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# GREEN AND BLUE INFRASTRUCTURE: SUSTAINABLE DEVELOPMENT OF THE URBANIZED TERRITORY

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**Abstract.** The article examines the relevance of strategy and blue infrastructure: which is a successfully proven tool for ensuring environmental, economic and social benefits through *natural solutions*.

The rapid urbanization of the territory made us look at a significantly new approach to understanding the urban design of new infrastructure facilities, thus it became necessary to introduce green and blue infrastructure into the canvas of the rural and urban environment based on the preservation and restoration of natural and artificial (human-created natural) zones that are likely to disappear. The green element structure plan that is formed can play an important role in protecting the existing open space and providing new green and blue infrastructure to serve the new development of the urbanized area. Site planning should likewise ensure that developments are properly located and designed to protect and enhance the natural features of the design site and the local landscape character.

A highly urbanized environment negatively affects the well-being of people, causing fatigue and nervous system disorders. To improve the sanitary condition of cities, workers' settlements and rural settlements, it is necessary to carry out large-scale work to increase the areas of green spaces - gardens, parks, squares, boulevards, protective green areas and forest parks, especially on reclaimed lands.

With the help of the studied literature, the potential role and importance of green and blue infrastructure for a modern urbanized area was identified. Populated areas need to reduce the negative impact on the environment, and one of the most important aspects is to make the urbanized area a favorable place to live and resilient to climate change.

The green and blue infrastructure is the soul in the body of the earth, and the person is the heart that, with the flow of time and development, turns the body into a soulless stone.

**Keywords:** green infrastructure, urbanization of the territory, blue-green infrastructure, climate change, natural zones, artificial natural zones.

**Statement of the problem.** The city is one of the most complex systems created by mankind. In the context of global changes, it acquires new characteristics and needs, and also faces many complex problems related to balancing urban development and its impact on the environment, while maintaining its importance as a center of gravity and socio-cultural development.

To the extent of the active growth of the «extensive» model of urban planning of a modern city, the problems caused by their magnitude turned out to be and worsened: (air pollution, soil and water pollution, noise, wastewater discharge, waste disposal, transport, energy supply, less and less green spaces and biodiversity), so there was a need to introduce green and blue infrastructure into the canvas of the rural and urban environment, as well as to preserve and restore the natural and artificial natural areas that are likely to disappear.

**Analysis of lastest researches and publications.** The theoretical base of the study is based on the works of scientists devoted to the social, environmental, architectural, urban planning, and economic aspects of the formation of green infrastructure in large cities. Modern cities are fundamentally different from their predecessors in that the current environmental situation in the

world has forced us to take a fresh look at the vital role of gardens, parks, boulevards, and other open and green spaces in improving the urban environment, organizing recreation and physical education, aesthetic education, etc. The established views and methods of urban planning are being reviewed. Moreover, the fundamental role in solving any architectural and planning tasks is given to nature, its conservation and restoration. [1-3].

Many scientists and researchers have studied the issues of green infrastructure and its impact on the sustainable development of the urbanized environment (Ahern, 2011; Apostolopoulou & Adams, 2015; Cortinovis & Geneletti, 2018; De Valck et al., 2019); (Benedict & McMahon, 2002); (Ying et al., 2011; Zhai, 2012); (Geneletti & Zardo, 2016; Takács et al., 2016); (Pappalardo et al., 2017; Raei et al., 2019); (Saaroni et al., 2018; Wang & Banzhaf, 2018); (Livesley et al., 2016); (Coutts & Hahn, 2015; Ko & Son, 2018; Sun et al., 2019); (De-Miguel-Molina et al., 2019; Graça et al., 2017; Wolf et al., 2020), and the results show a significant increase in the number of green infrastructure studies in recent years, with European and American countries leading the number of green infrastructure studies [7].

**Aim of the research.** Green and blue infrastructure in an urban environment and its impact on sustainable development.

