



Analysis of Cross-sectional Regulation of Green and Blue Infrastructure in the Context of Spatial Planning

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Abstract

Green and blue infrastructure represents a category of nature-based solutions that serve to preserve critical ecosystem services in densely built-up environments. However, its integration is insufficiently adapted and often subject to a fragmented legal framework. This study critically examines the regulatory deficits limiting the implementation of these innovative approaches in spatial planning. It identifies the primary obstacles, namely the absence of a binding, cross-cutting definition of green and blue infrastructure across national legislations; and duplicative competences and fragmented responsibilities between vertical and horizontal public administration structures, which prevent coherent, multifunctional design. It is essential to establish binding standards for the proportion and quality of green and blue components in new development projects and to revise subsidy and financial schemes in favor of unconventional solutions. Overcoming the current regulatory inaction is a prerequisite for the transformation of cities towards a sustainable and environmentally functional structure.

Keywords: green and blue infrastructure, legislation, green spaces, biodiversity

1 Introduction

Since ancient times, cities have been considered important places in countries, initially mainly for reasons such as being the seat of a leader or a commercial crossroads. In the last century, this trend began to change and cities became denser thanks to industry. People began to move for work and apartments appropriate for the number of people began to be built in cities. At that time, cities also began to become centers of intelligence and began to grow even more. This historical development caused densification and a change in the concept of urban development. Multi-story apartment buildings and necessary urban amenities began to be built. However, green spaces were often forgotten in this urbanization.

Currently, the global problem of urban warming and cooling is often mentioned. In a country where we have so far mainly dealt with heat loss, we are beginning to focus much more intensively on protection against the effects of heat. Urbanization and dense development lead to the warming of cities and urban areas, which are unable to cool down [1]. We know of several factors that influence urban warming. The first is based on global warming due to various influences, while the second is closely related to urban planning and building design. This phenomenon is defined as the urban heat island effect and describes the temperature differences

between cities and surrounding areas with less dense development [2]. Dense development can lead to the trapping of radiation, which, after a full day of sun exposure, causes temperatures in cities to remain high. Factors that contribute to cooling cities, such as wind and evaporation, are minimized due to the geometry of urban planning. The orientation of streets and the geometry of street canyons were studied, and it was found that vertical building structures absorb the most solar energy [3].

Urban development is gradually replacing most of the green spaces in the area, distancing people from greenery and nature. Greenery plays an important role in the urban ecosystem [1]. Several cities have conducted studies on the benefits of urban greenery for residents and other advantages of green structures [4]. People use greenery for recreation, it helps reduce noise, and it has social and health benefits. Although these benefits are considered vital, greenery is often found only in limited areas. When looking at the city as a whole, green spaces help bring nature back to cities. Thanks to greenery, biodiversity, fauna, and flora are returning to cities. The air heats up much less and is purified of carbon, carbon dioxide, and other pollutants in the atmosphere. Another key issue is the regulation and use of rainwater, which burdens the sewage system and often causes problems with excess water and, during hot periods, a shortage of water [5]. From an architectural and urban planning perspective, green spaces are an integral part of cities and have cultural, aesthetic, and social value. Some studies show a correlation between the availability of urban green spaces and different ethnic and religious groups. This way of thinking about green cities is changing people's attitudes towards the environment, lifestyle, values, and attitudes towards nature. Natural areas and green spaces such as playgrounds, gardens, parks, forests, avenues, and orchards increase the attractiveness of an area.

When planning cities, green spaces are often neglected and replaced by investment projects that meet with resistance from city residents. This has led to the creation of several research projects focusing on quality of life and the development of green spaces. Some countries have regulations on green spaces included in their urban zoning plans. Legislation on green structures varies around the world, but the ideal solution is to create regulations tailored specifically to each city. In Slovakia, the amount of green space in cities and municipalities has been designated as an indicator of sustainable development, and this parameter is included in the administrative bodies of the urban greenery department [6].

In addition to traditional types of greenery, we are also trying to create green spaces on buildings. One of the structures used is the green roof, which is currently a very popular green element in architecture and building design [7,8]. However, due to the shortage of space for construction, buildings are primarily designed with facades covering most of their surface area. This leads us to the idea of how to get greenery onto the building envelope and thus achieve better thermal conditions.

