



URBAN TRANSPORT INFRASTRUCTURE AND GREEN INFRASTRUCTURE: ACTIONS TO MITIGATE CLIMATE CHANGE

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Abstract

Globally, cities account for 75% of natural resource consumption and 60-80% of greenhouse gas (GHG) emissions. At the same time, 70% of urban areas around the world are already experiencing the consequences of climate change, including extreme flooding, temperatures, and droughts. Within this challenging context, green infrastructure helps to strengthen ecological connectivity through green spaces, encompassing the protection, restoration, and enhancement of biodiversity and ecosystem services. Green infrastructure provides improved resilience, mitigating the effects of extreme temperatures, heavy rainfall, floods, landslides, and droughts. This protection is not only essential for preserving nature, but also holds significant importance for the stability and functionality of the transportation network. The paper presents an analysis of interference between transport and green infrastructure, emphasizes the importance of this bond in struggling with climate change, as well as showing a brief on the approach in the Western Balkans.

Keywords: urban infrastructure, green infrastructure, climate change, mitigation, ecological connectivity

1 Introduction

Climate change is fundamentally transforming our world, society, economy, and everyday life at various levels. From small changes in weather patterns, such as consistent temperature increases, through the gradual disappearance of species and soil degradation, to the catastrophic impacts of heavy rainfall, strong storms, and drought-induced wildfires, almost every aspect of human existence is affected by this challenge.

Transport infrastructure is central to the global economy and society, forming a complex network for the transportation of passengers and goods. Designed to withstand standard weather conditions, it is largely exposed to climate change and various climate risks

1], such as temperature changes, sea level rise, floods, storms, and droughts, leading to a range of challenges due to the high sensitivity of the system to extreme weather events. The result can cause a significant impact on the sustainability of infrastructure and traffic safety, ultimately affecting people, their livelihoods, quality of life, as well as natural ecosystems.

During transportation planning in the 20th century, the emphasis was primarily on creating additional space for motorized vehicles. Now, as cities reconsider their priorities, opportunities arise for creating spaces enriched with greenery and accessible to people. Reducing the number of traffic lanes and parking spaces for motor vehicles provides the opportunity for planting tree lines, constructing rain gardens, linear parks, smaller parks, and paths for active pedestrian and cyclist movement.

These initiatives aim to improve the quality of life in cities, increase green areas, and create a more pleasant environment for residents [2]. With the emergence of the “Greenway movement” in the 1990s, the idea of green infrastructure received particular attention not only among planners, urbanists, and landscape architects, but also among environmental groups, ecologists, and politicians [3]. Green infrastructure helps mitigate the impact of climate change and extreme events. In cities, it contributes to mitigating the effects of urban heat islands, providing cooling through shade and evapotranspiration from vegetation. However, it also promotes solutions for non-motorized transportation with low carbon emissions and sustainable solutions (i.e., cycling and walking) [4].

With the main goal of determining current practices in the Western Balkans region, the paper presents the connections between urban transport infrastructure and green infrastructure, with a focus on reducing the negative impacts of climate change.

2 Green infrastructure

Sustainable urban development requires integrated actions in planning, investments, and the application of technologies that support sustainability [5]. Green infrastructure provides exceptional opportunities for cities and streets to achieve their sustainable goals [6].

Within the framework of the European Union (EU) Green Infrastructure Strategy [7], published in 2013, green infrastructure is defined as a strategically planned network of natural and semi-natural areas with different ecological characteristics, designed and managed to deliver a wide range of ecosystem benefits. It includes green spaces (or blue, in the case of aquatic ecosystems) and other physical features in terrestrial and marine areas. On land, green infrastructure can be present in both rural and urban environments [8]. The main goal of creating green infrastructure is to strengthen ecological connectivity, while protecting, restoring, and enhancing biodiversity and ecosystem services.

Green infrastructure provides physical, psychological, emotional, and socio-economic benefits for individuals and communities as a whole [9]. Some EU countries, such as Germany and Austria, have prioritized these practices in planning their national transportation systems. Germany early adopted the EU Strategy to Biodiversity [8], and in 2012, it adopted the Federal Defragmentation Programme [10] to maintain and restore green infrastructure across the national German road network.