**Research task.** Aims at the study of green and blue infrastructure by analyzing literature in the field of green and blue infrastructure in an urban environment, and aims at a systematic presentation of the evolution of knowledge and the boundaries of the development of green and blue infrastructure, which contributes to the sustainable development of the territory.

**Main body.** There is no single widely accepted definition of green infrastructure in the literature – however, the European Commission's latest description of green infrastructure uses a comprehensive version of the concept [8].

Green infrastructure is a strategically planned network of natural and artificial (human-created natural) areas with other ecological elements designed and managed to provide a wide range of ecosystem services such as water purification, air quality, space for recreation and climate change mitigation and adaptation [8]. Therefore, under the concept of green and blue infrastructure, it is customary to understand all green spaces and aquatic environments of social and natural significance, necessary for the quality of our life and ecosystem.

Ecosystem services are benefits that flow from nature to people. They can be *provision* (for example, the supply of food, clean air and water and materials), *regulatory* (for example, regulation of water and climate, nutrient cycling, pollination, or the formation of fertile soils) or *cultural* (for example, opportunities for recreation or inspiration that we draw from nature) [9].

From a physical perspective, green and blue infrastructure can include a wide range of natural and man-made green spaces and connections in both urban and rural areas.

Green and blue infrastructures include such elements (Fig. 1):

- Wildlife areas, nature reserves, semi-natural habitats (e.g. forests, rivers and river valleys, lakes and ponds, coastal areas, wetlands, hills / mountains, wastelands, grasslands, hedges);
- Street trees, urban green «open spaces» (including land, cemeteries, community gardens / orchards, country parks, city parks / forests, green roofs / walls, office / retail landscaping);
- Green driveways / areas (footpaths, cycle paths, horseback riding paths, open access lands, railroad and canal edges);
- Areas of multipurpose agricultural land or forests (managed for increased productivity and conservation, recreation, soil protection, etc.);
- Important landscapes of the landscape, river and city landscapes, views and attractions, historical sites;
- Flood mitigation zones, sustainable urban drainage systems, carbon capture land (e.g. peatlands, forests) [10].


Fig. 1. Potential elements of green infrastructure in urbanized areas

List of potential goals / functions for green and blue infrastructure:
- Biodiversity, wildlife habitats, nature conservation, sustainable ecosystems;
- Landscape, river landscape and nature of the cityscape, views and attractions;
- Sustainable (urban and rural) development and economics, management of development and recovery (new housing, industry, manufacturing, roads) and their mitigation to address environmental, social and economic considerations;
- The best places to live, work and invest, distinctive and attractive in nature;
- Archaeological, historical, cultural, architectural monuments;
- Available open space (pedestrian, bike paths), recreation areas;
- Water management, flood control, sustainable urban drainage;
- Erosion and Pollution Control - Clean Air, Habitat, Soil and Water;
- Climate change adaptation / mitigation, climate control, carbon sequestration;
- Healthy lifestyle;
- Sustainable forest management and sustainable agriculture;
- Eco-friendly transport;
- A sense of community;
- Closer relationships and connections between urban and rural areas, outdoor classes.

*Note: (Please note that the importance of these factors varies from place to place; accordingly, planning for green and blue infrastructure should prioritize, rather than seek to account for all of these factors everywhere)* [10].

The focus is on developing blue and green infrastructure design concepts and principles that not only support climate resilience, but contribute to a healthy and livable urban environment.

The set of functions covered by green infrastructure reflects its cross-functional nature. These functions should form part of a strategically planned network that aims to protect, improve, connect and expand certain green and blue infrastructure assets.

How can a legal design framework support green and blue infrastructure in an urban environment?

