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## A REVIEW OF SOLUTIONS FOR GREENING CITIES

BY

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**Abstract.** In recent years, special attention has been paid to the environment and the environment-society relationship. It is known that green areas in the urban landscape play a defining role in creating optimal environmental conditions. The research directions related to reducing the impact of human beings on the environment have highlighted a series of modern solutions for these important issues. This article aims to highlight the methods of greening cities, by comparing traditional methods (urban spatial planning) and modern methods used worldwide. From these directions, the ones closely related to the architecture and construction of buildings are noted, being known that there is a tendency in the development of the built area in cities, with results in the reduction of green spaces in the urban area. The researches have shown that green roofs and green walls can contribute positively to improving the environment in urban agglomerations. This study also presents the importance of each way of greening the cities and analyzes their benefits and the main features.

**Keywords:** environment; greening cities; green roofs; green walls.

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## 1. Introduction

Currently, most part of the global population is creating their life in urban areas or around them, a fact which will lead in 2040 to urban agglomeration where two of three people will live in cities (UN Habitat, 2016). This will be the cause of progressive expansion and/or densification of urbanized spaces (Haaland & van den Bosch, 2015). All these changes have an impact on the environment, causing ongoing degradation and a massive global loss of biodiversity (Seto *et al.*, 2012), so in this process, the urban green spaces suffered a number of modifications, which become an important topic in terms of sustainable urban development.

By definition, urban green space represents an area that is part of the city space, but not occupied by buildings, can be public or private and natural or human-maintained. Another characteristic is that presents a complex and diverse components of the urban ecosystem (Zhen *et al.*, 2019; Wolch *et al.*, 2014; Xu *et al.*, 2011). The presence of these spaces in the urban environment generates economic, social and ecological benefits (Gozalo *et al.*, 2019). All these benefits are related to air quality (James *et al.*, 2015; Escobedo *et al.*, 2011), the mitigate runoff (Zhang *et al.*, 2015), urban biodiversity (Fontana *et al.*, 2011), the mitigation effect of noise (Öhrström *et al.*, 2006), and the urban heat island (Shisegar *et al.*, 2011). On the other hand, taking into account the economic part of the society, these areas can be touristic destinations that will generate revenue (Jim & Chen, 2006).

The quality of the urban ecosystems can be reduced by the loss or degradation of the green spaces (Fang *et al.*, 2003) and also can have a direct and indirect impact on human well-being, mental or physical health (Tzoulas *et al.*, 2007). A part of these problems is directly related to the fragmentation of urban green spaces, a fact that increase the urban heat island effect (Zhou *et al.*, 2002), change the hydrological regime of the city (Gupta & Nair, 2011), and last but not least deteriorate the air quality (Santamouris, 2014). In this context of continues changes, urban green spaces in their traditional or modern forms can provide solutions to a series of urban problems that reinforce the goal of sustainable development in cities (Yan, 2003).

The roles of green urban spaces and their good function and protection have defined the key topics of concern for the entire world authorities. A series of policies have been elaborated in order to maintain and also to create green areas in the biggest urban agglomeration (Zhou & Wang, 2011). This process has been created and implements new, modern and innovative types of greening cities like green roofs and green walls. These new projects represent a new

perspective in order to solve the current problems in the built sector, as well as to create a new image for the agglomerate cities (Baciu *et al.*, 2019). The green infrastructure combines vegetations, energy-efficient systems, renewable energy sources, and advanced eco-technologies in order to provide many social, environmental, economic and aesthetical benefits.

This article aims to present and analyze the methods of greening cities, by comparing traditional methods (urban spatial planning) and modern methods used worldwide, and to highlight their impact. The researches have shown that green urban spaces in all its forms can contribute positively to improving the environment in urban agglomerations and provide a well-being mood for the citizens. This study also presents the importance of each way of greening the cities and analyzes their benefits and the main features. The new trends and types of using the green space represent the results of a good collaboration between engineers, horticulturists, landscape designers, architects, urban planners, and of course, contractors. By this approach, the present paper claims that the impact of the green urban area in all its forms is highly related to the goals of sustainability.

The following sections present an overview of the types of traditional landscape and the modern ones. In addition, the current interpretations, details and the classification of both types of urban green areas are presented. The third section focuses on the benefits and the impact on the environment. In conclusion, the future directions of research, the potential of these methods of greening cities to be combined and promote sustainability in the urban environment are presented.

