SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2026
ORGANIZATION AND MANAGEMENT SERIES NO. 249

ECOSYSTEM SERVICES OF URBAN GREEN SPACES AND THEIR IMPACT ON QUALITY OF LIFE

Taras KHARANDZIUK

University of Information Technology and Management, Rzeszów, Poland; taraskharandziuk@gmail.com, ORCID: 0009-0006-4332-6774

Purpose: Natural landscapes have changed fast lately, mostly because urbanization is pushing cities to grow. Resources are consumed faster. Natural areas disappear. Air pollution gets worse. Temperatures rise in dense city zones. In this situation, urban green spaces matter more. In the research, the focus is on urban green infrastructure and ecosystem services, their impact on the environment, and the quality of life.

Design/methodology/approach: The study is based on a review of scientific literature related to ecosystem services and urban green infrastructure. Different academic articles and analytical reports were considered during the analysis. To explore how ecosystem services affect environmental conditions and human well-being in cities, comparative and thematic analyses were used.

Findings: Urban green spaces provide essential ecosystem services across four specific categories. Trees and plants trap dust to improve air quality and reduce temperatures during extreme heat waves, acting as crucial regulating services. These areas sustain rich biodiversity as a supporting service. Parks provide cultural services by offering vital space for relaxation and social interaction. This routine access to nature lowers stress, improves health, and often boosts local property values. Urban greening can also facilitate provisioning services like agriculture right in the city. There are numerous disservices associated with these environments. Issues such as pollen allergies, root damage, pests, and safety concerns require careful management. Balancing these positive and negative realities is exactly what maximizes human well-being and promotes truly sustainable living.

Research limitations/implications: This study relies only on previously published literature, so its conclusions depend on the scope of existing research. Naturally, the results are mirrors of the data and approaches used in previous research. To truly understand the environmental and social reach of green infrastructure, we need to see more empirical research conducted across a wider range of urban environments.

Originality/value: This study synthesizes findings from several scientific sources to highlight the ecological, social, and economic importance of urban green infrastructure. The results make it clear: sustainable urban development and better city life are only possible if ecosystem services become a central part of the planning agenda.

Keywords: urban green spaces; ecosystem services; green infrastructure; urban sustainability; quality of life.

Category of the paper: literature review.

1. Introduction

Urban areas are great places for culture and jobs, but they also use too many global resources. As these zones grow, concrete and asphalt replace natural land. As a result, living spaces become overcrowded, and complex environmental problems begin to emerge. The world is changing fast. More than 50 percent of the global population is currently living in urban areas (Wentworth, 2017). But in Europe, the situation is even more extreme. Today, about 75 percent of the EU population lives in urban areas (Figure 1), which is a huge number considering these environments cover only 24.5 percent of the total land area (Eurostat, 2024). And this number will grow in the next decades.

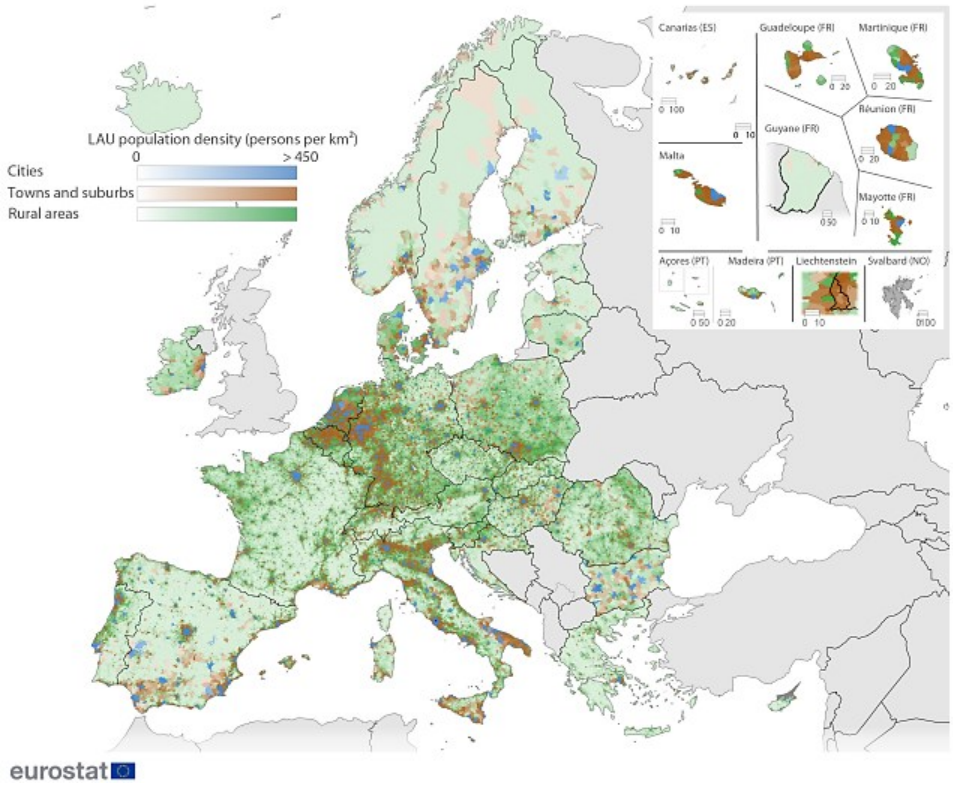


Figure 1. Degree of urbanisation, 2021.

Source: Eurostat (2024).

Life in a big city can be tough on human health because of dirty air, loud noises, and extreme heat during summers. In fact, sickness and mortality rates increase during heatwaves. Chronic stress is another big issue, because it leads to cardiovascular diseases and costs healthcare systems billions of euros every year (Kowarik et al., 2017). However, there are not only physical health problems. Modern urban lifestyles also cause hidden psychological issues, such as depression and social isolation (Bratman et al., 2019; Jennings, Bamkole, 2019). This loss of connection to nature is bad for children, who often experience an "indoor childhood" and do not play outside much (Kowarik et al., 2017).

Fortunately, there is a natural way to fight these urban issues. It is called Urban Green Infrastructure (UGI). Under the term UGI, a network of natural and semi-natural city areas is meant. This includes parks, trees, and gardens. Such locations provide "ecosystem services" to the people. Basically, these are simple benefits that humans obtain from nature, like clean water, climate regulation, or recreation (Breuste et al., 2013). At the local city level, green elements are the main providers of these daily benefits for residents.

How do these services work? Air dust is filtered by trees, and on a hot day, a park can be much cooler than the built-up streets around it. Expensive floods are prevented because natural soils and plants soak up extra rainwater (Kowarik et al., 2017). Furthermore, nature is vital for the social fabric of a city. Green spaces build social cohesion, giving different demographic groups a safe place to meet and interact (Jennings, Bamkole, 2019). Nature is also a strong economic factor. Attractive green areas increase local real estate values and save maintenance costs for governments (Kowarik et al., 2017; Trojanek et al., 2018).