*The generated local plan can play an important role in protecting existing open space and providing new green and blue infrastructure to serve new development. Likewise, planning should ensure that the development is properly located and designed to protect and improve the natural features of the site and local landscape character.*

In particular, planning policies and decisions should:

- Protect floodplain green spaces from development;
- Require developers to create new livelihoods, focusing on the 12 priority livelihoods of BAP (Biodiversity Action Plan), as part of the planning and design of green infrastructure in new developments;
- Ensure that existing habitats and protected species are accommodated and any loss is adequately mitigated during all new developments, and that development in areas of biodiversity opportunities does not significantly increase the fragmentation of wildlife habitats or neutralize significant opportunities for habitat restoration or recreation;
- Preservation and strengthening of the original character of the design area (existing natural beauty and their setting);
- Encourage developers of large sites in areas where gardens have existed to provide appropriately public gardens as part of their proposal;
- Require developers to maintain and improve existing publicly accessible green spaces on building plots;
- Ensure that developers of new residential areas are provided with all types of public open space according to a specific standard, if there is not enough open space available;
- Ensure developers provide detailed information on how green and blue infrastructure will be managed and maintained at high quality over the long term [11; 13].

Based on the material presented, potential problems of the urbanized environment were identified, as well as the solution to the sustainable development of the territory based on the strategy of green and blue infrastructure (see Fig. 2):

*Problem (lack of blue-green infrastructure approach):*

- Air pollution;
- Wastewater pollution of water bodies;
- Poor evaporation;
- Limited access to green areas;
- Urban heat island effect;
- High rate of urbanization of the territory;
- The growing level of motorization of the population;
- Low infiltration and low groundwater recharge;
- Critical load on urban drainage system.

*Solution (integrated blue-green infrastructure approach):*

- Natural cleansing processes;
- Storm water maintenance and treatment;
- Interception and accelerated rate of moisture evaporation;
- Interception of airborne contaminants;
- Deep infiltration and high groundwater recharge;

- Active use of underground space;
- Wildlife biodiversity;
- Active rainwater harvesting and reuse [12].