2 Methods

The preparatory phase included a comprehensive review of the relevant legislative and regulatory framework for urban greenery and vegetation elements in built-up areas. The identified regulatory provisions were then stratified based on the hierarchy of their scope of application. This classification includes regulations applicable at the supranational level (European Union), national level (including the legislation of the Slovak Republic), and finally at the local territorial administration level (local government). The discourse is further enriched

by an analytical assessment of selected incentive policies aimed at supporting, developing, and permanently protecting urban vegetation. Finally, the results of a survey on the state of legislation in Slovakia are presented. Twenty-five of the 141 cities surveyed participated in the survey and answered the questions. Seventeen of them had a population of less than 10,000, and eight had a population of less than 20,000.

2.1 Legislation from the perspective of the European Union

The substantial scope of developed economies has implemented an extensive set of regulatory measures, technical norms, and standards that codify the management and development of urban vegetation at various administrative levels. Strategic documents focused on the principles of sustainable development have been adopted at the European level (e.g., European Union, Central and Eastern Europe, Visegrad Group). These initiatives complement global programs (e.g., UNESCO, Agenda 21). Key European Union documents that stimulate sustainable urban expansion are listed in Table 1.

Table 1: Key European Union documents [Author]

Title	Year
European Landscape Convention	2002
Cities and Lisbon Agenda	2006
Thematic Strategy on the Urban Environment	2006
Leipzig Charter on Sustainable European Cities	2007
Sustainable City Biodiversity	2008
Urban Space: Urban Landscape	2008-2011
European Green City Convention	2009
Green city- per-capita urban green area – LP	2014
High density- residential densification – LCF	2015
Towards an EU Research and Innovation Policy Agenda for Nature-Based Solutions & Re-Naturing Cities	2015
Nature-Based Solutions	2017
EKLIPSE-Expert Working Group on Nature-Based Solutions	2017
The European Green Deal	2019

According to the European Environment Agency, green spaces in cities should not be more than 15 minutes away from people, which is 900-1000 m. An assessment of European cities has shown that most of them meet this condition.

2.2 Legislation from the perspective of countries

As part of the spatial planning of large urban areas, several research studies focused on the systematic planning of urban greenery were carried out. In New York City, attention has focused primarily on applying ecological principles to the development of green structures and their integration into the urban environment. In China, comprehensive principles for urban green space planning have been formulated, taking into account a wide range of environmental, social, and urban factors. Variables such as the proportion of green spaces in the area, their spatial accessibility, methods for assessing the quality of green spaces, and planning based on

ecological principles have gradually been introduced into the professional discourse. At the same time, many cities have established specialized institutions focused on the systematic management and development of urban greenery.

2.2.1 UK

In the United Kingdom, research has been conducted to assess the availability of public green spaces, analyze social conditions, and evaluate the extent to which private green spaces complement the functions of public green spaces. The results showed that the distance of households from green spaces is significantly uneven and only about half of the population meets the criterion of green space accessibility within a five-minute walk. Based on these findings, it was concluded that green spaces should be considered part of public policy and should be made systematically accessible to residents. Current recommendations stipulate that city residents should have at least 60 m² of public green space per person within walking distance of approximately 500 meters.

2.2.2 Germany

German legislation sets standards for the spatial accessibility of green infrastructure (GI) for residents within walking distance. Empirical findings from German metropolitan areas (over 100,000 inhabitants) indicate that the average availability of green space per inhabitant is 183 meters, with an allocation of 8.11 m² per resident [9]. Since the 1990s, intensive research has been conducted to mitigate the effects of climate change, in particular the elimination of urban heat islands (UHI). The initial phases focused on greening parks and protecting existing areas. Current initiatives, such as the 'Green City of the Future' project, integrate complex factors (urban planning, building insulation, and vegetation elements). Successful implementation requires a revision of building regulations (e.g., Bauordnung, Baugesetzbuch), zoning plans, and the setting of specific criteria in public procurement. Many municipalities (e.g., Munich) are applying blue-green infrastructure (BGI) as a basic measure to minimize the effects of climate change. BGI includes horizontal systems (parks, forests), blue elements (rain gardens, permeable surfaces) and vertical solutions such as green roofs and facades [10,11].

2.2.3 China

The Chinese government is actively codifying environmental legislation, particularly environmental regulations, which are strongly supported by authoritative government control. This legislation is characterized by its regional segmentation, which ensures its more targeted application. The amendment of the legislative act in 2015 led to an increase in the number of binding regulations. Key documents after 2020 include, for example, the Urban Construction Law of the People's Republic of China (2020) and the Green Building Construction Management Measures (2020). The Green Building Construction Management Measures (2020) are a set of regulations that define the requirements for the construction of green buildings.