Scientists call certain problems ecosystem disservices. Severe pollen allergies, for example, or tree roots that damage city pavements (Sokolova et al., 2024). There is also the problem of unfair distribution. Fewer parks, more noise, and more pollution are usually found in socially disadvantaged neighborhoods, which creates a clear social problem.

Even with all these good things, cities still destroy green spaces to build new houses or roads. Many city planners only see parks as a maintenance cost. This must change. This research explains why urban green spaces are so important for daily life. It reviews the literature on the different ecosystem services they provide and shows how green infrastructure affects human well-being. Sustainable city development is only possible if ecosystem services become a central part of the urban planning agenda.

2. Theoretical framework and methodology

To better understand how different authors assess urban green spaces, this study uses a qualitative synthesis of existing scientific literature and research reports instead of conducting primary research. Because the selected articles focus on various cities and urban spaces, a wider perspective on the chosen topic is provided.

The principles of transparency and reproducibility were directly taken into account while choosing the literature. The study was mostly based on searches carried out in Google Scholar using the following keywords: "urban green spaces", "ecosystem services", "green infrastructure", and "urban sustainability". Preferably, the studies chosen for review were those published within the last 20 years and available in open-access full-text format. Thus, any reader can easily verify all cited sources without the need for paid subscriptions.

Thematic and comparative methods were applied to analyze the collected data. The first step was to categorize information into specific themes, including climate regulation, health benefits, social impacts, and economic benefits. A comparative method was then used to look at data from different urban spaces after the information was arranged by theme. This helped determine the most significant benefits of green spaces and how they function in various cities.

There are some limitations to this method as well. Because this paper is based entirely on previously published literature, it cannot cover all aspects of a particular topic in specific cities. Moreover, since no primary research was conducted, the findings are limited by the original authors' perspectives. Future primary research methods, such as conducting surveys among local residents, could be used to obtain a wider perspective on the local effects of green spaces.

3. An overview of the literature

Throughout the past few decades, the interest in urban nature has expanded from numerous points of view. The literature indicates significant growth in this area. According to Sokolova et al. (2024), the evolution of this domain has been examined through a bibliometric analysis of scientific articles published since 1995 (Figure 2). Prior to 2010, Green Infrastructure and Ecosystem Services were usually considered as separate and independent concepts. However, later researchers recognized the need to examine both concepts in an integrated manner.

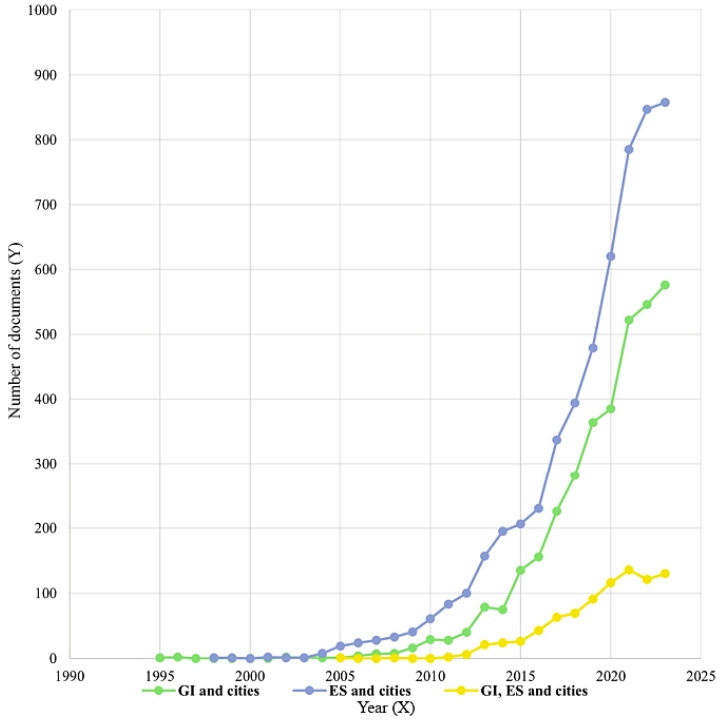


Figure 2. Trend of Green Infrastructure and Ecosystem Services-related publications from 1995 to 2023. Source: Sokolova et al. (2024).

Global research in the contemporary world has focused on human wellbeing, urban resilience, nature based solutions and mitigating climate change (Sokolova et al., 2024). The literature has categorized the services provided by the ecosystem into several types. Four main types of ecosystem services are defined by the TEEB approach: provisioning, regulating, cultural, and supporting services (Breuste et al., 2013; Kowarik et al., 2017; Wentworth, 2017; Coutts, Hahn, 2015). To systematically evaluate the benefits of urban green infrastructure, this study uses these categories as a clear analytical framework linking theoretical concepts to specific empirical indicators. Regulating services include essential environmental controls like temperature reduction, air purification and water absorption (Coutts, Hahn, 2015). Cultural services provide intangible benefits to the population such as psychological restoration, active recreation and social cohesion (Jennings, Bamkole, 2019). Supporting services are necessary to maintain basic ecological functions including soil formation and habitats for urban biodiversity (Hanna et al., 2024). Finally, provisioning services supply direct material goods to city residents, for example fresh food from urban agriculture (Kowarik et al., 2017). Through this structured framework, the numerous empirical studies provided by the literature can be logically organized to show how these services function and directly impact the quality of life in modern cities.

However, the quantification of the benefits provided by these services has proven to be difficult. The measurement of regulating services, such as air cooling and water absorption, is usually done directly using physical measurement tools (Hanna et al., 2024). On the other hand, the evaluation of cultural services has proven to be more difficult, as it relies heavily on human perceptions and subjective surveys (Bratman et al., 2019; Hanna et al., 2024). A bias has also been observed in the literature. For a long time, large urban parks and forests were the main focus of research. Moreover, the literature often ignored small green infrastructure such as green roofs, wetlands, and sports facilities (Sokolova et al., 2024). The contemporary literature is now trying to examine the functioning of green infrastructure as a whole (Stangl et al., 2022).

For example, regulating services are crucial because city environments are often very stressful. They have too much concrete and asphalt. This increases the temperatures in these regions compared to those in the surrounding rural areas. This effect is referred to as the urban heat island effect (World Health Organization, Regional Office for Europe, 2016). For example, Wentworth (2017) shows that temperatures in central London are 5 degrees Celsius higher than in the surrounding rural areas. This high heat increases the risk of heat-related diseases. In fact, Kowarik et al. (2017) indicate that in Berlin, heat stress contributes to 4-5 percent of total deaths. In contrast, trees and green spaces have the advantage of reducing air temperatures (Figure 3). It is notable that a park with a width of 50-100 meters is 3-4 degrees cooler than the streets surrounding it during hot weather (Kowarik et al., 2017; Meili et al., 2021). Air pollution is another major concern in the literature. In the United Kingdom, vehicle emissions form the major cause of air pollution in urban areas (Wentworth, 2017). Green spaces have the advantage

of filtering pollutants in the air. For example, dense tree avenues can reduce air pollution by 15 percent (Kowarik et al., 2017). Ineffective planning of spaces in urban areas can actually increase exposure to air pollution. Specifically, poorly planned street trees can trap dirty air and make pollution worse (Wentworth, 2017). In this case, it is apparent that low hedges are often more effective than tall trees in improving air quality in major roadways.

