

## Evaluating the green infrastructure concept in combating climate change

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### Abstract

The concept of green infrastructure is an important element of sustainable cities. As components of the green infrastructure system, natural habitats, green corridors, open and green spaces in the urban landscape are interrelated and contribute to the development of urban ecology. In this context, this study aimed to investigate the definition, planning, and the concept of green infrastructure for a sustainable city, to improve the existing green infrastructure in cities in the fight against climate change, within the framework of a theoretical evaluation. Within the framework of sustainable urban development, the concepts have been researched with a qualitative method in a way to provide a theoretical evaluation. After the literature review of this research, conclusions and recommendations were developed. At this point, the concept of green infrastructure has increasing importance for the formation of resilient cities capable of coping with the consequences of global warming and climate change.

Keywords: green infrastructure; global warming; sustainability; urban ecology

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## **1. Introduction**

Since the emergence of humanity, cities and their relations with the natural environment have gained a brand-new dimension after the industrial revolution (Stearns, 2020). The destruction of cities to the natural environment is increasing day by day due to the rapid increase in population, the coming of people living in rural areas to cities, excessive misuse of resources, and urban sprawl. Along with urban activities, the excessive and unconscious use of natural resources reduces the sustainability of ecosystem services day by day. This situation causes environmental problems on a large scale.

The negative effects of cities on the ecosystem accelerate environmental problems. Issues that directly concern urban life, such as waste, water, energy, pollution, and natural resources, cause environmental damage (Appannagari, 2017). As a result, it becomes a situation that threatens the future of the planet we live in, such as climate change, ocean acidification, deforestation, desertification, loss of fertile lands, reduction of biodiversity, and extinction of species. However, in the face of this situation, cities can produce and implement new plans instead of being the cause of problems.

Climate change is the cause of sudden and unexpected weather events on Earth. Cities are the areas where the effects of climate change are most affected and felt (Ebi et al., 2021). These effects occur in cities such as increased heat island effect, air pollution, heat waves, water scarcity, changes in precipitation regime, increase in the number of dry days, and rainwater causing floods or overflows. It has many benefits to ecosystems, humans, and other living things.

Regulatory ecosystem services provided by ecosystems have an important benefit in reducing the effects of climate change in cities and increasing the resilience of cities against these effects (Mngumi, 2020). These services are; are the benefits provided by ecosystem services, where ecosystems act as regulators. (for example, improving air and soil quality, climate regulation, mitigation of natural disasters such as floods and landslides, disease control, water purification, waste management, pollination/pollination, biodegradation, or control of harmful species).

The high density of people and buildings in cities makes cities more sensitive to the effects of climate change. To reduce the negative effects of weather events caused by global climate change and to make cities more resilient against these effects, it is possible to protect and/or increase the benefits offered to us by ecosystem services (Appannagari, 2017; Mngumi, 2020). The ecosystem services provided by a green area network (green infrastructure system) formed by interconnected natural, semi-natural and cultural areas that preserve ecosystem values and functions in cities (with high ecological qualities) have an important role in reducing the effects of climate change.

The fact that the green infrastructure system becomes a part of the spatial planning process, the components that make up this system include precipitation water management solutions, the protection of the fragile ecosystems of the cities, the development of rational solutions for the improvement of the ecosystem services provided by the green areas contribute positively to the city's becoming resistant and resilient to the effects of climate change. will provide.

### **1.1. Purpose of study**

In this context, the subject of this study is to investigate the definition, planning, and the concept of green infrastructure for a sustainable city, to improve the existing green infrastructure in cities in the fight against climate change, within the framework of a theoretical evaluation. After the literature review, conclusions and recommendations are given.

## **2. Materials and Methods**

Within the framework of sustainable urban development, the concepts and definitions have been researched with a qualitative method in a way to provide a theoretical evaluation. After the literature review of this research, conclusions and recommendations were developed.

### **2.1. Data collection**

Data for this research was collected from previous literature. The collected data were analyzed by comparing various studies and concepts and discussing them based on the content.

## **3. Results**

### **3.1. Urbanization and Sustainability**

The urbanization trend in the world started to be experienced especially after the Industrial Revolution (Debnath et al., 2014). With the increasing trend of urbanization, environmental, social, etc. problems have occurred (Beyaz & Asilsoy, 2019). Today, urbanization rates continue to increase rapidly in both developed and developing countries. This situation causes deterioration and even disappearance of natural areas (Kim & Pauleit, 2007).

