantages humans gain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences." Physical, emotional, and mental benefits are provided by cultural ecosystem services, which are often subtle and intuitive in nature (Kenter et al. 2011) and implicitly reflected through indirect manifestations (Anthony et al. 2009). Individual and cultural conceptions of the contribution of cultural ecosystem services to well-being determine the value assigned to them.

Recreation, aesthetic appreciation, spiritual experiences, sense of place, and social cohesiveness enrich and contribute to human life by providing meaning and emotions that improve city dwellers' physical and mental well-being (Altman and Low, 1992; Chiesura, 2004; Gómez-Baggethun et al. 2011, Mader, A. et al., 2011). Understanding the value of cultural ecosystem services is one way to demonstrate the importance of non-monetary benefits from nature that are valuable to humans, and can thus be used to inform green infrastructure planning (Chan et al., 2012). People attribute different meanings to nature, and numerous methods and approaches for valuing cultural ecosystem services in urban environments have been used, ranging from the use of Hedonic pricing, contingent pricing, and other monetary valuation methodologies, Valuation choice trials, and travel cost approaches (Teknomo, 2005), to non-monetary approaches based on observational research, self-reported happiness, claimed well-being, physiological well-being, time management, and other factors.

The use of monetary and non-monetary approaches to quantify the value of cultural ecosystem services allows for a range of inconsistent outcomes. The methodology used, the survey design, the questions asked, and the metrics used can all have a significant impact on which specific values are to be recorded. The valuation of ecosystem services, whether monetary or non-monetary, is meant to provide relevant information for urban planning and management. Ignoring critical value dimensions of ecosystem services when evaluating green infrastructure initiatives can lead to incorrect decision-making and, as a result, inadequate planning and management. Complementary valuation approaches and integrated assessments help to reduce the sensitivity to the assumptions and limitations of single methods.

By integrating the values of cultural ecosystem services to planning and management, the benefits associated with various green infrastructure types can be discovered. As a result, it may provide additional data for urban green infrastructure programs as well as concrete planning. Urban green infrastructure can help to promote social cohesiveness by boosting place identity and attachment (Altman & Low, 1992; Peters et al., 2010; Stedman et al., 2006). Public green space that is easily accessible and has low management intensities may encourage social activities, hence strengthening social cohesion. Green places with less management may allow for more plant and animal observation, resulting in a better understanding of natural processes such as plant growth.

A rigorous accounting for the values of cultural ecosystem services in relation to current land-uses and management intensities, as well as future plans, can meet the policy need for information on synergies and trade-offs between ecosystem services under alternative green infrastructure types (De Groot et al., 2010). It can also help urban policymakers and practitioners evaluate green infrastructure plans (Andersson et al., 2007; Barthel et al., 2010; Potschin & Haines-Young, 2012). On the one hand, determining the links between values and land uses reveals information about the biological structure of urban green spaces that promote cultural benefits. Ecosystem service values associated with land-use and management regimes, on the other hand, assist policymakers in better understanding how to actively change cultural benefits and increase the city's adaptive capacity to meet social needs through green infrastructure plans.

To ensure comparability across varied assessments and to provide accurate recommendations to urban policymakers, general agreement on standardized methodological procedures is essential. Green infrastructure initiatives can be evaluated in terms of trade-offs and synergies in the provision of ecosystem services by spatially explicating the benefits of cultural ecosystem services. (Langemeyer,2015)

**Future perspective steps to reduce temperature levels in urban areas:**

As metropolitan regions expand, the topography changes. Buildings, roads, and other infrastructure are displacing open space and vegetation. Permeable and moist surfaces eventually become impermeable and dry (U.H.I. 2011).As the Earth's climate changes over the next few decades, urban areas will be particularly hard hit by global warming because their buildings and pavements readily absorb sunlight and raise local temperatures, resulting in the formation of urban heat islands—the phenomenon in which urban areas experience warmer temperatures than their rural surroundings. Cities are thus more likely to endure dangerously hot periods (Hoag, 2015). This increases energy expenses (for example, air conditioning), air pollution, and heat-related sickness and mortality. As a result of climate change, summer heat waves are predicted to grow more frequent, more severe, and last longer.