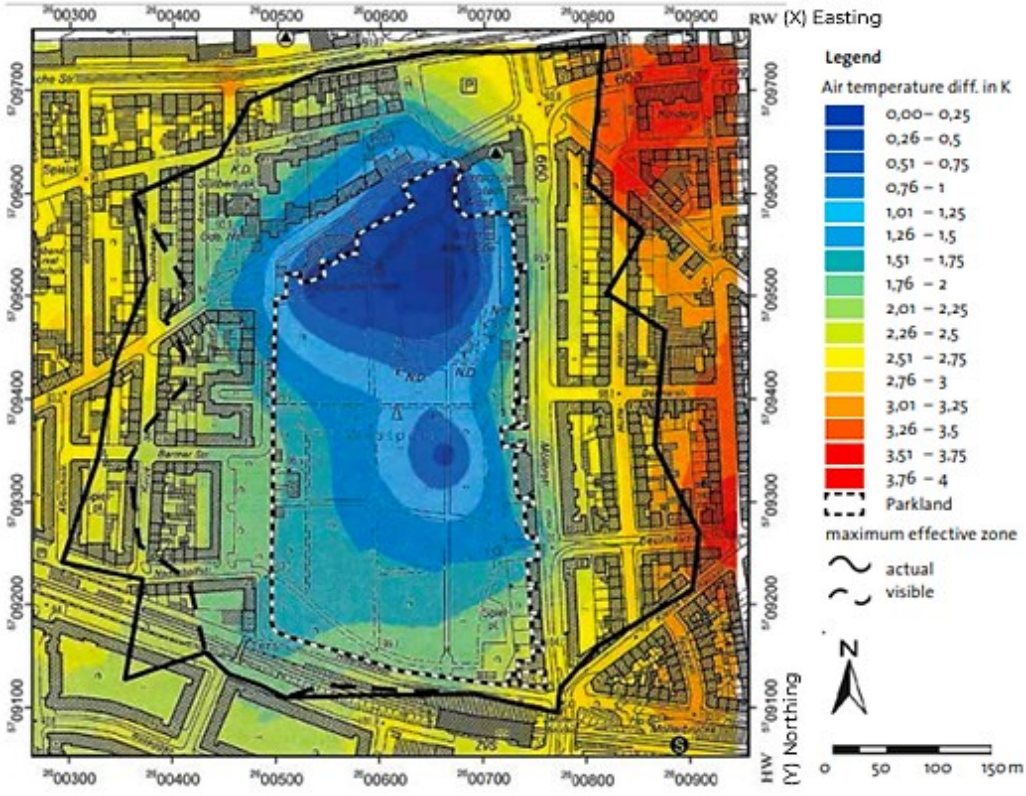


Figure 3. Lower night air temperatures in a Dortmund park and their effects on the environment. The differences refer to the coldest point on the north edge of the park.

Source: Bongardt (2006), as cited in Kowarik et al. (2017).

Another important issue is water management (Coutts, Hahn, 2015). Heavy rain often floods city streets. Hanna et al. (2024) did a big study in Zaragoza, Spain. They evaluated how various green spaces regulate water. They found that "imperviousness", which means hard surfaces like asphalt, is the main reason why water regulation fails in cities. During heavy rain, these hard surfaces block water infiltration and become a major source of runoff pollution (Zhao, Ma, 2019). To overcome this problem, Sustainable Drainage Systems can be implemented, as suggested by Wentworth (2017), Hanna et al. (2024), and Hoffmann et al. (2015). Such natural interventions will not only control flooding but will also reduce the expenses for the government.

Beyond physical conditions, psychological well-being is a major theme in recent studies. In modern cities, mental health problems are growing. A large review by Bratman et al. (2019) explains that contact with nature works as a "psychological ecosystem service". Sleep problems, high anxiety, and depression are significantly reduced when people spend time in green

environments. To measure this practically, scientists often use specific rules. For example, the new 3-30-300 green space rule was recently tested in Barcelona by Nieuwenhuijsen et al. (2022). According to this rule, every person should see three trees from their window, live in a neighbourhood with 30 percent tree cover, and be only 300 meters away from a park. Sadly, only about 4.7 percent of people met all these criteria in the Barcelona study. However, the results were very clear. When the full rule was met, people visited psychologists or psychiatrists much less. Also, they used fewer antidepressant medications. Daily nature contact acts as a strong medicine (Bratman et al., 2019; Chen et al., 2021).

Social networks are significantly affected by urban greenery. By taking simple walks in a park, communities build social capital and trust. Jennings and Bamkole (2019) highlight that green spaces support social cohesion. They provide a secure environment where different people can meet and feel a sense of belonging (Chen et al., 2021). This naturally reduces social isolation. Breuste et al. (2013) offer empirical evidence on how this works in several global cities. In Buenos Aires, people visit parks mostly to relax and relieve stress. Once there, visitors usually spend over two hours sitting or walking. In fact, a large number of residents use these green spaces on a daily basis. For almost half of the respondents, visiting the local park is their most important free-time activity. However, these visitors focus much more on basic cleanliness and security than on the actual trees and plants. The majority of people travel less than 500 meters to access these green spaces (Figure 4). This shows that local neighborhood parks are the most useful. In Shanghai, public parks offer the urban population a rare chance to observe and learn about nature. Without these accessible green zones, building a cohesive and healthy community becomes very difficult. Because daily access is so critical, the physical distance from home plays the biggest role.

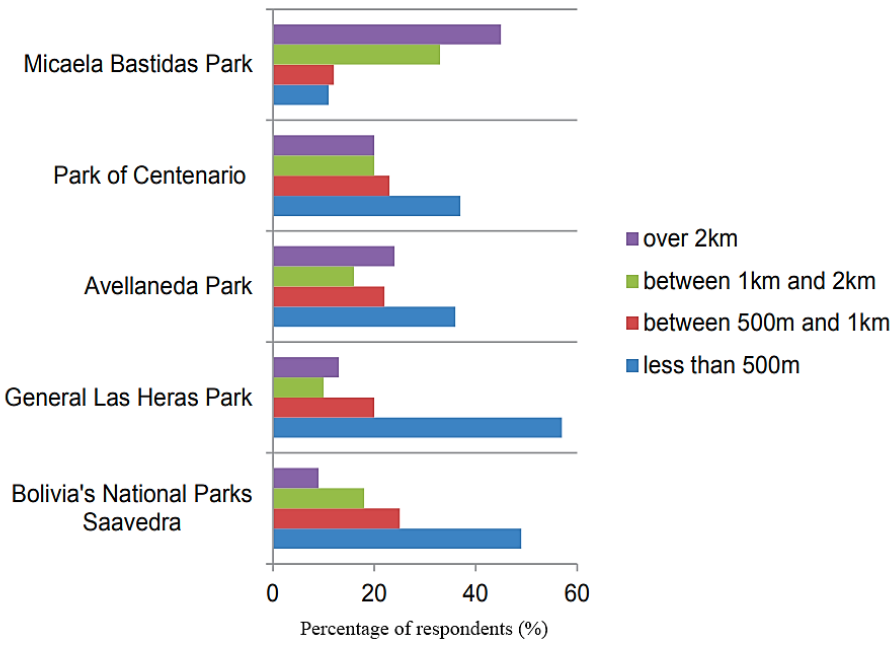


Figure 4. Distance from where the visitors came to the parks in Buenos Aires.
Source: Breuste et al. (2013).