Conceptually, sustainability is to enable the continuity of the ecosystem or any system that has continuity. To create modern cities in our developing world, the natural environment is damaged as a result of human activities (Aslan & Yazıcı, 2016). The concept of sustainability is important in cities where human activities that cause environmental problems are concentrated. In this context, especially since the 1970s, different movements have been implemented in different geographies of the world for sustainable urban development. Movements such as New Urbanism, Ecological City, Green City, and Slow City can be mentioned. The concept of green infrastructure, which overlaps with these trends and can even be said to be the common component of all these trends, has been put forward as a new term especially since the 2000s (Kambites and Owen, 2006). It should be noted that the increasing effects of global warming and climate change also play a role in the spread of this concept.

When green infrastructure is examined in terms of environmental gains, protection from the bad effects caused by climate change, improving clean air, water, and soil quality, accumulating and using rainwater, reducing the risk of flood and overflow, reducing carbon emissions, reducing the urban heat island effect, disaster prevention, erosion protection, biodiversity enhancement, ecosystem restoration, ecological corridors, improved habitats for wildlife, and landscape transitivity. In terms of socio-economic gains, it can be mentioned about creating an environment for cities to have healthier weather conditions and creating tourism and recreation opportunities (Özeren, 2012). Among the most important reasons for choosing green infrastructure applications, providing cost-effective solutions, reducing energy consumption, reducing the damage caused by floods, and caring for and protecting public health can be counted (EPA, 2012).

### **3.2. Green Infrastructure Planning for Combating Climate Change**

Urban green infrastructure planning, which is a strategic planning type, aims to integrate green and blue networks, and is also a planning method that includes urban areas designed in a wide range. Thanks to its integrative and functional approach, green infrastructure planning is implemented to protect biodiversity, support the green economy, and contribute to the socio-cultural dimension.

According to Benedict and McMahon (2012), Green Infrastructure Planning can be applied in landscape areas at different scales. These scales can be from the building scale to the regional scale that

includes the cities. For example, green roofs, green walls / vertical gardens, rain gardens can be given as examples of green infrastructure components at the building scale. On the neighborhood scale, there are district and neighborhood parks, afforested green streets, rain ditches, permeable surfaces, and water channels. Urban parks, green streets, streams and rivers, green belts, green wedges, and urban forests are among the elements that make up the green infrastructure at the urban scale. On a regional scale, green corridors, urban farms, wetlands, groves, etc. are available. Considering the green infrastructure planning in layers at different scales, it is aimed to create interconnected large landscape areas or to preserve existing connections and also to create habitats for the habitats of animals.

**Table 1**

*Green infrastructure planning principles (Aslan and Yazıcı, 2016)*

GREEN INFRASTRUCTURE EKELERİ	GREEN INFRASTRUCTURE TARGETS
What Functionality	<ol style="list-style-type: none"> <li>1. It should cover many eco-systems.</li> <li>2. It must adapt culturally.</li> <li>3. It should consider the different functions used together.</li> <li>4. With detailed analysis and the participation of stakeholders, targets should be determined and a systematic hierarchy should be established between functions. <ul style="list-style-type: none"> <li>• About the green infrastructure functions of society</li> </ul> </li> </ol>
connectedness	<ol style="list-style-type: none"> <li>1. Physical and functional connections such as rainwater, recreation, etc. should be established between green areas with different scales and perspectives. <ul style="list-style-type: none"> <li>• Urban green space resources and factions should be shaped in the analysis to be carried out.</li> <li>• Urban green infrastructure should be taken functionally and physically as a whole with other infrastructures.</li> </ul> </li> </ol>
Integration	<ul style="list-style-type: none"> <li>• Administrative units, different professional groups, and stakeholders need to be communicated and joint studies are required</li> <li>• Cooperation of different professional experts should be ensured in both private and public fields of all stakeholders and all stakeholders should be taken into consideration and joint decisions should be made in the decision-making process.</li> </ul>
Contact / Social ContentEd Process	
Long-term Strategy	<ol style="list-style-type: none"> <li>1. Long-term interests, not short-term gözetilmelidir.</li> <li>2. Within the framework of sustainable development should be considered.</li> </ol>

### **3.3. Green Infrastructure Solutions within the Scope of Climate Change**

The earth in which we live is a living organism, and like all living things, it is healthy. It needs certain temperature conditions to survive. Human-induced effects that disrupt the composition of the atmosphere cause the temperature to rise in the world. Unfortunately, the functioning of natural systems on earth is damaged because the atmospheric temperature has increased by one degree compared to the the1800s due to the change of the climate outside the natural world.