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

* Incorporate green infrastructure improvements into regular roadway restorations and capital improvement projects to ensure continuous investment in heat-reducing technologies throughout your neighborhood.
* Plant trees and other vegetation, Although space is restricted in metropolitan settings, minor green infrastructure initiatives can be easily integrated into grassy or barren areas, vacant lots, and street rights-of-way.
* A tree canopy review can help the city use trees to solve issues including urban heat, storm water management, and other concerns. Mayor Greg Fischer said, "Knowing where we need canopy, down to the street and address level, would enhance our efforts immensely."
* Established water quality methods can do double duty by planting trees in or near roadside planters and other green infiltration-based initiatives to improve roadside cooling and shading.
* Plant native, drought-tolerant shade trees and smaller plants such as shrubs, grasses, and groundcover wherever possible to transform your neighborhood one project at a time.
* Build green roofs—Green roofs are an excellent heat island reduction solution because they provide both direct and indirect cooling. Green roofs also improve air quality by decreasing the heat island effect and absorbing pollutants. Many communities offer tax breaks for green roofs. Look for job openings on the website of your local government. Two existing programs are the District of Columbia's River Smart Rooftops Green Roof Rebate Program and Philadelphia's Green Roof Tax Credit Program.
* Light-colored concrete and white roofs have been shown to reflect up to 50% more light and reduce ambient temperature. These methods have been shown to be effective in reducing the impact of the urban health island. Black and bleak colors absorb a lot of solar heat, warming up the surface. The use of light-colored concrete and white roofs can also help to lessen the need for air conditioning.

Green Roofs and Vegetation Coverage-Green roofs are a good approach to mitigate the effects of urban heat islands. Green roofing is the cultivation of plants on a roof in the same manner as it is done in a garden. Rooftop plants are excellent insulators in the summer and contribute to the reduction of the urban heat island effect. Plants also help to keep the area cool, reducing the demand for air conditioning. Additionally, because the plants absorb CO2 and produce fresh air, air quality improves. Other ways that can be used include open space planting, street trees, and curbside planting. All of these strategies have a cooling effect in cities and reduce the cost of decreasing the temperature.

* **Tree Planting in Cities** - Planting trees in and around cities is an excellent method for reflecting solar radiation while also lowering the urban heat island effect. Trees provide shade, absorb carbon dioxide, release oxygen and fresh air, and provide a cooling effect. Deciduous trees are suitable for urban environments because they provide shade in the summer and do not interfere with heat transmission in the winter.
* Green parking garages use green infrastructure to mitigate the effects of urban heat islands. It guards against pavement temperature rise, which can greatly minimize thermal pollution caused by rainwater runoff. With technologies in place, the hazard to aquatic systems has diminished.
* Heat Reduction Policy and Rule Implementation and Sensitization-When implemented by the state, environmental laws such as the Clean Air Act, low carbon fuel standards, renewable energy use, and clean automobile rule norms can effectively manage the anthropogenic inducers of the urban heat island effect.
* With fewer emissions, the amount of greenhouse gases in the atmosphere can be lowered, reducing the impacts of climate change and global warming. Through education and outreach, communities can also be taught and informed about the economic and social benefits of tree planting and eco-roofing..

Increased building density and more street trees and urban forests/parks are the most effective techniques for minimizing midday outdoor heat stress. Increases in surface albedo, thermal admittance, and permeability have little effect on exterior thermal conditions but have a considerable impact on surface heat storage and, as a result, indoor climate (Erell et al., 2014).