Its inclusion in transportation network planning is not only a practice implemented at the European level. Cities worldwide are grappling with the effects of changing environmental conditions, prompting many to take steps to reduce carbon emissions and become environmentally sustainable [11]. The “Green in Cities” initiative represents a global trend, developed to promote, and implement green solutions in urban areas. As of November 2022, 80 cities are participating in this initiative [12]. Different types of urban green infrastructure and nature-based solutions (NbS) are being applied. These include public parks, urban forests, as well as urban agriculture systems such as urban farms and community gardens. They also include the use of permeable pavements, green drainage systems such as rain gardens, and the implementation of green roofs and walls. In addition, cities are increasingly turning to the creation of water bodies, the establishment of green belts and corridors, as well as protected natural areas to improve resilience to extreme weather events and reduce the negative impacts of urbanization [13, 14].

Understanding the benefits provided by green infrastructure is essential for identifying needs and locations for investment in green infrastructure [4]. There are different economic (adaptation and mitigation of climate change impacts, reduction of flood and soil erosion risks, promotion of recreational activities, protection of biodiversity, improvement of health conditions, reduction of healthcare costs), socio-cultural (improvement of citizens’ quality of life through creation of a more pleasant environment for living, working and recreation,

promotion of local culture and identity, increase of social cohesion and inclusivity), and ecological (preservation of natural resources, protection of ecosystems and habitats of wild species, preservation of water resources and air quality) factors that drive the development of green infrastructure strategies and plans, varying from territory to territory and from region to region. All these factors together influence the shaping of green infrastructure strategies and plans to achieve more sustainable development and a better quality of life for all citizens [15].

3 Connectivity between urban and green infrastructure

Cities are at the forefront of dealing with environmental challenges. Globally, they account for 75% of natural resource consumption and 60-80% of GHG emissions [13]. At the same time, 70% of urban areas worldwide are already facing the consequences of climate change. The high population density in urban areas exacerbates the exposure to these consequences [16]. Typical urban infrastructure falls under so-called “gray infrastructure” and includes technical, often interconnected elements that support societal functioning (roads, railways, water supply, sewerage, telecommunications, power grid, etc.). On the other hand, green infrastructure represents a network of green spaces that conserve ecosystem values and functions, thus providing benefits to society. Clearly, both types of infrastructure are necessary and complement each other. Therefore, it is important to find ways for them to work together to achieve a sustainable and functional urban environment [17].

Considering the scope and complexity of transportation infrastructure, its replacement is not a simple task. Therefore, it is crucial to consider adapting to climate change from the outset of the planning and design process. In this context, green infrastructure can be of great assistance. The idea is to integrate infrastructure into the existing landscape and ecosystems, considering the risks posed by changing climate conditions, as well as reducing the negative impacts of infrastructure on biodiversity. This approach allows for the establishment of sustainable and resilient transportation infrastructure that will effectively function in line with future challenges [4, 17].

There are many ways to integrate green elements into transportation infrastructure. For example, NbS for roads and railways include, for example, green bridges and eco-tunnels for safe animal crossing/passage or green noise barriers that, in addition to providing noise protection, also create additional habitat for animals contributing to ecosystem preservation in urban areas [17]. Public transport rail corridors occupy significant space in urban areas. Using this space for vegetation planting can help reduce carbon emissions. Additionally, it enables a permeable surface, which can aid in flood risk mitigation, improve water quality, and reduce soil erosion. An example of applying green infrastructure in the railway sector are the High Speed Two (HS2) lines in the United Kingdom as a support for modal shift from road to rail transport in the London-Manchester and London-Leeds corridors. The solution involved introducing an ecological corridor along the railway line with the creation of carbon-neutral stations, green bridges, and new habitats for wildlife [17]. In this way, a balance between infrastructure development and preservation of the natural environment was ensured, providing sustainability of the project.