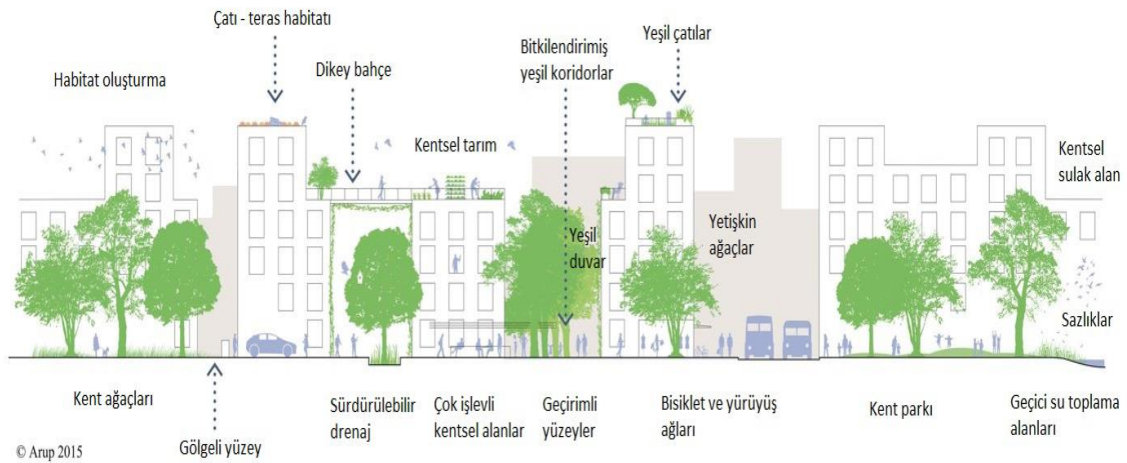
The life of all living things on Earth depends on the ecological process on earth and the healthy functioning of the world (climate). Most of the world's population lives in cities and this rate is expected to increase. In the areas where we live, the sudden and reduce the negative effects of unexpected weather events and make cities resistant to these effects with the benefits of ecosystems (Anonymous, 2019).

### 3.4. Green Infrastructure System and Components

Green infrastructure is defined as a network of connected natural, semi-natural and cultural areas that preserve ecosystem values and functions (Benedict, 2000; European Commission, 2013). This network of par players (centers) and corridors includes natural areas such as forests, shrubs, wetlands, stream corridors, parks, sports fields, school gardens, campuses, and soot gardens, roof gardens, vertical/vertical gardens, zoos, botanical gardens, farmland, cemeteries, planted roads, etc.

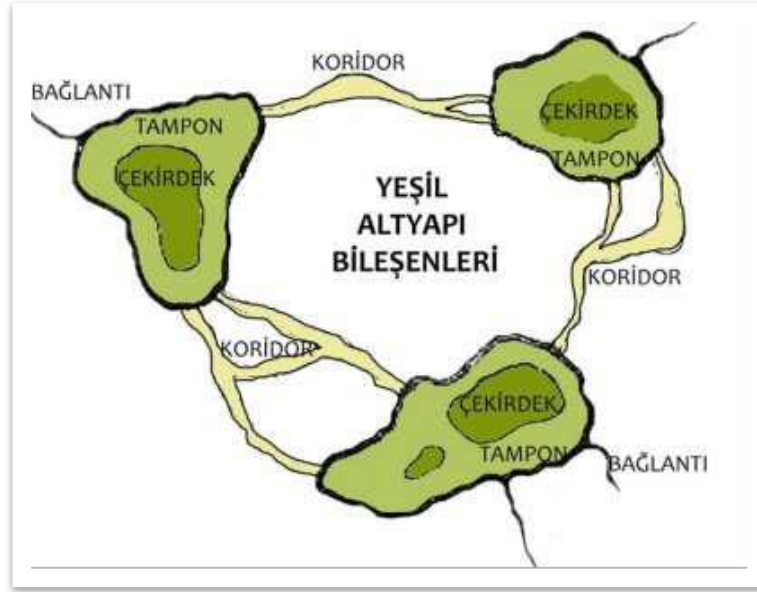
**Figure 1**

*Integration of Green Infrastructure Components into Urban Landscapes (Arup, 2019)*