There are a number of tools available to help you calculate the advantages of reducing heat-related stress in your community. In conjunction with the Institute for Sustainable Infrastructure (ISI), Impact Infrastructure recently developed the Business Case Evaluator (BCE) for Stormwater, a risk-based spreadsheet economic companion tool to ISI's Envision Sustainable Infrastructure Rating System. The tool includes estimates for the value of a lengthy number of benefits, including lower heat-related morality rates (Oliveira, S., H. Andrade, and T. Vaz. 2011).

**REFERENCES**

Altman I. and Low S.M.(2004) Place Attachment, 1992, Plenum Press; New York.Chiesura A., The role of urban parks for the sustainable city, Landsc. Urban Plan. 68, 129–138.

Andersson, E., Barthel, S., &Ahrné, K. (2007). Measuring social–ecological dynamics behind the generation of ecosystem services. *Ecological applications*, *17*(5), 1267-1278.

Andersson, E; Barthel, S; Ahrné, K (2007): Measuring social-ecological dynamics behind the generation of ecosystem services. In: Ecological Applications 17 (5), 1267-1278.

Anthony, A., Atwood, J., August, P., Byron, C., Cobb, S., Foster, C., &Vinhateiro, N. (2009). Coastal lagoons and climate change: ecological and social ramifications in US Atlantic and Gulf coast ecosystems. Ecology and Society, 14(1).

Armstrong, D (2000): A survey of community gardens in upstate New York: implications for health promotion and community development. In: Health & Place 6, 319–327.

Barthel, S., Folke, C., & Colding, J. (2010). Social–ecological memory in urban gardens—Retaining the capacity for management of ecosystem services. *Global environmental change*, *20*(2), 255-265.

Barthel, S; Folke, C; Colding, J (2010): Social–ecological memory in urban gardens - Retaining the capacity for management of ecosystem services. In: Global Environmental Change 20 (2), 255–265.

Barthel, S; Isendahl, C (2013): Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities. In: Ecological Economics 86, 224-234.

Basics, U. H. I. (2011). Reducing urban heat islands: Compendium of strategies. *US EPA http://www. epa. gov/heatisland/resources/compendium. htm. Viewed*, *14*.

Beilin, R; Hunter, A (2011): Co-constructing the sustainable city: how indicators help us ‘grow’ more than just food in community gardens. In: Local Environment 16, 523–538.

Blows, W. T. (1998). Crowd physiology: the ‘penguin effect’. *Accident and emergency nursing*, *6*(3), 126-129.

Bolund, P., &Hunhammar, S. (1999). Ecosystem services in urban areas. Ecological economics, 29(2), 293-301.

Borowski, J., Loboda, T., & Pietkiewicz, S. (2009). Photosynthetic rates and water use efficiencies in three climber species grown in different exposures at urban and suburban sites. *Dendrobiology*, *62*, 55-61.

Buchmann, C (2009): Cuban home gardens and their role in social–ecological resilience. In: Human Ecology 37 (6), 705-721.

Cameron, RWF; Blanusa, T; Taylor, JE; Salisbury, A; Halstead, AJ; Henricot, B; Thompson, K (2012): The domestic garden – Its contribution to urban green infrastructure. In: Urban Forestry & Urban Greening 11, 129-137

Chan, K. M., Satterfield, T., & Goldstein, J. (2012). Rethinking ecosystem services to better address and navigate cultural values. Ecological economics, 74, 8-18.

Chen, L., Ng, E., An, X., Ren, C., Lee, M., Wang, U., & He, Z. (2012). Sky view factor analysis of street canyons and its implications for daytime intra‐urban air temperature differentials in high‐rise, high‐density urban areas of Hong Kong: a GIS‐based simulation approach. *International Journal of Climatology*, *32*(1), 121-136.

Corrigan, MP (2011): Growing what you eat: Developing community gardens in Baltimore, Maryland. In: Applied Geography 31, 1232-1241.

Costanza, R., Mitsch, W. J., & Day Jr, J. W. (2006). A new vision for New Orleans and the Mississippi delta: applying ecological economics and ecological engineering. Frontiers in Ecology and the Environment, 4(9), 465-472.