## **2. The Traditional Methods of Greening Cities**

Cities and urban regions have become central to ensure a sustainable future. The challenges of the urbanization process have multiple faces. Nowadays, land allocations for urban green areas are usually neglected, a fact that becomes one of the most important problems in the process of city development. Urban Green Infrastructure represents a needful part of urban planning and their importance is closely connected with the natural quality and the sustainability of the city (Anguluri & Narayanan, 2017; Gee *et al.*, 2009). The Urban Green Spaces of a city is composed of the parks, gardens, bio-parks, informal green spaces (aquatic fronts, green spaces of historical sites, road corridors, railway, and native vegetation).

The green spaces of a locality consist of all units of urban and periurban green space, which have interdependence relationships and tend to constitute a complex and unitary ensemble, and which actually represents the "green lung"

of area, which ensures multiple environmental protection, recreation and population rest. Green spaces or other landscaping, both urban and periurban, are judiciously distributed, dimensioned, profiled, and structured through urban systematization solutions (Iliescu, 2003). The urban design seeks to achieve an optimum density of buildings, limiting the building perimeter, organizing urban functional areas (residential area, politico-administrative area, industrial area, street networks, different accessories supplied: wastewater treatment station, water distribution stations, methane gas, electricity, thermal energy, etc.).

As a general rule, green spaces are sized in relation to assigned functions, the size, and characteristics of the area or areas it serves. Within a locality, the units of green space can be distributed in the form of stains, strips or mixed according to the systematization of the populated center, in close correlation with the structure of the city, the topographical and climatic conditions, and the street system (Iliescu, 2003). The categories of green spaces are numerous, different in size, location, equipment, and functions. They may be classified in relation to several criteria.

One of the classifications (Negrutiu, 1976; Simonds, 1967) is made according to the position in the city:

a) urban (city): recreation parks, public gardens, scarves, green strips, and planting street, botanical gardens, plantations in addition to some public facilities, landscape landscaping in the premises Institutions, enterprises, educational establishments or social-cultural establishments, plantations in cemeteries, green roofs (Fig. 1);

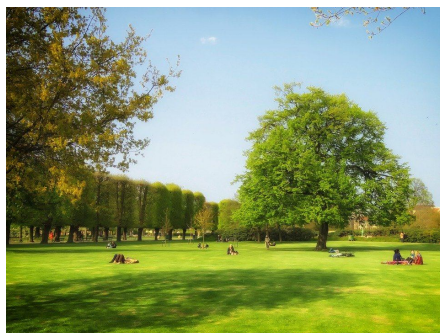


Fig. 1 – Public Park, Copenhagen, Denmark

(<https://pixabay.com/photos/copenhagen-denmark-public-park-385679/>).

b) periurban (pre town): culture and rest parks, recreational areas (recreation forests, park forests), zoos, botanical gardens, alignment plantations along the road or railways, protection plantations (of localities, soil, water, balneo-climatic resorts), nurseries (Fig. 2).



Fig. 2 – Cave Boardwalk

(<https://www.nps.gov/ruca/planyourvisit/outdooractivities.htm>).

The second classification (Negrutiu, 1976) of the urban green areas takes into account the accessibility of the wider population. So it can be defined in three categories as follows:

a) with unlimited access, general use, also called public green spaces, which are managed by public administration, and they are represented by parks, gardens, and public areas, street green spaces or those in residential districts, recreational forests;

b) with limited access, where access is carried out according to certain rules, for a fee or just for a category of people, some green spaces even private (the gardens of individual dwellers), being managed by legal persons, here being included: green spaces from the premises of cultural or educational establishments, hospitals, sanatoria or industrial establishments, parks and sports bases, botanical gardens and zoos, the gardens of individual dwellings.

c) with strict access, in which access is allowed only for those operating in these areas, or in the case of studies or profile works, here: experimental resorts, nurseries, anti-erosive plantations, water protection or roads, fire-fighting plantations.

The last classification (Sonea *et al.*, 1979; Negrutiu, 1976) according to the specialty literature is made based on the functions of each urban green area:

a) green spaces with a recreational role: squares, gardens, and public parks, park forests, recreational forests, sports parks, green spaces for children and youth;

b) green spaces with specialized profile: botanical gardens, exhibition parks, parks and zoos, dendrological parks, rosaries, mounds, green areas of cemeteries;

c) green spaces with a decorative role: decorative squares, the landscape in addition to administrative, cultural or educational institutions, private green spaces related to dwellings;

d) utilities and protect green spaces: alignment along road or railroads, watercourses protection plantations and open water accumulation, parasitic plantations, protective curtains, plantation plantations, and anti-erosional consolidation, nurture, floricultural or lawn production grounds.