Creating and planning a system based on continuity for green spaces in cities is essential for today's users as well as future users. The presence of more green spaces in cities, the connections between them, the creation of uses such as pedestrian paths and bicycle paths allow natural life to be sustained within the cities. The most obvious and fundamental aspect of green infrastructure planning is that it is based on connectivity and multi-functionality. In other words, the green infrastructure plan strengthens natural and cultural resources and the local landscape character based on connectivity (Benedict and McMahon, 2012).

**Figure 2**  
*Green infrastructure components (Benedict and McMahon, 2012)*



The concept of green infrastructure in cities is also focused on the integration of natural and cultural plants and surface waters. While green infrastructure works differ, they are among the networks of natural areas based on landscape ecology in rural areas that refer to integration. In the urban euphemistic, it defines a multifunctional network of green spaces (Wickham et al., 2010).

### **3.5. Green Infrastructure Ynet**

Green infrastructure is planned, implemented, and clarified at different scales. Planning area (stream corridors, natural ecosystems), basin, city (urban parks, wide tree-lined boulevards, groves), neighborhood (neighborhood and neighborhood parks, planted streets and streets), and area (rain gardens, vertical gardens, precipitation water plant melted) can be based on the roots. The application and maintenance process are a costly and long-term process that requires many entretaxuals to work together in harmony. However, this cost is not more than the budget spent on the construction and maintenance of gray infrastructure components such as transportation and communication lines, clean and wastewater systems in cities. These studies are gradually programmed into stages, as the implementation process requires time and budget to complete.

Although local and centralized education is mainly responsible for the humidity of green infrastructure components, ensuring the participation of non-governmental organizations, local people and other people in the phases of the year contributes to the adoption and protection of applications and increases the chances of success. In addition, by developing solutions to increase awareness and raise public awareness, users should own and protect green infrastructure components can be provided.

In the process of operation and supervision, rules regarding operation and supervision are determined, and in some cases, solutions such as expropriation or long-term lease of land are developed. In addition, these areas need to be monitored in a manner that is necessary for maintenance and improvement work (Cameron et al., 2012; Jabareen, 2013).

The development of green infrastructure also includes mapping green areas, identifying biodiversity, identifying diseases and problems, and developing solutions, as well as maintenance and monitoring stages. In this context, rules are defined for the maintenance and clarification of green infrastructure components in cities, and guides containing these rules are prepared.

Mapping green infrastructure components of cities and processing them into information systems provides moated data for the study of the year. In particular, the **inventory** of green space and road **trees**, processing this data into information systems, updating it at regular intervals, facilitates green infrastructure and moisture works in large part (Anonymous, 2019; Kambites and Owen, 2006).

#### 4. Conclusion

We are the head moon with negative effects from global warming and climate change, which is one of the consequences of environmental problems in today's world. As a result, it can be said that it is an unavoidable fact that we need green infrastructure to reduce these negative effects that are felt most in our cities. The concept of green infrastructure was born in the early 2000s, which was born in the early 2000s, with the principles of the Brundtland Report, which was prepared in 1987 and laid out the goals of sustainable development.

The green infrastructure allows various disciplines to work together on different scales. It is an approach that brings solutions by working with planning and design ideas. Green infrastructure, if properly planned and specified, can provide a variety of benefits for both individuals and nature. In other words, the establishment of both gray and green infrastructure systems for a city to be livable, sustainable, and healthy, and existing infrastructure needs to be strengthened.

As can be seen from the literature review in this study, very different components of this concept Has. Urban open and green areas, corridors, streams, and streams are essential elements that make green infrastructure. Of course, it should be added that the concept of green infrastructure may have other components besides the elements discussed in this study. Green infrastructure components should also be a key element of resilient cities aimed at tackling the effects of global warming and climate change more strongly. In other words, it is essential to make cities more resilient to reduce the risk and impact of climate change threats and to improve the safety and well-being of residents.

In summary, green infrastructure will also contribute to this urban resilience every time it is included in urban planning. Therefore, in the zoning plan studies within the framework of these concepts, green infrastructure strategies should be made gradually by determining green infrastructure strategies for different layers of the city.

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