De Groot, R. S., Alkemade, R., Braat, L., Hein, L., &Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological complexity*, *7*(3), 260-272.

Edmondson, JL, Davies, ZG; McCormack, SA; Gaston, KJ; Leake, JR (2014): Land-cover effects on soil organic carbon stocks in a European city. In: Science of the Total Environment 472, 444-453.

Erell, E., Pearlmutter, D., Boneh, D., &Kutiel, P. B. (2014). Effect of high-albedo materials on pedestrian heat stress in urban street canyons. Urban climate, 10, 367-386.

Escobedo FJ, Adams DC, Timilsina N (2015) Urban forest structure effects on property value. *Ecosyst Serv* 12:209–217.

Gartland, L. M. (2012). *Heat islands: understanding and mitigating heat in urban areas*. Routledge.

Giridharan, R., Ganesan, S., & Lau, S. S. Y. (2004). Daytime urban heat island effect in high-rise and high-density residential developments in Hong Kong. *Energy and buildings*, *36*(6), 525-534.

Gómez-Baggethun E. & Barton D.N. (2013). Classifying and valuing ecosystem services for urban planning, Ecol. Econ. 86, 235–245

Gómez-Baggethun, E., & Ruiz-Pérez, M. (2011). Economic valuation and the commodification of ecosystem services. Progress in Physical Geography, 35(5), 613-628.

Gómez-Baggethun, E; Barton, DN (2013): Classifying and valuing ecosystem services for urban planning. In: Ecological Economics 86, 235–245.

Guitart, D; Pickering, C; Byrne J (2012): Past results and future directions in urban community gardens research. In: Urban Forestry & Urban Greening 11, 364– 373

Hoag, H. (2015). How cities can beat the heat: rising temperatures are threatening urban areas, but efforts to cool them may not work as planned. *Nature*, *524*(7566), 402-405.

Iamtrakul, P., Teknomo, K., & Hokao, K. (2005, May). Public park valuation using travel cost method. In *Proceedings of the Eastern Asia Society for Transportation Studies* (Vol. 5, No. 2005, pp. 1249-264).

Jim, C. Y., & Chen, W. Y. (2009). Ecosystem services and valuation of urban forests in China. *Cities*, *26*(4), 187-194.

Kaplan, R (1973): Some psychological benefits of gardening. In: Environment &Behaviour 5, 145–162

Kenter, J. O., Hyde, T., Christie, M., &Fazey, I. (2011). The importance of deliberation in valuing ecosystem services in developing countries—evidence from the Solomon Islands. Global Environmental Change, 21(2), 505-521.

Koomen E, Diogo V (2015) Assessing potential future urban heat island patterns following climate scenarios, socio-economic developments and spatial planning strategies. *Mitig Adapt Strateg Glob Chang.*

Lafortezza R, Davies C, Sanesi G, Konijnendijk C (2013) Green Infrastructure as a tool to support spatial planning in European urban regions. iForest – Biogeosci For 6:102–108.

Langemeyer, J. (2015). Socio-cultural values of urban ecosystem services. Ecosystem Services: concepts, methodologies and instruments for research and applied use, 113.

MA - Millennium Ecosystem Assessment (2005): Ecosystems and human wellbeing. Washington, DC: Island Press

Mader, A., Patrickson, S., Calcaterra, E., & Smit, J. (2011). TEEB manual for cities: Ecosystem services in urban management. Geneva, Switzerland: The Economics of Ecosystems and Biodiversity, UN Environment.

McPhearson, T., Kremer, P., & Hamstead, Z. A. (2013). Mapping ecosystem services in New York City: Applying a social–ecological approach in urban vacant land. *Ecosystem Services*, *5*, 11-26.

Oliveira, S., Andrade, H., & Vaz, T. (2011). The cooling effect of green spaces as a contribution to the mitigation of urban heat: A case study in Lisbon. *Building and environment*, *46*(11), 2186-2194.