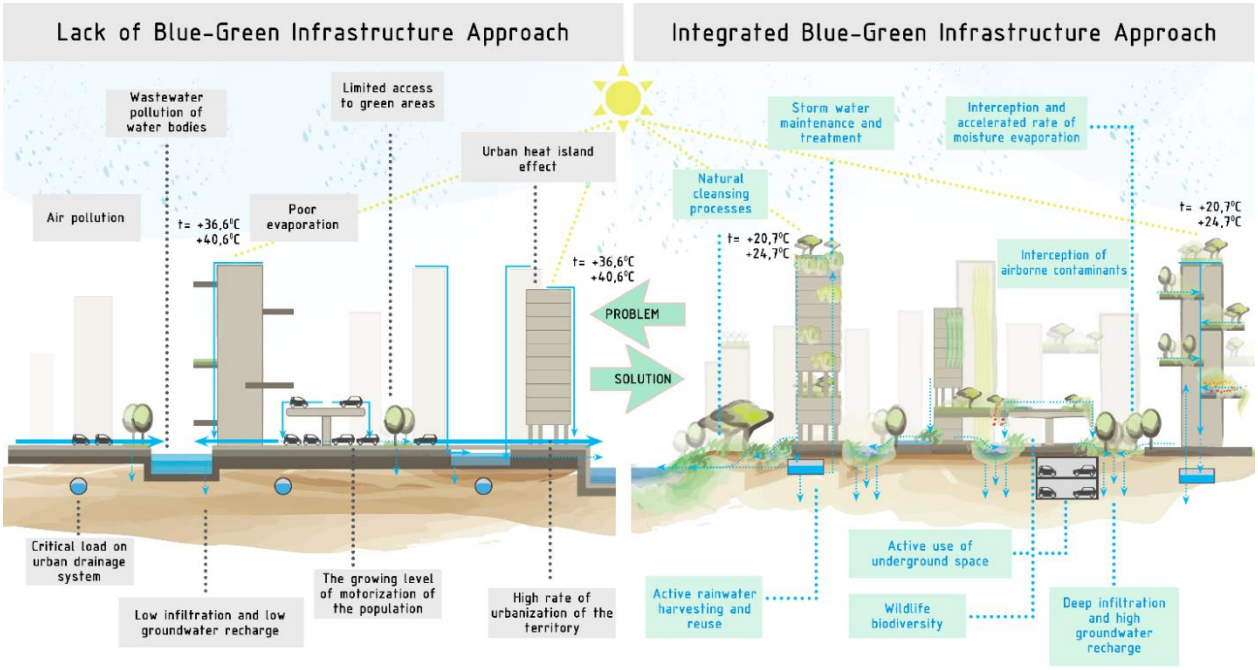


Fig. 2. Lack and integrated blue-green infrastructure approach

**Conclusion.** An analysis of research sources and best practices have identified a number of benefits that green and blue infrastructure can bring:
- Mitigation and adaptation to climate change;
- Integration of sustainable traffic and access for all;
- Promoting an expressive cityscape and landscape;
- Maintaining and improving biodiversity, water and air quality;
- Providing opportunities for sports, recreation, relaxation and health;
- Maintaining and improving a quality investment environment through development;
- Ensuring community participation and learning opportunities.

Thus, the study allows us to conclude that green and blue infrastructure is one of the main elements of the improvement of an urbanized area. Green spaces form a favorable ecological environment: they help in the fight against the effect of «heat islands» by participating in the process of moisture evaporation; reduce the runoff of storm water, retaining water by the root system; improve air quality by absorbing atmospheric pollutants. The positive impact also affects the social, urban and economic spheres of life.

The world practice of research shows that due to the lack of territories in cities, alternative gardening methods are now increasingly being used: vertical and multi-level gardening, roof gardening, reprofiling streets from vehicles to pedestrians - the creation of linear parks, the arrangement of new green public spaces on the ground industrial territories.

The set of functions covered by green infrastructure reflects its cross-functional nature. And so, the strategically planned network of green and blue infrastructure aims to protect, improve, connect and expand certain assets of the urban environment.

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# ЗЕЛЕНА ТА СИНЯ ІНФРАСТРУКТУРА: ЗАБЕЗПЕЧЕННЯ СТІЙКОГО РОЗВИТКУ УРБАНІЗОВАНОЇ ТЕРИТОРІЇ

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**Анотація:** У статті розглянуто актуальність зеленої та синьої інфраструктури: яка є успішно перевіреним інструментом для забезпечення екологічних, економічних та соціальних вигод за допомогою *природних рішень*.

Стрімка урбанізація території, змусила поглянути на суттєво новий підхід до розуміння містобудівного проектування нових інфраструктурних об'єктів, таким чином виникла потреба впровадження зеленої та синьої інфраструктури в полотно сільського та міського середовища на основі збереження та відновлення можливих до зникнення природних та штучних (створених людиною природних) зон . Формований план структури зелених елементів може грати важливу роль у захисті існуючого відкритого простору та забезпеченні нової зеленої та синьої інфраструктури для обслуговування нового розвитку урбанізованої території. Планування території має також забезпечувати належне розміщення забудови та її розробку для захисту та покращення природних особливостей ділянки проектування та місцевого ландшафтного характеру.

Високоурбанізоване середовище негативно впливає на самопочуття людей, спричиняючи стомлення, розлад нервової системи. Для покращення санітарного стану міст, робочих селищ та сільських населених пунктів необхідне проведення у широких масштабах робіт із збільшення площ зелених насаджень – садів, парків, скверів, бульварів, захисних зелених зон та лісопарків, особливо на землях, що рекультивуються.

За допомогою вивченої літератури, було виявлено потенційну роль та значення зеленої та синьої інфраструктури для сучасної урбанізованої території. Населені території потребують зниження негативного впливу на навколишнє середовище, а також один з найважливіших аспектів – це зробити урбанізовану територію сприятливим місцем для життя та стійким до кліматичних змін.

Зелена та синя інфраструктура – це душа в тілі землі, а людина – це серце, яке з потоком часу та розвитку, перетворює тіло на бездушний камінь.

**Ключові слова:** зелена інфраструктура, урбанізація території, синьо-зелена інфраструктура, кліматичні зміни, природні зони, штучні природні зони.