In urban areas, green transportation infrastructure can be designed through pedestrian or cycling paths that are integrated with green spaces, such as parks or urban forest belts. These solutions respond to the challenges of climate change and adaptation by promoting a shift to active transportation modes and providing natural solutions to prevent and mitigate the impacts of floods and droughts. Greening, i.e., using vegetation along streets, can help address urban heat island and water drainage issues. Such initiatives also contribute to the creation of public green spaces, improving public health and air quality, thus achieving beneficial social and ecological outcomes. A few examples are presented in Figures 1 and 2.



Figure 1 Solar panels at bus stops [6] and traffic-free route and ecological corridor associated with railway [2]



Figure 2 Dry retention basin with a spillway and drainage ditch in the urban area [9]

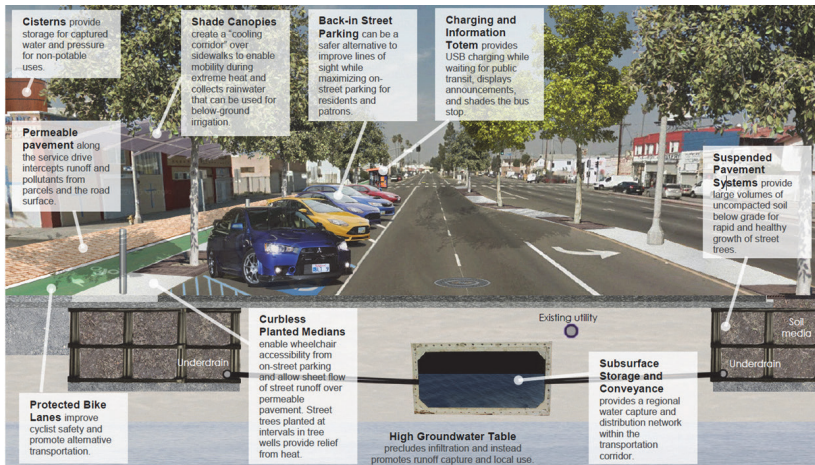


Figure 3 Rendering of green infrastructure features that create a multi-benefit cooling corridor along Vermont Avenue in Los Angeles (USA) [18]

Another NbS solution in the transportation sector is the development of green spaces in parking lots. For example, in Edmonston (USA), an NbS initiative was developed to manage urban stormwater through bike paths with permeable pavement and rain gardens along the main city street. This initiative effectively manages 90% of annual rainfall, provides improved water quality, and filters pollutants from the air. Additionally, trees along these paths provide shade during summer months, helping to combat the urban heat island effect [3]. Figure 6 shows planned features of green infrastructure that create multiple benefits and a refreshing corridor along Vermont Avenue, connecting downtown Los Angeles with the port. This corridor would provide pedestrians with areas for movement, especially during periods of high temperatures, sustainable water supply, ecosystem restoration, and pollution reduction [1].

4 Green infrastructure within the Western Balkans

As a concept, green infrastructure is not yet clearly established in the legislation of Western Balkan countries, and there is no systemic approach to this issue. An analysis of current practices indicates that there is no legislation directly regulating green infrastructure. However, there are some laws that should be related to green infrastructure, relating to nature protection, environmental protection, planning, climate change, water, forests, municipal services, etc. [19]. Individual initiatives and attempts can be identified in major urban areas. In addition to old, inherited spaces such as parks and tree-lined streets, the solution that are often implemented comprise green areas along riverbanks, new parks, and green spaces. Initiatives to establish ecological corridors that would connect urban parks and natural habitats for biodiversity conservation are most observed, as well as initiatives to build bicycle paths and promote cycling as an active and environmentally friendly mode of transportation. However, these plans and initiatives often give way under the pressure of demands for the provision of technical infrastructure in mostly poorly equipped areas and compared to still largely car-centric development approaches.

Three cities in the Western Balkans have pledged to become climate-neutral and smart cities by 2030: Elbasan (Albania), Sarajevo (Bosnia and Herzegovina) and Podgorica (Montenegro). In this way, they entered among the 100 cities of the EU that will participate in the EU Mission for 100 climate-neutral and smart cities by 2030 [20].