In Nanjing (northern subtropical climate zone), urban green space planning was based on key planning issues related to: protecting existing green spaces, integrating green spaces into densely built-up areas, optimizing the design of green spaces for residents, and formulating an action plan [12]. The outcome of this effort was a partial zoning plan for green infrastructure.

2.2.4 Czech Republic

The key legislative instrument for spatial planning in the Czech Republic is the Building Act (Act on Spatial Planning and Building Regulations, No. 183/2006 Coll.). This Act codifies spatial planning, which plays an essential role in the development of the natural values of the territory, including the protection of urban and architectural heritage. The Act defines the conditions for built-up and undeveloped areas and delimits areas based on their potential and degree of use.

In the context of strengthening the powers of local territorial administration, metropolitan entities are taking on an increasingly active role in strategic planning. One example is the city of Ostrava, which initiated and developed a new Green Concept. This document, approved by the city council in October 2025, demonstrates a commitment to the systematic development of green infrastructure at the local level.

2.2.5 Slovak Republic

In urban design, attention was also paid to quantifying urban green space within built-up areas. As early as 1967, a standard of 30 m² of green space per inhabitant was considered, which was subsequently adjusted to 50–75 m² per inhabitant. This range was approved by the relevant Slovak ministry and published in 1987 in the document Methodology of Territorial Green Space Plans for Settlements.

Since 2010, Slovakia has also had the Slovak Green Building Council (SKGBC), whose mission is to promote sustainable building standards and reduce the environmental impact of construction and building use. The organization aims to support sustainable development and foster professional dialogue between experts and the general public. Another relevant publication is Developing Green Infrastructure Elements in Slovakia (2017), which discusses, among other topics, green façades as a form of vertical greenery and their various types. The document is primarily informational, focusing on green-blue architecture, including approaches to rainwater management [13]. However, Slovakian legislation does not directly address vegetation elements. There are only laws that regulate vegetation regulations in general terms. Some of the main ones are listed in Table 2.

Table 2: Legislation in Slovakia [Author]

Sektor	Key legislation	Direct relationship to GBI	Green roofs and facades	Impact and function
Nature conservation (Green component)	Act No. 543/2002 Z. z. o ochrane prírody	Territorial system of ecological stability (TSES)	Indirectly linked as part of the protection of overall greenery	Ensures the protection and interconnection of greenery; binding for spatial plans
Water management (Blue component)	Act No. 364/2004 Z. z. o vodách	Regulation of rainwater management	Key retention measure; retains rainwater	Indirectly enforces blue infrastructure; obligation to

		(infiltration, retention)		minimize drainage into sewers
Land use planning and construction (integration)	New building laws 2022 (Since 2025)	Introduction of binding technical standards through decrees	Expected introduction of mandatory standards (or incentives) for roofs on selected buildings	Key to systemic change: setting quantifiable standards for developers

2.3 Legislation at the municipal level

At the level of smaller political units, such as states, cities, and even individual investors and builders, standards and regulations have been introduced to encourage the implementation of environmentally friendly buildings. Within these regulations, the most significant support is for green roofs, while green facades are only mentioned marginally. Separate green walls without integration into the facade structure are not mentioned in most regulations. Some cities are listed in Table 3.

Table 3: Legislation in selected cities [Author]

City	Legislation	Obligations
Munich	Bauordnung der Landeshauptstadt München	-Every new building over 500 m ² must have a green facade covering at least 20% of the facade area
Paris	Paris' broader strategy 2021	-The city of Paris has set a target that 50% of new buildings will have green roofs or facades by 2050
Vienna	Resolution of the Vienna City Council on the introduction of mandatory greening of facades	-conditions for green facades 20% of the facade area in this document are specified for new buildings with a facade area of more than 100 m ²
Amsterdam	Bestemmingsplan Centrum Amsterdam	-new buildings with an area of more than 1000 m ² must meet the green facade area requirement of 25% of the facade area
Prague	"Concept for the development of green infrastructure in Prague until 2030"	-The city of Prague has committed to meeting the requirement of 20% green elements, such as roofs and facades, by 2030

The Metropolitan Institute of Bratislava prepared the Public Space Manual titled Principles and Standards for Green Walls. The document identifies increasing the share of greenery in areas where traditional vegetation cannot be implemented as the main reason for installing green walls. The publication includes classifications, methods of establishing vegetated façades, plant selection guidelines, and basic parameters of individual types [14,15].