Urban environments offer habitats for many wild animals, and green spaces become vital to ensure high biodiversity. Breuste et al. (2013), for instance, assessed 19 public parks in Linz, Austria by means of breeding bird populations as a measure of environmental quality. As shown in their research findings, the park with mature trees and a wild forest area had 37 bird species, while the smallest one and the most disturbed hosted only one species. Therefore, such factors as park size and level of human disturbance play a significant role in ensuring the diversity of species in these sites. In addition to being a habitat for birds, urban green infrastructure provides an environment for important insect pollinators, such as bees. According to Coutts and Hahn (2015), pollination is a key aspect of ecosystem services. However, an important drawback associated with this issue is the lack of awareness among a vast majority of the population. Breuste et al. (2013) found in their Shanghai case study that park users were primarily motivated by recreation rather than the acquisition of ecological knowledge. At the same time, people have a special emotional relationship towards urban parks, which may be transformed into useful ecological knowledge through effective educational activities.

Provisioning services associated with food production have been discussed in the literature. There is growing interest in urban food production. In London, 21 tonnes of food were produced through urban farming in 2013, as stated in Wentworth (2017). Although this is a small quantity for a big city, community gardens have other benefits. In urban farming, people tend to eat more vegetables and also increase their level of physical activity (Wentworth, 2017). In Germany, 50 percent of fruits and vegetables for households with allotment gardens are provided by their gardens (Kowarik et al., 2017). In addition, gardening programs help children learn about healthy diets. The "Vegetable Academy" in Germany is described in Kowarik et al. (2017), where school children learn to grow and prepare vegetables (Figure 5). Children today do not know much about their food, but by growing and harvesting their own food, they develop a stronger understanding of nature, which may help them fight obesity and develop social skills.

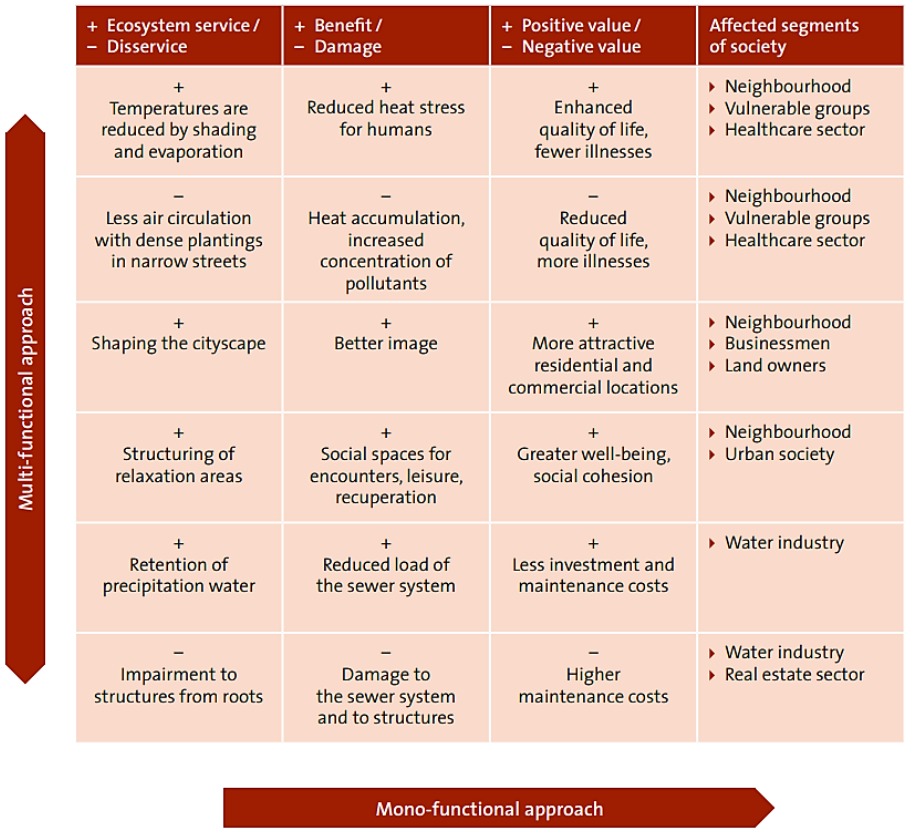
Figure 5. A litter-strewn wasteland at Moritzplatz in Berlin-Kreuzberg (left) was transformed into the "Princess Gardens" (right). (Photographs: Marco Clausen).

Source: Kowarik et al., 2017.

Nature is not always perfect. The scientific literature also looks at ecosystem disservices. These are the negative effects that nature can have on city life. Sokolova et al. (2024) state that researchers must study these negative sides to make smart planning decisions. What are these disservices? Some plants cause severe pollen allergies for residents. Tree roots can break pipes and damage the asphalt on roads. Additionally, new green spaces can accidentally introduce invasive species that displace local plants (Sokolova et al., 2024). Also, Wentworth (2017) notes that urban environments can have dangerous pests or diseases. Sometimes, people are simply afraid of dark, overgrown parks because of crime. Because of this fear, local communities might avoid these areas completely (World Health Organization, Regional Office for Europe, 2016). To fix this, city authorities must hold open discussions with residents to ensure these negative effects remain tolerable (Wentworth, 2017). Planners need to balance these negative things with the positive benefits.

Why do city planners often destroy parks to build new houses? Because they usually see green spaces as a financial cost, not as an asset. But the literature proves that nature has real economic value (Xu, Zhao, 2021). Urban nature is a strong location factor. Companies want to open offices in green, attractive cities. Having natural grounds around an office saves maintenance costs and creates a positive "green address" for the business (Kowarik et al., 2017). This green environment directly improves employee motivation and work performance. Also, green spaces increase the price of local real estate (Chen et al., 2022). A study in Cologne showed that moving 100 meters closer to a park increases an apartment's price by about 600 euros (Kowarik et al., 2017). Furthermore, living near a park makes people happier. Statistically, one extra hectare of green space in a neighborhood gives people a feeling of satisfaction equal to 276 euros of extra annual income (Kowarik et al., 2017).