In Serbia, within the territory of the City of Belgrade, there is an old urban area known as “Savski blokovi” in the municipality of Novi Beograd. This neighborhood presents an example of how the concept of green infrastructure can be incorporated into urban areas, creating more sustainable and pleasant urban environments. Bicycle and pedestrian paths are provided, as well as green spaces, in the form of parks and tree rows [21]. Still, it should be emphasized that it was developed during the 1970’s and gradually improved. In the latest period, its population is struggling against the City’s authorities to completely occupy and reshape the area through its commercialization.

Albania has taken steps to promote sustainable development, including the adoption of the National Strategy for Sustainable Development, which focuses on economic growth, social development, environmental protection, and good governance [22]. In the capital, Tirana, there is the first building with zero emission of harmful gases in Albania [23], while the creation of green belts, the expansion of parks and green areas are also included. However, only within the ambitious planning stage.

In previous years, Montenegro has been committed to accelerating sustainable and smart early development through a series of ambitious, national, regional, and local measures, such as digitization of public services, modernization of public transport and increased environmental protection. However, the initiatives were slowed down due to the lack of data and planning documents at the regional level, which prevented the local administration of Podgorica from accurately assessing the issues of illegal construction and energy efficiency [24], and efforts also weakened in the parts of the city due to economic migration of residents from other parts of the country. Sarajevo in Bosnia and Herzegovina is a similar case - individual initiatives in certain, small parts of the city while still retreating when faced with the increase of population, and “concreting and asphaltting” whatever is available.

The Action Plan [25] represents one of the results of the Sofia Declaration on the Green Agenda for the Western Balkans and is used as a tool to guide its implementation. After intersectoral and interinstitutional cooperation, the main responsibility rests with the authorities of the Western Balkans. The Action Plan takes into account key political processes, international frameworks and agreements, as well as the latest policy developments, including legislative and non-legislative acts adopted at EU level. This includes the European Green Deal and the Western Balkans energy and climate targets/ambitions for 2030 in line with the EU’s me-

dium-term climate targets to reduce GHG emissions by at least 55%, as well as many others. Development progress across the region often differs, as economies are at different stages of the EU accession process and have different green transition paths. Following the impact of the global COVID-19 pandemic and the war in Ukraine, increase in energy prices, concerns about energy security and high inflation in 2022 are evident. The economies of the region have shown an urgent need to embrace the green and digital transition as drivers of sustainable growth. The crisis also highlighted the importance of the strategic partnership between the EU and the Western Balkan region.

5 Conclusion

Green infrastructure represents a response to the negative consequences of urbanization, climate change, and overall environmental degradation. Green infrastructure not only improves water quality, reduces carbon emissions, and protects communities from the impacts of climate change but is also a critical strategy for improving health, equity, and social justice. With the increasing awareness of the need for action in various areas, the EU has been working for several years on the development and implementation of the Strategy of Green Infrastructure, treating it as a concept that brings environmental, economic, and social benefits through the application of integrated solutions [19].

Across the world, active development of principles and approaches for the practical implementation of “green” and sustainable development of urban transportation infrastructure has been observed, although unified approaches and criteria for carrying out such activities are yet to be established. Additionally, significant financial support is needed to enable numerous benefits. Despite increasing interest and efforts to integrate green infrastructure into urban planning and projects, the Western Balkans still lag in actual implementation.