2.4 Overview of incentive policies

In urban planning, we often encounter reluctance on the part of private investors to implement green measures, mainly due to the higher costs of implementation and maintenance, while their economic benefits are difficult to quantify [16]. However, non-monetary benefits play an important role in green features such as green roofs and facades, serving as the basis for incentive policies. These policies aim to encourage investors to create green features while educating them about environmental sustainability [17]. The choice of specific incentive measures depends on several factors, including local policy, climatic conditions, available financial resources, and attitudes towards environmental issues. Incentive policies are most widespread in Europe and North America, with most measures focusing on promoting the implementation of green roofs; green facades are only sporadically subject to regulation and support. In Figure 1, we see motivational politics being used around the world.

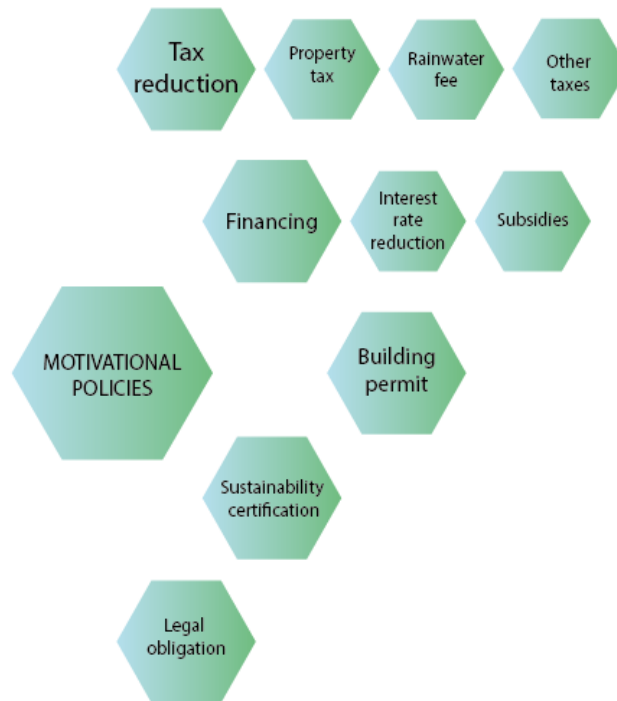


Figure 1: Distribution of incentive policies [Author]

Motivational policies (Table 4) supporting the introduction of green infrastructure vary globally by region. In Europe, they focus primarily on financial support for green projects and, to some extent, on the legal obligation to implement them, while the use of tax breaks or fee reductions is limited. In Asia, legal requirements dominate the enforcement of green policies, such as the obligation to have green roofs and vegetation walls on new buildings. The second most common tool is project financing, including preferential interest rates. Incentives to reduce taxes or fees are rarely used in the region.

Table 4: Motivational policies in selected countries [Author]

Criteria	DE Germany	NL Netherlands	FR France	SK Slovakia
Main Approach	Regulatory with Fiscal Incentives	Climate Adaptation and Water Focus	National Strategy & Municipal Obligations	Territorial System of Ecological Stability (TSES)
Key Regulation	Stormwater Fees – Many cities offer reduced fees for installing green roofs. Federal Nature Conservation Act (BNatSchG) – Integrates the national ecological network concept.	National Water Management – Strong focus on retention and infiltration measures within urban planning. National Adaptation Programme.	Biodiversity Law (2016) – Introduced the obligation to "avoid, reduce, compensate" (Eviter, Réduire, Compenser) for natural impacts. "Green Building Codes" in major cities.	Act on Nature and Landscape Protection – Enshrines TSES (ÚSES) as a mandatory part of spatial planning. The GI concept is still new and developing.
Specific Obligations (Municipal Level)	Mandatory green roofs in some cities (e.g., Hamburg, Berlin, Stuttgart) and subsidies for them.	"Climate-proof" building standards – Require solutions for water retention and minimization of urban heat islands.	Mandatory green/solar roofs on new commercial buildings (applies to certain categories).	Emphasis on water retention in building permits, but lacks widespread mandatory green roof/facade policies.
Fiscal Tools/Incentives	Reduced charges for surface water runoff. Local subsidies for green roofs.	Grants for water retention projects and ecological innovations.	Tax breaks for ecological investments in properties.	National grant schemes (e.g., for green roofs) – typically smaller in scale and with limited budgets.

North and South America mainly use legislative and regulatory mechanisms. In North America, financing and subsidies are used in addition to legal measures, while in South America, support in the form of financial incentives is limited. Both continents also use adjustments and reductions in fees such as property taxes; rainwater fees are mainly applied in North America. Further support is provided by simplified building permits and building sustainability certificates.