Papinchak, H. L., Holcomb, E. J., Best, T. O., &Decoteau, D. R. (2009). Effectiveness of houseplants in reducing the indoor air pollutant ozone. *HortTechnology*, *19*(2), 286-290.

Peters, K., Elands, B., & Buijs, A. (2010). Social interactions in urban parks: Stimulating social cohesion?. *Urban forestry & urban greening*, *9*(2), 93-100.

Pokhriyal, T. C., & Rao, B. S. (1986). Role of forests in mitigating air pollution. *Indian Forester*, *112*(7), 573-582.

Popek, R., Gawrońska, H., Wrochna, M., Gawroński, S. W., & Sæbø, A. (2013). Particulate matter on foliage of 13 woody species: deposition on surfaces and phytostabilisation in waxes–a 3-year study. *International Journal of Phytoremediation*, *15*(3), 245-256.

Potschin, M., & Haines-Young, R. (2013). Landscapes, sustainability and the place-based analysis of ecosystem services. *Landscape Ecology*, *28*(6), 1053-1065.

Qaid, A., Lamit, H. B., Ossen, D. R., &Shahminan, R. N. R. (2016). Urban heat island and thermal comfort conditions at micro-climate scale in a tropical planned city. *Energy and Buildings*, *133*, 577-595.

Quintas, A. V., & Curado, M. J. (2009). The contribution of urban green areas to the quality of life. City Futures in a Globalising World, 4-6.

Shetye, R. P., & Chaphekar, S. B. (1980). Some estimations on dust fall in the city of Bombay, using plants. Vol. 4: pp. 61-70. *Progress in Ecology. VP Agarwal and VK Sharma (Eds.). Today and Tomorrow’s Printers and publishers, New Delhi*.

Souch CA, Souch C (1993) The effect of trees on summertime below canopy urban climates: a case study Bloomington, *Indiana. J Arboric* 19:303–312

Stedman, R., Amsden, B. L., & Kruger, L. (2006). Sense of place and community: Points of intersection with implications for leisure research. Leisure/Loisir, 30 (2), 393-404.

TEEB, (2010). The economics of ecosystems &biodiversity : mainstreaming the economics of nature. UNEP

Tyrväinen, L., Pauleit, S., Seeland, K., & Vries, S. D. (2005). Benefits and uses of urban forests and trees. In *Urban forests and trees* (pp. 81-114). Springer, Berlin, Heidelberg.

United Nations (2014). Open working group proposal. Sustainable Development Goals. A/68/970

Van Leeuwen, E., Nijkamp, P., & de Noronha Vaz, T. (2010). The multifunctional use of urban greenspace. International journal of agricultural sustainability, 8(1-2), 20-25.

Voogt, J. A., &Oke, T. R. (2003). Thermal remote sensing of urban climatesRemote Sensing of Environment.

Wang, H., Shi, H., & Wang, Y. (2015). Effects of weather, time, and pollution level on the amount of particulate matter deposited on leaves of Ligustrum lucidum. *The Scientific World Journal*, *2015*.

Weber, F., Kowarik, I., &Säumel, I. (2014). Herbaceous plants as filters: Immobilization of particulates along urban street corridors. *Environmental pollution*, *186*, 234-240.

White, M. P., Alcock, I., Wheeler, B. W., & Depledge, M. H. (2013). Would you be happier living in a greener urban area? A fixed-effects analysis of panel data. *Psychological science*, *24*(6), 920-928

Wong, P. P. Y., Lai, P. C., Low, C. T., Chen, S., & Hart, M. (2016). The impact of environmental and human factors on urban heat and microclimate variability. *Building and Environment*, *95*, 199-208.

Wong, P., Lai, P. C., & Hart, M. (2013). Microclimate variations between semienclosed and open sections of a marathon route. *Advances in Meteorology*, *2013*.