One of the most important aspects related to these ways of greening cities is the plants used. The way the species of plants are associated (combined) and how specimens are placed from each other, determine the decorative and sanitary effect pursued. Often the association and improper disposition of species considerably reduce the chances of achieving the functions of the green area or composition or lead to additional costs, which are not found in the obtained effect (Negrutiu, 1976).

Floricultural species through the habitus, leaves, and flowers make up a temporary decoration, of the vegetation season, constituting the main element of the daily variety of green space (Sonea *et al.*, 1979). They play a fundamental psychological role, contributing to the creation of the climate of relaxation and rest that people seek in a green space. Any artificial ambiance is more enjoyable when flowers are present. The decorative character of the floricultural plants is given both by each plant separately and the combination of specimens of the same species or different species.

Taking into account the above mention, the traditional ways of greening cities have more aspects that must be considered for optimized their benefits. To maximize their impact on the urban environment the issues related to the plants, their association, the climatic conditions, and the urban needs are some of the most important aspects.

The specialty literature highlighted the importance of these greening methods and the significant impact on the urban environment, related to air pollution, noise, urban heat island, and aesthetical issues.

### **3. The Modern Methods of Greening Cities**

In the last period, there were promoted and implemented new and innovative solutions for greening cities, methods that are based on the several types of systems that were used in different countries for centuries for many benefits and different considerations. Several problems, like 50% of the world's population living in urban areas and the 66% reach by 2050 (UNDESA, 2014), the continued spreading of the cities and the growth of the intensive agriculture are the most important causes of land loss and fragmentation worldwide (Grimm *et al.*, 2008).

In this context, the urban green spaces can have a major impact and become a key in the conservation of the biodiversity in the urban areas

(Goddard *et al.*, 2010) and the increasing of the urban ecosystem strength (Colding, 2007). Green infrastructure, like green roofs and living walls, can compensate for the loss of green areas by replacing the spaces occupied by building and by contributing to the increase of urban biodiversity (Brenneisen, 2003).

In fact, these systems replicate specific habitat features and conditions and can host native plants in artificial biotopes (Köhler, 2006; Kadas, 2006; Baumann, 2006). The green roofs and living walls represent a part of a new perspective as a solution to the current environmental problems. Besides the ecological benefits, these two types of the landscape may provide social, economic and aesthetical advantages in the built sector (Baciu *et al.*, 2019).

The existing literature shows that both types of greening cities have an impressive history and during the time, they were changed according to the world's changes and the technologies. In the more recent researches, attention has been focused on the improved technologies, low cost and the innovation of these systems.

The concept of the green walls (Fig. 3) refers to all systems that allow the greening of a vertical surface with specific species, in a special solution that enable the growth of plants (Newton *et al.*, 2007). On the other hand, the green roofs represent the systems that introduce various plants of seeds in a medium on a rooftop (Snodgrass & Snodgrass, 2006). The green walls can be divided into two main categories, like green facades and living walls (Köhler, 2008; Dunnett, 2008), which can be differed by the type of plants used on each system; in the case of the green facades, there are utilized climbing vegetation that grows along the wall and covers it, and the living walls are composed by a system that supports a variety of plants in order to create a compact surface (Baciu *et al.*, 2019; Manso & Castro-Gomez, 2014).



Fig. 3 – Example of green wall, Paris, France  
([https://fr.m.wikipedia.org/wiki/Fichier:Green\\_wall\\_Paris.jpg](https://fr.m.wikipedia.org/wiki/Fichier:Green_wall_Paris.jpg)).

In the case of the green roofs (Fig. 4) the specialty literature presents different classification, according to the system used, the plants, the growth medium, the dimension of the layers, and the costs and maintenance.

Therefore, most common classification presents three major types of green roof: the extensive green roof, which is designed just for the aesthetical and ecological benefits and has generally a growth media less than 150 mm, with different variations according to other researchers (Berndtsson *et al.*, 2009; Fassman & Simcock, 2008); the second category is represented by the intensive green roofs or “green gardens” which are used as parks and buildings attraction and are usually designed for recreation and socialization; the third category is an intermediary one and is named semi-intensive green roofs and represents a compromise between the two categories previously presented.