2.4.1 Motivational policies in Slovakia

In 2020, Act No. 255/2020 Coll. on the support of building renovation was adopted, which allows for the provision of subsidies for the renovation of buildings, including the implementation of green facades. Incentives are also supplemented by measures at the local government level. Cities and municipalities can use zoning documentation and building regulations to define requirements for the incorporation of vegetation elements into new buildings. In some cities, green facades are a mandatory feature for new buildings.

Financial support for the development of green infrastructure is currently provided by the cities of Banská Bystrica, Nitra, Trnava, Žilina, Prešov, and Košice. The amount of the subsidy varies depending on the type of green element implemented and in some cities reaches €50-100 per m². Both individuals and legal entities can apply for support for the construction of new buildings or the renovation of existing buildings. The financing of green facades is an effective tool for improving the quality of the urban environment. In addition to direct financial support, several cities are involved in projects aimed at raising awareness of Nature-based Solutions. Grant programs, such as Green City, support initiatives focused on the development of greenery in urban areas. Private investors can also support the implementation of green facades as part of their CSR activities.

2.5 Legislative status based on the survey

A quantitative questionnaire was developed and distributed with the aim of comprehensively assessing the current state of implementation of adaptation measures at the local territorial administration level in the Slovak Republic (SR). The questionnaire survey was specifically focused on mapping knowledge about blue-green infrastructure and its systemic integration. The primary research questions focused on three key areas:

- The state of local legislation and regulations: Identification of existing generally binding regulations and technical regulations that directly address elements of blue-green architecture (e.g., green roofs, facades, and permeable surfaces).
- Degree and nature of implementation: Determining the extent to which these measures are incorporated into spatial plans and whether they are binding or merely recommendatory in nature.
- Motivational and incentive mechanisms: Analysis of the tools used by local governments to encourage developers and investors to actively incorporate elements of blue-green infrastructure into private construction projects (e.g., in the form of subsidies or tax breaks).

A survey among local governments confirms that there is a high level of strategic awareness of the need to integrate blue-green infrastructure. 100% of respondents have introduced generally binding regulations for the protection of green spaces, and 92% have elements of blue-green infrastructure and adaptation measures incorporated directly into their spatial plans or binding parts thereof. Beyond the basic regulations, 68% of cities and municipalities have developed their own Green Concept or Blue-Green Infrastructure Concept, which indicates a medium to high level of strategic management of Nature-based Solutions. Data on the number of regulations can be seen in Chart 1 (Figure 2).

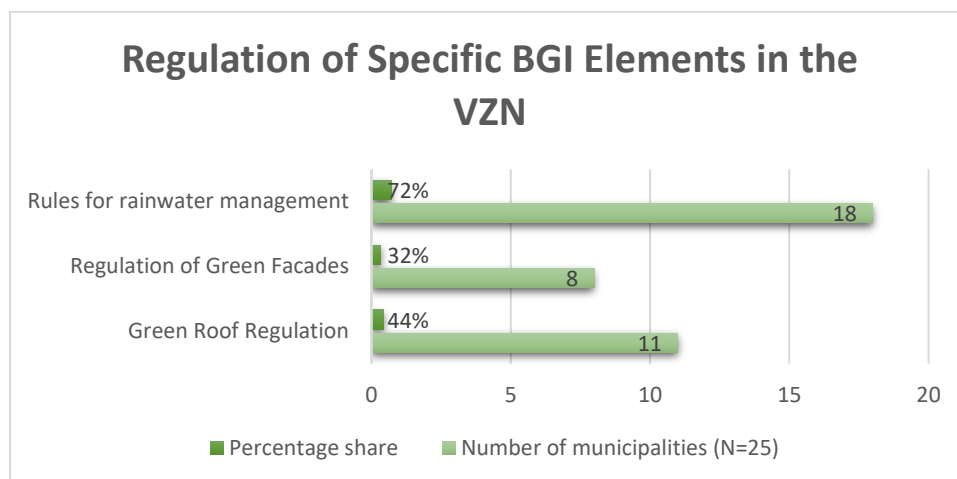


Figure 2: Regulation of Specific BGI Elements in the VZN [Author]

Although strategic support is strong, the survey revealed a key discrepancy between strategic intent and legislative enforceability. Only 28% of local governments have binding regulations for blue-green infrastructure elements (e.g., setting minimum permeability rates for surfaces). In 72% of cases, local governments only provide recommendations.