References

- [1] Kammerer, S., Mehrotra, P, Mohamed, H., Westgate. S., Zawadzki, A.: Adaptation & Resilience through land transport infrastructure systems, protecting communities and economies, A Boston consulting Group and UN Climate Change High-Level Champions Joint Publication, 2023.
- [2] Grant, G., Mounsdon, D., Warburton, C., Houghton, J., Fanaroff, D.: Green Infrastructure Planning and Design Guide, Designing nature-rich, healthy, climate-resilient, and thriving places, Natural England Design Guide Project Manager, 2023.
- [3] Monteiro, R., Ferreira, J.C.: Green Infrastructure Planning Principles: An Integrated Literature Review, *Land*, 9 (2020) 525, DOI: 10.3390/land9120525
- [4] OECD, Green infrastructure: Conceptual framework and international context, Developing an Integrated Approach to Green Infrastructure in Italy, OECD, Paris, 2023.
- [5] UNIDO: Sustainable Cities, Hubs of Innovation, Low Carbon Industrialization and Climate Action, Sustainable Cities, Austria, 2016.
- [6] Sturiale, L., Scuderi, A.: The Role of Green Infrastructures in Urban Planning for Climate Change Adaptation, *Climate*, 7 (2019) 119, DOI: 10.3390/cli7100119
- [7] European Commission, COM (2013) 249 - Green Infrastructure (GI) - Enhancing Europe's Natural Capital, European Commission, https://environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en, 8.02.2024.
- [8] European Commission (2020), COM (2020) 380 - EU Strategy to Biodiversity to 2030: bringing nature back into our lives, European Commission, https://eurlex.europa.eu/resource.html?uri=cellar:a-3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF, 8.02.2024.
- [9] Toth, A., Halajova, D., Halaj, P.: Green Infrastructure: A Strategic Tool for Climate Change Mitigation in Urban Environments, *Ecology & Safety*, 9 (2015), pp. 132-138

- [10] Federal Defragmentation Programme, https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Naturschutz/bundesprogramm_wiedervernetzung_eng_bf.pdf, 25.02.2024.
- [11] Streets Reconsidered, <https://www.restreets.org/green-infrastructure>, 19.02.2024.
- [12] The Borgen Project, <https://borgenproject.org/green-cities-initiative/>, 15.02.2024.
- [13] Nature Squared, Investing in a Green Urban Future, 2021.
- [14] OECD: Building resilience: New strategies- for strengthening infrastructure resilience and maintenance, OECD Public Governance Policy Papers, No. 5, OECD, Paris, 2021.
- [15] John, H., Marrs, C., Neubert, M. (eds.): Green Infrastructure Handbook - Conceptual & Theoretical Background, Terms and Definitions, Interreg Central Europe Project MaGICLandscapes, Dresden, 2019.
- [16] Frantzeskaki, N., McPhearson, T.: Mainstream Nature Based Solutions for Urban Climate Resilience, *BioScience*, 72 (2022) 2, pp. 113-115, DOI: 10.1093/biosci/biab105
- [17] Lucius, I., Dan, R., Caratas, D.: Green Infrastructure - Sustainable Investments for the Benefit of Both People and Nature, SURF-nature project, 2011.
- [18] United States Environmental Protection Agency (EPA): Green Infrastructure and Climate Change - Collaborating to Improve Community Resiliency, EPA, 2016.
- [19] Tutundžić, A., Teofilović, A., Šabanović, V., Vujičić, D., Jevtović, A.: Evropska strategija zelene infrastrukture - mogućnosti primene u Srbiji, Udruženje pejzažnih arhitekata Srbije, Beograd, 2020.
- [20] Balkan Innovation, <https://www.balkaninnovation.com/news/49/three-western-balkans-cities-to-become-climate-neutral-and-smart-cities>, 19.03.2024.
- [21] Simić, I., Stupar, A., Djokić, V.: Building the Green Infrastructure of Belgrade: The Importance of Community Greening, *Sustainability*, 9 (2014) 7, 1183, DOI: 10.3390/su9071183
- [22] Constructive Voices, <https://constructive-voices.com/green-building-in-albania/>, 19.03.2024.
- [23] Archello, <https://archello.com/project/zero-emissions-municipality-building-of-tirana>, 19.03.2024.
- [24] UNECE, <https://unece.org/housing-and-land-management/news/uneces-city-profile-podgorica-montenegro-support-smart-urban>, 19.03.2024.
- [25] Action plan for the implementation of the Sofia Declaration on the Green Agenda for the Western Balkans 2021-2030, Regional Cooperation Council, <https://www.rcc.int/docs/596/action-plan-for-the-implementation-of-the-sofia-declaration-on-the-green-agenda-for-the-western-balkans-2021-2030>, 18.03.2024.