These major sustainable concepts have a significant influence on the climatic conditions and human health and well-being, having a major impact on air pollution, noise, decreasing the surface of urban green spaces, and aesthetical considerations. In the specialty literature, there are different research on behalf of the environmental benefits of these two concepts, which provides an impact on the urban environment. The first benefit is the improvement of the general image of the cities and the unitary urban landscape. The ecological impact is sustained by the instant changing of the climatic conditions in the urban area (Perini & Roscaso, 2013; Jaffal *et al.*; 2012), the reduction of the air pollution (Currie & Bass, 2005; Scarpa *et al.*, 2014), the decreasing of the heat and the energy consumption from buildings (Tan & Sia, 2005).



Fig. 4 – Example of green roof in Museum of Skógar, Iceland  
(<https://fshoq.com/free-photos/p/376/green-houses-in-museum-of-skogar-iceland>).

The analysis in the field of the greening solutions of the cities establishes that there is a significant interest in the implementation of these structures and a meaningful evolution in this domain. The various advantages



presented in the research papers support their impact in the urban environment and encourage their using.

#### **4. The Policies and Regulations Regarding the Urban Green Spaces**

In recent years, urban green spaces in different forms have been the subject of extensive research with a direct impact on green space planning and management (Hansen *et al.*, 2015; Kabisch, 2015; Rall *et al.*, 2015). The trend related to urban green spaces is combining the urban ecology and urban construction with ecological engineering. Worldwide, great progress has been made by implementing urban ecology in road (Zong *et al.*, 2003), industrial zones, while the traditional practices became very active, combining the modern with tradition and resulting in the urban ecological industrial park (Gnedel & Auenby, 2004), urban ecological community (Zhao & Bao, 2001), urban biodiversity protected areas and urban natural conserved zones.

The greening of cities is a major component in the sustainable development of cities, defined by the urban green spaces in different forms, traditional or modern ones. Also named urban green infrastructure, the green spaces in different forms is an inter-linked network of green spaces that create an ecosystem for the benefit of the society (Lafortezza *et al.*, 2003). Urban green infrastructure is composed of large urban parks, urban woodlands, street trees/parks, green fields, green roofs, green walls, and private green gardens.

Even if all over the world, the tendency is to promote new and innovative technologies to implement green spaces in the cities, in Romanian cities the reality is different. The most part of the urban green spaces is represented by the traditional methods of greening cities, such as parks, squares, street trees, private gardens.

In some research, there are noted some examples of natural green roofs in Romania, where the plants have grown spontaneously (Vasiliiu-Oromulu *et al.*, 2012). Only in the last years, the development of green roofs has been studied and analyzed. The identification and selection of the species of plants that can be implemented in these systems, taking into account the specific meteorological conditions of the geographical area is one of the most studied aspects regarding the green roofs and the living walls. On the other hand, the growth medium is another important aspect studied and related to the species of the plants.

According to the specifics of this country, there is a need in the research field according to the implementation of the new solutions of greening cities, like green roofs and living walls. In this direction, it is important to know the natural environment-specific, and the fact that the vegetation of Romania is

determined by geographical location, relief, and climate conditions, illustrated in Fig. 5, and completed with the details presented in Table 1.

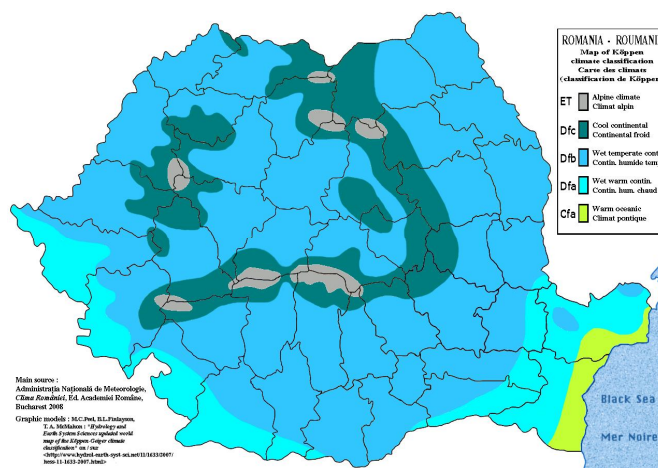


Fig. 5 – Romania map of Köppen climate classification ([https://en.wikipedia.org/wiki/Climate\\_of\\_Romania](https://en.wikipedia.org/wiki/Climate_of_Romania)).