Regulatory mechanisms are inconsistent: green roofs are regulated in generally binding regulations in 44% of cases, while regulation of green facades is significantly lower (32%). This low level of binding regulation, especially for vertical systems, suggests that implementation is still heavily dependent on private initiative and financial incentives (Figure 3).

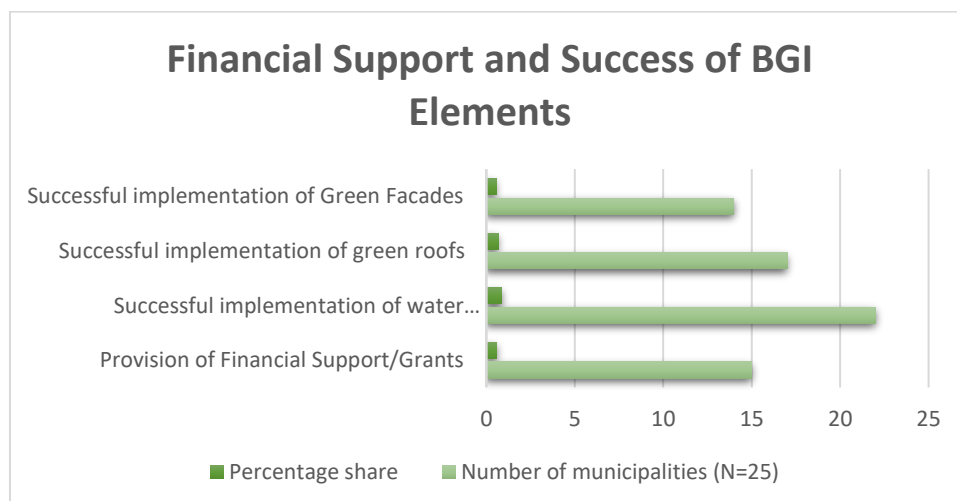


Figure 3: Financial Support and Success of BGI Elements [Author]

The Slovak Republic follows European Union directives, but terms related to green infrastructure on buildings are still rare in national legislation. Implementation is primarily supported by financial incentives – 60% of local governments provide subsidies for blue-green infrastructure elements, thereby stimulating the spread of green architecture.

However, local governments have identified three main barriers to implementation:

- Financial costs (80%).
- Lack of technical information and qualified companies (72%).
- Insufficient legislative support (64%).

3 Results and discussion

The findings confirm that a revision of the national legislative framework is essential to increase the effectiveness of implementation and systemic integration of green infrastructure. Codifying more precise binding regulations for vertical systems (facades) and horizontal elements (roofs, permeability) would lead to more effective design and ensure that blue-green infrastructure becomes standard construction practice, not just a strategic vision.

4 Conclusion

Modern urban agglomerations face escalating environmental challenges resulting from climate change, primarily in the form of urban overheating (UHI effect) and poor rainwater management. In response to these climate risks, adaptation strategies aimed at implementing nature-based solutions (NBS) in an architectural context are being initiated. Green roofs are now an established and globally accepted trend in the promotion of green architecture. Within the legislative framework, we find a growing number of regulations and standards addressing GI elements on buildings. While many cities have codified extensive strategic plans to improve environmental quality, these documents often represent a vision of the future rather than binding standards of current practice. Regulatory mechanisms are most frequently applied to green roofs, while specific regulations focused exclusively on green walls and facades are still the exception. The highest concentration of specific requirements is therefore currently found in the internal Generally Binding Regulations (VZN) of individual local governments.

The Slovak Republic follows the developments and directives of the European Union. Terms related to green infrastructure (GI) on buildings are still rare in national legislation. Implementation is primarily supported by initiatives focused on urban adaptation and financial instruments for the implementation of GI elements, which stimulates the spread of green architecture.

In order to increase the effectiveness of implementation and systematic integration of green infrastructure in densely built-up areas, it is essential to review and amend the national legislative framework. Codification of more precise regulations would lead to more effective design, and binding normative standards would motivate designers to routinely incorporate them into construction projects. In addition, it is necessary to sufficiently motivate investors, for example by introducing tax breaks, reducing stormwater fees, or providing direct subsidies for the installation of green roofs and facades. Supporting training programs for designers, architects, civil engineers, and local governments focused on the technical details of design. This is a very important part of the process, as the quality of the design is directly related to the effectiveness of the solution. Mandatory inclusion of a minimum percentage of green infrastructure in all new public projects and renovations.

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