Other European data also show this economic impact. In Warsaw, Trojanek et al. (2018) analyzed over 43,000 apartment sales. They found that an apartment less than 100 meters from a green area costs about 2.8 to 3.1 percent more. But distance really matters. The price bonus drops significantly after 200 meters. Beyond 400 meters, it completely disappears (Trojanek et al., 2018). Interestingly, this price premium is much higher for modern apartments constructed after 1989. New housing estates usually have too much concrete, so buyers highly value nearby public parks. Some cities adopt new policies to protect these spaces. Stauffer and Chagnon (2025) describe "Warsaw's Green Vision" and Budapest's "pocket parks" as great examples of this. These projects aim to bring nature back into crowded zones. The Hungarian pocket parks cover only about 1400 square meters. Yet, they successfully combine recreation with community food production (Stauffer, Chagnon, 2025). Even with such progress, many local planning authorities still lack ecological experts on their staff. In England, fewer than 35 percent of local councils actually employ an in-house ecologist (Wentworth, 2017). This highlights the need for a more comprehensive approach to managing urban greenery, moving from individual benefits to integrated multifunctional systems (Figure 6).



Source: Kowarik et al., 2017.

Figure 6. Approaches to city tree ecosystem services. Compares monofunctional (individual benefits) and multifunctional (synergies/trade-offs) methods. List of examples is not exhaustive.

The literature review also points out important gaps in current research. Sokolova et al. (2024) highlight a major problem. While large parks and forests are frequently studied, other green components like green roofs, sports facilities, and wetlands are often completely ignored. Because of this, stakeholders cannot fully comprehend the value of these alternative spaces. Hanna et al. (2024) observe that numerous projects currently concentrate heavily on green spaces inside dense urban cores. To overcome this, an increase in studies on peri-urban areas is strongly proposed, since these transition zones between city and country are critical for mitigating climate change. Another big challenge is measuring highly subjective cultural ecosystem services. To get a comprehensive understanding of urban sustainability, physical measurements must be combined with social and economic data (Sokolova et al., 2024).

4. Results of the investigation

A comparison of different scientific studies shows how urban green spaces work in reality. The results indicate that green infrastructure provides various ecosystem services depending on its location, size, and level of naturalness. Several city case studies illustrate these patterns.

Climate and water regulation are highly dependent on the design of the city (Hoffmann et al., 2015; Zhao, Ma, 2019). In Karachi, Pakistan, rapid growth occurred. According to Breuste et al. (2013), the built-up area increased massively between 1986 and 2003. At the same time, green coverage decreased from 111 to 75 sq. km. As a result, temperatures rose by up to 4°C. Small parks could not provide adequate air cooling due to the blocking effect of tall concrete structures (Breuste et al., 2013). The results of research in Zaragoza, Spain, prove this negative effect of concrete construction. By conducting tests on 30 green sites, Hanna et al. (2024) concluded that "imperviousness", or the surface covered with materials such as asphalt, is the core factor causing the ineffectiveness of climate and water regulation. Meanwhile, sites characterized by high naturalness and ecological functions provided more effective water supply and temperature cooling (Hanna et al., 2024). Nowadays, local authorities implement various initiatives to overcome dangerous urban heat islands. The threat is deadly: in Berlin alone, extreme heat causes about 4 to 5 percent of all mortalities (Kowarik et al., 2017). Furthermore, across Europe, up to 43,000 deaths could be prevented simply by meeting standard green space recommendations (Stauffer, Chagnon, 2025). For example, when adapting to heat waves in urban areas, Munich introduced temporary measures involving "walking tree alleys", while Basel adopted mandatory green roofs in new constructions to cut down energy use (Stauffer, Chagnon, 2025; Nasr et al., 2024). These practical solutions perfectly demonstrate the value of alternative green infrastructure that previous studies overlooked. The adoption of such sophisticated solutions, nevertheless, depends on the economic environment in which they are to be implemented. As far as affluent urban centers like Basel are concerned, it is relatively easy to mandate expensive strategies like green roofs. These interventions, however, may often prove beyond the financial reach of urban areas still growing economically (Breuste et al., 2013). In cases where cities lack sufficient resources, it becomes imperative to resort to more accessible options. Solutions which are both simple and highly efficient, like planting street trees and preserving local woodlands, become common practice (Kowarik et al., 2017).

One other equally important feature is whether city parks do indeed support wildlife. And the answer lies totally within the structure of the park itself. As noted by Breuste et al. (2013), in a study conducted across 19 public parks in Linz, Austria, the number of breeding birds was used as an index for biodiversity. The outcome of the research was unambiguous. With a size of 9.5 hectares, old trees, and patches of wild forests, the top park hosted 37 species of birds. But the worst park was very small and highly disturbed by human activity. It had only 1 bird species. This clearly shows that park size and human disturbance directly control urban biodiversity (Breuste et al., 2013). Furthermore the supporting services provided by these habitats yield immense economic value. For example the annual economic value of the pollination service that bees alone provide is estimated at 14.6 to 40 billion dollars in the United States (Coutts, Hahn, 2015).

In addition to physical and ecological factors, some interesting behavioral and mental health trends were uncovered by the findings. High urban density correlates positively with psychological stress. As stated by Bratman et al. (2019), access to nature can be viewed as a certain "psychological ecosystem service". But how much greenery do people actually need to feel better? To solve this problem, Nieuwenhuijsen et al. (2022) tested the new 3-30-300 green space rule on Barcelona residents. Under this guideline, a person should be able to see three trees from their home, have 30 percent tree canopy cover in their neighborhood, and live within 300 meters of a park. In the Barcelona study, only 4.7 percent of people met all these criteria. However, when the full rule was met, residents used less antidepressant medication. Also, their visits to psychiatrists or psychologists dropped significantly (Nieuwenhuijsen et al., 2022).

Social connections also grow stronger in green areas. Jennings and Bamkole (2019) report that urban parks create safe spaces where diverse groups interact. This builds social capital and reduces isolation. Distance is a very important factor for these visits. In Buenos Aires, Argentina, Breuste et al. (2013) interviewed park visitors. They found that most people walked less than 500 meters to get to their local park. Once there, the majority stayed for more than two hours. Many people visited every single day.

To fully understand these behavioral patterns, they must be integrated into a broader conceptual model of interaction between humans and nature proposed by Bratman et al. (2019). According to this framework, the actual psychological benefits depend heavily on the specific experience and the environmental awareness of the user. For instance, perceived safety and upkeep strongly moderate the relationship between natural features and park exposure. This perfectly explains why visitors often care more about cleanliness and security than about natural elements like plants (Breuste et al., 2013). Furthermore, the interaction model suggests that the delivered dose of nature is affected by the individual attitudes and receptivity of the people (Bratman et al., 2019). This theoretical concept is supported by empirical findings from Shanghai, where a study by Breuste et al. (2013) showed that most people visit parks primarily for psychological restoration and to escape the crowded city. Since engaging with biodiversity depends on previous environmental education, the educational potential of these spaces is frequently ignored. As a result, about 37 to 53 percent of visitors admit they never use the park to learn about nature.