Corresponding to the geographical position, there is a temperate climate characterized by:

- average temperature: 8 – 10°C;
- precipitation: 400 – 600 mm/year;
- recorded temperature limits: the absolute minimum temperature of –38.5°C in cold winters and the absolute maximum temperature of +44.5°C in warm – dry summers.

**Table 1**

*The Climate Floors of Romania* (Romania’s Sixth National Communication on Climate Change and First Biennial Report, 2013)

The climatic floor	Average annual temperatures	Precipitation
Alpine climate	>0 → 2°C	> 1,200 mm
Cool continental	2 – 4.1°C	801 – 1200 mm
Wet temperate continental	4.1 – 8.1°C	601 - 801 mm
Wet warm continental	8.1 – 12°C	401 – 601 mm
Warm oceanic	> 12°C	< 400 mm

An important factor in the design of green roofs and living walls is the climate. It is considered that the economic, environmental, and aesthetical

benefits are more evident in the arid climates. The characteristics of the climate require the selection of plant species, as follows:

- *in arid climates* – plants with drought resistance;
- *in cold ones* – plants with frost resistance;
- *in those with alternate wet and dry seasons* – plants which can adapt to the climatic variations.

Starting from these details related to geographical and climatic conditions, the specific layers of a green roof are carefully chosen, with special attention to the vegetation. The same approach will be in the case of green walls, where the attention is given to the green wall system and the vegetation chosen for this system.

All the above mentioned are important aspects in the field of greening cities and represent some of the significant issues underlying the solving of a series of ecological and social problems.

## 5. Conclusions

The present paper finds its roots in the growing interest in the use of solutions for greening cities and the vast list of journals that focused on them. Even if the traditional ways of greening cities are more and more implemented, there is a tendency of using green roofs and green walls as new and innovative solutions taking into account the highest number of buildings. In this way, the buildings become the support for them.

These two concepts are two of the sustainable strategies and have been studied and designed all over the world in recent years. Revising recently published studies, this paper analyzes and compares the traditional and modern ways of greening cities. Also, they are defined, and classified, and not the least, it is established their impact on the urban environment. Findings confirm that all the ways of greening cities have crucial importance in the development of the urban areas, and green walls and green roofs include enough benefits with regard to environmental sustainability. The analysis highlighted that each concept has a meaningful influence on the climatic conditions, the development of the city, and also human health.

This paper also establishes the need for research on the field of green roof and green walls according to the specifics of Romania. The species of plants and their growth medium must be chosen in concordance with the climatic conditions and the local needs. Even if in Romanian urban environment, the traditional ways of greening are more used, there is an interest in studying and implementing the modern ones. The analysis of the greening systems established that there is a meaningful evolution in this field. There are a

lot of aspects that need to be understood and closely analyzed, but the major issues of these systems are already set.

In fact, the evaluation of these systems and their adaptation in the Romanian environment are some of the aspects that must be studied. Their contribution to the improving of the building's characteristics and comparing the impact of the urban climatic conditions can lead to the development of their integration in buildings. Meanwhile, research is necessary to implement policies for inspiring the use of these systems.

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## O REVIZUIRE A SOLUȚIILOR DE ECOLOGIZARE A ORAȘELOR

(Rezumat)

În ultimii ani, s-a acordat o atenție deosebită mediului înconjurător și relației dintre societate și mediu. Este cunoscut faptul că zonele verzi din peisajul urban joacă un rol definitoriu în crearea unor condiții de mediu optime. Direcțiile de cercetare legate de reducerea impactului umanității asupra mediului au evidențiat o serie de soluții moderne pentru aceste aspecte importante. Acest articol urmărește să evidențieze metodele de ecologizare a orașelor, prin compararea metodelor tradiționale (amenajarea spațiului urban) și a metodelor moderne utilizate în întreaga lume. Dintre aceste direcții, cele strâns legate de arhitectura și construcția clădirilor sunt evidențiate, fiind cunoscut faptul că există o tendință în dezvoltarea zonei construite în orașe, cu rezultate negative în reducerea spațiilor verzi în zona urbană. Cercetările au arătat că sistemele de

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acoperișuri verzi și pereții verzi pot contribui pozitiv la îmbunătățirea mediului înconjurător în aglomerările urbane. Acest studiu prezintă, de asemenea, importanța fiecărui mod de ecologizare a orașelor și analizează beneficiile lor și principalele caracteristici.