Synthesized data shows that environmental and social benefits translate into real economic results. Natural capital directly saves money for local governments (Kowarik et al., 2017; Xu, Zhao, 2021). Natural drainage systems prevent expensive floods (Stangl et al., 2022; Hoffmann et al., 2015; Wentworth, 2017), while billions of euros are saved on healthcare by lowering stress and respiratory diseases (Kowarik et al., 2017; World Health Organization, Regional Office for Europe, 2016; Roe et al., 2013). Furthermore, this economic impact extends directly to the real estate market (Chen et al., 2022). In Warsaw, Trojanek et al. (2018) analyzed over 43,000 apartment sales. An urban green area within 100 meters increases an apartment's price

by 2.8 to 3.1 percent. This price premium is significantly amplified for newer apartments built after 1989. Since modern concrete housing estates lack natural elements, an extra 8.0 to 8.6 percent is willingly paid by buyers for homes near public urban green areas (Trojanek et al., 2018).

Based on the findings presented in the scientific literature concerning various ecosystem disservices, it becomes evident that the negative aspects of urban green infrastructure should not be ignored in favor of positive ones. While green spaces help in mitigating climate change, they are capable of exerting physical pressures on urban infrastructure as well. In this regard, tree roots tend to damage pavement and penetrate into underground sewage systems, causing considerable economic problems for both water utilities and real estate developers (Kowarik et al., 2017). Apart from that, negative health outcomes can arise from the presence of green spaces as well. There is no doubt that certain tree species produce large amounts of pollen that can trigger asthma and allergies. Additionally, natural spaces can serve as hosts for vectors of certain diseases such as ticks and mosquitoes, which results in a higher prevalence of conditions such as Lyme disease within the area (World Health Organization, Regional Office for Europe, 2016). Lastly, the benefits of social interaction in green spaces can be hindered by issues of safety. The overgrowth of plants may cause anxiety due to the fear of crime, hence discouraging the elderly, women, and ethnic minorities from using parks (World Health Organization, Regional Office for Europe, 2016). In this regard, to counteract the undesirable aspects of the ecosystem and improve the positive ones, the following measures should be taken by park management: planning the space to reduce pollen exposure, installing proper lighting systems, and conducting regular maintenance to prevent vegetation overgrowth.

In order to give a complete overview of the available research, the empirical findings and their corresponding indicators from the literature were systematized using the TEEB framework discussed earlier. These results have been provided in Table 1.

Table 1.
Summary of main empirical findings by ecosystem service category

ES Category	Indicator	Main Findings	Reference
Regulating	up to 4 degrees Celsius rise	loss of greenery caused extreme heat islands in Karachi	Breuste et al. (2013)
Regulating	30 green sites analyzed	impervious surfaces reduce climate and water regulation in Zaragoza	Hanna et al. (2024)
Regulating	4 to 5 percent of mortality	extreme heat increases death rates in Berlin	Kowarik et al. (2017)
Regulating	3 to 4 degrees Celsius lower temperatures	parks measuring 50 to 100 meters wide effectively cool surrounding streets during hot weather	Kowarik et al. (2017)
Regulating	up to 15 percent reduction in particulate matter	dense tree avenues effectively filter particulate matter from the air	Kowarik et al. (2017)
Regulating	43 000 prevented deaths	impact of meeting green space recommendations across Europe	Stauffer and Chagnon (2025)
Regulating	11.7 percent mortality reduction	green infrastructure reduces heat related deaths in Sydney	Stauffer, Chagnon (2025)

Cont. table 1.

Cultural	8.0 to 8.6 percent price increase	observed for newer apartments (built after 1989) located within 100 meters of an urban green area in Warsaw	Trojanek et al. (2018)
Cultural	2.8 to 3.1 percent price increase	observed for all apartments located within 100 meters of an urban green area in Warsaw	Trojanek et al. (2018)
Cultural	almost 600 euros price increase	observed for apartments located 100 meters closer to a park in Cologne	Kowarik et al. (2017)
Cultural	276 euros income equivalent	extra hectare of green space increases life satisfaction equivalently	Kowarik et al. (2017)
Cultural	Less than 500 meters distance	crucial threshold for daily park visits in Buenos Aires	Breuste et al. (2013)
Cultural	4.7 percent of residents meet the 3-30-300 rule	meeting the rule significantly reduces visits to psychologists or psychiatrists in Barcelona	Nieuwenhuijsen et al. (2022)
Cultural	37 to 53 percent of visitors	visitors primarily seek rest ignoring educational potential of parks	Breuste et al. (2013)
Supporting	37 versus 1 bird species	larger natural parks boost urban biodiversity in Linz	Breuste et al. (2013)
Supporting	14.6 to 40 billion dollars	annual economic value of pollination services provided by bees in the United States	Coutts, Hahn (2015)
Provisioning	21 tonnes of food	urban farming supplied fresh food in London in 2013	Wentworth (2017)
Provisioning	50 percent self sufficiency in fruit and vegetables	allotment gardens provide half of the required produce for gardening households in Germany	Kowarik et al. (2017)
Provisioning	1400 square meters	pocket parks integrate community food production in Budapest	Stauffer and Chagnon (2025)

Note. ES refers to Ecosystem Service. Indicator refers to the specific empirical metric used to quantify the service's impact as identified in the reviewed studies. Higher property values serve as an indicator of cultural services, reflecting residents' willingness to pay for the aesthetic and recreational amenities that local green spaces provide.

Source: own work based on the literature review.

Urban planning needs real changes. Large forests and regular parks are simply not enough anymore. To actually deliver ecosystem services, smaller components like green roofs, wetlands and sports areas must be incorporated into dense neighborhoods (Sokolova et al., 2024; Nasr et al., 2024). The solution is clear. Cities should reduce impervious areas to protect natural soils. Vital green spaces must be located very close to residential areas. Without this approach, future health problems cannot be avoided.

5. Conclusions

In modern cities, urban green spaces must be viewed as a basic survival tool rather than simple decoration. As the urban population grows, routine nature contact is lost completely. Cities face extreme heat, dirty air, and heavy flooding. Fortunately, these dangerous problems can be fixed by ecosystem services to improve human quality of life significantly. The comparative analysis of the literature allows drawing several overarching conclusions:

1. *The physical quality of green spaces matters*. Planting a tree in a small hole surrounded by asphalt is not enough (Stangl et al., 2022). Too much concrete ruins water regulation, as Hanna et al. (2024) proved. To protect cities from floods and heat, impervious surfaces must be reduced. Also, the "naturalness" of urban soils and plants needs to increase. A mix of different green areas is required. Often, scientists focus only on large forests. However, green roofs, wetlands, and sports areas are just as important for urban sustainability (Sokolova et al., 2024; Nasr et al., 2024). Small spaces work well. Budapest created "pocket parks" to bring nature back into dense city zones (Stauffer, Chagnon, 2025).
2. *Green infrastructure regulates climate and air quality.* Urban environments suffer from the heat island effect. These elevated temperatures pose severe health hazards (Coutts, Hahn, 2015). According to Kowarik et al. (2017), about 4 to 5 percent of all deaths in Berlin are linked to extreme heat. Trees and parks help lower the temperature (Meili et al., 2021; Reis, Lopes, 2019). In the Sydney area, green infrastructure could reduce daily mortality from heat by up to 11.7 percent (Stauffer, Chagnon, 2025). Vegetation also acts as a crucial filter. Particulate matter pollution kills around 47,000 people per year across Germany. Urban trees could reduce these pollution levels by up to 15 percent (Kowarik et al., 2017). Bad planning makes things worse. Pollutants are actually trapped by poorly planned street trees along busy roads (Wentworth, 2017). For air quality next to big roads, low hedges are sometimes a much better choice.
3. *Distance and accessibility control human health*. If a park is too far away, people do not visit it. The World Health Organization recommends that residents should have access to at least 0.5 hectares of green space within 300 meters from home (Stauffer, Chagnon, 2025). Recently, researchers tested the 3-30-300 rule. According to Nieuwenhuijsen et al. (2022), every person should see three trees from home, have 30 percent tree cover in the neighborhood, and live within 300 meters of a park. When this rule is met, mental health gets much better. Also, Bratman et al. (2019) define nature contact as a strong "psychological ecosystem service". Regular nature visits lower stress and reduce the use of antidepressant medication (World Health Organization, Regional Office for Europe, 2016; Roe et al., 2013). Because healthy people cost less, healthcare systems save a huge amount of money every year (Kowarik et al., 2017). Therefore, giving everyone equal access to nature is a matter of social justice.
4. *Size and human disturbance affect urban biodiversity.* Many wild animals can live in urban parks. As seen in Austria, large parks with mature trees hosted 37 different bird species, whereas small, highly disturbed areas supported only one (Breuste et al., 2013). There is, however, a wide gap between this ecological reality and what residents perceive. Given that most people view parks in terms of recreational activities and ignore their ecological features, city governments need to make use of such settings to

impart knowledge of ecological systems to the citizens (Breuste et al., 2013; Kowarik et al., 2017).

5. *Urban nature builds communities and provides food*. Community gardens do much more than agriculture. Different social groups are brought together in these places. By working in a garden, residents build social capital and strong place attachment (Jennings, Bamkole, 2019; Chen et al., 2021). This naturally reduces social isolation. Growing food in the city also teaches people about healthy diets. Gardening projects fight obesity and help children escape an "indoor childhood", as Kowarik et al. (2017) highlight.
6. *City planners must be realistic about ecosystem disservices.* Nature has a negative side too. Tree roots can penetrate underground sewage systems and cause structural damage. This directly leads to higher maintenance costs for local authorities and the real estate sector (Kowarik et al., 2017). As the World Health Organization, Regional Office for Europe (2016) noted, unmanaged vegetation can increase anxiety due to fear of crime among vulnerable populations like older people, women and ethnic minorities. They also highlighted the real risk of vector-borne conditions such as Lyme disease spreading through ticks and mosquitoes in these areas. Furthermore, pests can live in urban environments, and severe allergies and asthma can be triggered by some plants (Wentworth, 2017; World Health Organization, Regional Office for Europe, 2016). Poorly planned street trees can even trap vehicle emissions and worsen local air quality (Wentworth, 2017). New green spaces might also accidentally introduce invasive species that displace local plants (Sokolova et al., 2024). These negative effects must be considered by planners. Ignoring these environmental and social issues can potentially lead to community resistance against new green projects (World Health Organization, Regional Office for Europe, 2016). Balancing both the benefits and the negative effects is necessary to make safe decisions, as Sokolova et al. (2024) noted.
7. *Nature is a basic public service, not a financial burden.* Urban green spaces are a highly valuable part of natural capital (Chen et al., 2022). In Cologne, reducing the distance to a park by 100 meters increases an apartment price by almost 600 euros (Kowarik et al., 2017). According to Trojanek et al. (2018), an urban green at a distance of less than 100 meters increases the price of an apartment in Warsaw by 2.8 to 3.1 percent. This financial premium steadily declines as the distance increases and completely disappears beyond 400 meters. Furthermore, this value is significantly amplified for newer housing. Buyers willingly pay an extra 8.0 to 8.6 percent for modern homes built after 1989 and located less than 100 meters from an urban green. However, many local authorities still lack ecological experts on their staff (Wentworth, 2017). This critical gap must be closed. The true economic value of nature should be calculated directly in city budgets (Xu, Zhao, 2021). Because green infrastructure is not considered a luxury, ecosystem services belong at the heart of all future urban planning (Kowarik et al., 2017).

The study demonstrates that urban greening contributes significantly to all four categories of ecosystem services, with regulating and cultural benefits being the most frequently reported in the reviewed literature. The worldwide relevance of green infrastructure in the context of urbanization cannot be questioned. However, the techniques applied to it cannot be identical everywhere. Modern urban development must consider urban morphology and different stages of economic development. Advanced and expensive technologies like green roofs and complex living walls will have the maximum efficiency in developed cities like Basel (Nasr et al., 2024; Stauffer, Chagnon, 2025). They also play an integral part in sustainable urban drainage systems. These installations retain rainwater and significantly reduce the load on traditional municipal sewers (Hoffmann et al., 2015). On the other hand, rapidly growing cities and less economically developed regions need to focus on cost effective nature-based strategies. The protection of existing local forests and the planting of street trees will be among the most efficient actions for these locations (Breuste et al., 2013). Urban ecosystem initiatives also require customization to specific local conditions. High-density historical centers and modern concrete residential areas will benefit greatly from compact green infrastructure like pocket parks (Stauffer, Chagnon, 2025). At the same time, peri-urban areas will need extensive green infrastructure systems for mitigating climate change effects (Hanna et al., 2024). In order to achieve sustainable urban development, experts may incorporate regional geographic location, climatic conditions, and socio-economic factors in urban planning. Such an intentional approach is, according to Kowarik et al. (2017), a key determinant of high residential quality of life.

References

1. Bongardt, B. (2006). Stadtklimatologische Bedeutung kleiner Parkanlagen – dargestellt am Beispiel des Dortmunder Westparks. *Essener Ökologische Schriften, Vol. 24.* Westarp Wissenschaften. Retrieved from: https://duepublico2.uni-due.de/servlets/MCRFileNodeServlet/duepublico_derivate_00014473/Dissertation_Bongardt_FB_BioGeo.pdf, 09.04.2026
2. Bratman, G.N., Anderson, C.B., Berman, M.G., Cochran, B., de Vries, S., Flanders, J., Folke, C., Frumkin, H., Gross, J.J., Hartig, T., Kahn, P.H., Jr., Kuo, M., Lawler, J.J., Levin, P.S., Lindahl, T., Meyer-Lindenberg, A., Mitchell, R., Ouyang, Z., Roe, J., …, Daily, G.C. (2019). Nature and mental health: An ecosystem service perspective. *Science Advances*, *5(7),* eaax0903. https://doi.org/10.1126/sciadv.aax0903
3. Breuste, J., Schnellinger, J., Qureshi, S., Faggi, A. (2013). Urban ecosystem services on the local level: Urban green spaces as providers. *Ekológia, 32*(3). Bratislava, 290-304. doi:10.2478/eko-2013-0026

4. Chen, K., Lin, H., You, S., Han, Y. (2022). Review of the impact of urban parks and green spaces on residence prices in the environmental health context. *Frontiers in Public Health*, *10*, Article 993801. https://doi.org/10.3389/fpubh.2022.993801
5. Chen, K., Zhang, T., Liu, F., Zhang, Y., Song, Y. (2021). How does urban green space impact residents' mental health: A literature review of mediators. *International Journal of Environmental Research and Public Health*, *18*(22), Article 11746. https://doi.org/10.3390/ijerph182211746
6. Coutts, C., Hahn, M. (2015). Green infrastructure, ecosystem services, and human health. *International Journal of Environmental Research and Public Health*, *12*(8), 9768-9798. https://doi.org/10.3390/ijerph120809768
7. Eurostat (2024). *Urban-rural Europe - introduction*. European Commission. Retrieved from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Urban-rural_Europe_-_introduction, 19.03.2026.
8. Hanna, E., Bruno, D., & Comín, F. A. (2023). The ecosystem services supplied by urban green infrastructure depend on their naturalness, functionality and imperviousness. *Urban Ecosystems*, *27*, 187-202. https://doi.org/10.1007/s11252-023-01442-9
9. Hoffmann, B., Laustsen, A., Jensen, I.H., Jeppesen, J., Briggs, L., Bonnerup, A., Hansen, L., Sommer Lindsay, R., Rasmussen, J., Andersen, U.R., Rungø, M., Uggerby, M., Bay, H., Quist Rasmussen, S., Vester, M., Riise, J.C., Krag Strømberg, C., Dreiseitl, H., Astrup, R., ..., Milert, T. (2015). *Sustainable urban drainage systems: Using rainwater as a resource to create resilient and liveable cities*. State of Green. Retrieved from: https://backend.orbit.dtu.dk/ws/files/118747536/SUDS_White_paper.pdf, 23.03.2026.
10. Jennings, V., Bamkole, O. (2019). The Relationship between Social Cohesion and Urban Green Space: An Avenue for Health Promotion. *International Journal of Environmental Research and Public Health*, *16*(3), 452. https://doi.org/10.3390/ijerph16030452
11. Kowarik, I., Bartz, R., Brenck, M., Hansjürgens, B. (2017). *Ecosystem services in the city: Protecting health and enhancing quality of life. Summary for decision-makers*. Natural Capital Germany - TEEB DE; Technical University of Berlin; Helmholtz Centre for Environmental Research - UFZ. Retrieved from: https://www.ufz.de/export/data/global/190507_TEEB_De_Broschuere_KF_Bericht3_Stadt_engl_web.pdf, 02.03.2026.
12. Meili, N., Manoli, G., Burlando, P., Carmeliet, J., Chow, W.T.L., Coutts, A.M., Roth, M., Velasco, E., Vivoni, E.R., Fatichi, S. (2021). Tree effects on urban microclimate: Diurnal, seasonal, and climatic temperature differences explained by separating radiation, evapotranspiration, and roughness effects. *Urban Forestry & Urban Greening*, *58*, Article 126930. https://doi.org/10.1016/j.ufug.2020.126970
13. Nasr, Y., El Zakhem, H., Hamami, A.E.A., El Bachawati, M., Belarbi, R. (2024). Comprehensive assessment of the impact of green roofs and walls on building energy performance: A scientific review. *Energies*, *17*(20), Article 5160. https://doi.org/10.3390/en17205160

14. Nieuwenhuijsen, M.J., Dadvand, P., Márquez, S., Bartoll, X., Barboza, E.P., Cirach, M., Borrell, C., Zijlema, W.L. (2022). The evaluation of the 3-30-300 green space rule and mental health. *Environmental Research*, *215*(Part 2), 114387. https://doi.org/10.1016/j.envres.2022.114387
15. Reis, C., Lopes, A. (2019). Evaluating the cooling potential of urban green spaces to tackle urban climate change in Lisbon. *Sustainability*, *11*(9), 2480. https://doi.org/10.3390/su11092480
16. Roe, J.J., Thompson, C.W., Aspinall, P.A., Brewer, M.J., Duff, E.I., Miller, D., Mitchell, R., Clow, A. (2013). Green Space and Stress: Evidence from Cortisol Measures in Deprived Urban Communities. *International Journal of Environmental Research and Public Health, 10(9),* 4086-4103. https://doi.org/10.3390/ijerph10094086
17. Sokolova, M.V., Fath, B.D., Grande, U., Buonocore, E., Franzese, P.P. (2024). The role of green infrastructure in providing urban ecosystem services: Insights from a bibliometric perspective. *Land, 13(10),* Article 1664. https://doi.org/10.3390/land13101664
18. Stangl, R., Minixhofer, P., Wultsch, T., Briefer, A., Scharf, B. (2022). Green-blue infrastructure in the built environment: Sustainable and resource-saving designs for urban structures and open spaces. *IOP Conference Series: Earth and Environmental Science*, *1078*, Article 012132. https://doi.org/10.1088/1755-1315/1078/1/012132
19. Stauffer, A., Chagnon, M. (2025). *Greening cities for better health: Good practice from across the EU* [Policy brief]. Health and Environment Alliance (HEAL). Retrieved from: https://www.env-health.org/wp-content/uploads/2025/07/EN_Green-spaces-policy-briefing_v6.pdf, 25.03.2026
20. Trojanek, R., Gluszak, M., Tanas, J. (2018). The effect of urban green spaces on house prices in Warsaw. *International Journal of Strategic Property Management*, *22*(5), 358-371. https://doi.org/10.3846/ijspm.2018.5220
21. Wentworth, J. (2017). *Urban green infrastructure and ecosystem services*. Parliamentary Office of Science and Technology. Retrieved from: https://cdn.cyfoethnaturiol.cymru/682198/urban-green-infrastructure-ecosystem-services.pdf, 10.03.2026.
22. World Health Organization, Regional Office for Europe (2016). *Urban green spaces and health*. Retrieved from: https://iris.who.int/handle/10665/345751, 30.03.2026
23. Xu, H., Zhao, G. (2021). Assessing the value of urban green infrastructure ecosystem services for high-density urban management and development: Case from the capital core area of Beijing, China. *Sustainability*, *13*(21), Article 12115. https://doi.org/10.3390/su132112115
24. Zhao, W., Ma, J. (2019). Landscape applications of rainwater resources in urban green space: A case study of green space reconstruction along Riverside Street in Suzhou. *IOP Conference Series: Earth and Environmental Science*, *349*, Article 012020. https://doi.org/10.1088/1755-1315/349/1/012020