ZESZYTY NAUKOWE POLITECHNIKI POZNAŃSKIEJ
Nr 25 Architektura, Urbanistyka, Architektura Wnętrz 2025
DOI: 10.21008/j.2658-2619.2025.25.2

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IMPLEMENTING THE BLUE-GREEN INFRASTRUCTURE APPROACH IN LANDSCAPE ARCHITECTURE

The Blue-Green Infrastructure (BGI) represents an innovative and integrative approach in landscape architecture, combining water and vegetation systems to create a more firmly established, resilient, and multi – functional urban environment. This study explores the role of BGI in promoting sustainable development, emphasizing its capacity to manage stormwater, enhance biodiversity, and improve urban microclimates.

Through architecture design interventions such as green roofs, rain gardens, vertical greening systems, and permeable pavements, BGI transforms conventional grey infrastructure into dynamic ecological networks that support environmental and social benefits.

By introducing a few case studies from urban contexts and urban campuses, the findings highlight the significance of integrating ecological processes and social values into landscape architecture design, reinforcing BGI as a cornerstone of sustainable and livable urban futures.

Implementing the Blue-Green Infrastructure approach creates more inclusive cities by integrating people with nature as well as facilitating climate adaptation.

Keywords: Blue-Green Infrastructure (BGI), landscape architecture, sustainable development, social benefits, biodiversity

1. RESEARCH BACKGROUND

The In landscape architecture,Blue-green infrastructures(BGI)is not simply an engineering solution for stormwater management – it is a design philosophy. It integrates water as a visible, dynamic, and expressive element, and vegetation as a functional infrastructure that supports life and well-being. The blue-green palette becomes both a technical strategy and a poetic language of urban form.

Blue-green Infrastructures (BGI) integrate solutions implemented to enhance water management and landscape values for more climate resilient and livable cities. BGI

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have created an opportunity to renew the natural structure of water balance in cities through the increase in rainwater retention and enlargement of permeable areas [Pochodyła, Glińska-Lewczuk, Jaszczak 2021].

Blue-Green Infrastructure (BGI) incorporates natural and semi-natural systems designed to alleviate the impacts of climate change, notably urban heat, in city environments [Almaaitah et al. 2021: 223-230]. Green infrastructure refers to an interconnected network of green spaces, consisting of various open spaces and natural areas, including parks, green belts, green roofs, and green facades, all covered with vegetation. It regulates surface energy processes through mechanisms like evaporation, shadowing, and adjusting emissivity [Vo, Hu 2021:10491].

Introducing Blue-Green Infrastructure to cities offers benefits in water retention, micro-climate regulation, and biodiversity enhancement. In cities with a rich history of historical watercourses, these features can be an incentive for activities involving the discovery, restoration, and exposure of cultural heritage. The discussed examples from Poznan, Milan, and Beijing show that the restoration of historical watercourses in cities is possible under certain circumstances [Skórzewski et al. 2025: 6325].

Both Green Infrastructure, widely regarded as a primary strategy for mitigating urban heat environments, and Blue Infrastructure play significant roles in influencing the spatial distribution of surface temperatures. Jung et al. (2021) found that the canopy area of trees is negatively correlated with surface temperature, with the mitigating effect varying based on the degree of urbanization and current canopy coverage [Jung, Dyson 2021].

The term "infrastructure" in BGI indicates that the role of natural processes involving vegetation or water features is essential in providing a variety of ser-vices to urban residents. The GI and BI in BGI are a significant enhancement of the GI idea. It should be noted that the proper functioning of plant elements depends on water resources. Simultaneously, vegetation determines the activity of local hydrological processes [Dreiseitl, Wanschura 2016].

Against the backdrop of accelerated urbanization, traditional hard infrastructure such as drainage systems and sewage treatment plants cannot effectively solve many environmental problems, especially water pollution, air quality decline and biodiversity loss.

Green infrastructure makes up for this deficiency by restoring and utilizing natural systems and playing an ecological role. Its main application areas include urban rainwater management, ecological restoration, green building and wetland restoration. For example, rain gardens, green roofs and permeable paving technologies have been widely used in urban rainwater management to absorb rainwater, reduce flood risk and improve water quality, and optimize the structure of urban ecosystems.

At the same time, ecological restoration methods such as wetland restoration and vegetation cover have also been applied in many areas. These methods restore soil and water conservation functions and biological habitats through natural ecological processes and enhance the environmental adaptability of cities. In the field of green building, more and more new buildings are beginning to adopt green infrastructure such as green roofs and green walls, which not only improve the microclimate of buildings, but also effectively reduce energy consumption.

The construction of green space systems such as urban parks and greenspace has also become an important part of urban ecosystem construction, and green infrastructure plays an indispensable role in this regard. Taking some large cities in China as examples, many cities have improved the ecological function of public spaces, mitigated the urban heat island effect, and improved the quality of life for citizens by implementing green infrastructure construction. However, the widespread application of green infrastructure still faces challenges such as insufficient funding, incomplete technical standards, and inadequate policy support. These constraints have, to some extent, affected its effectiveness. Further improving the technological maturity of green infrastructure, perfecting the relevant policy system, and strengthening cooperation among all sectors of society are key to promoting its in-depth development.

2. THE DESIGN FRAMEWORK OF BLUE-GREEN INFRASTRUCTURE

The Blue-Green Infrastructure (BGI) Design Framework integrates water and vegetation systems to create resilient, multifunctional, and connected urban environments. It combines blue systems (wetlands, rain gardens), green systems (parks, green roofs), and hybrid elements (permeable pavements, green streets) to manage stormwater, enhance biodiversity, and improve urban livability.

Applied across urban, neighborhood, and site scales, BGI supports flood control, cooling, habitat creation, and social well-being. Its success depends on collaboration among planners, ecologists, and communities, supported by policies and continuous monitoring. Overall, BGI links ecological and social functions, transforming cities into sustainable, climate-adaptive, and people-centered landscapes.

As the research approach, the literatures based on WoS fig. 1 has been collected, searching the key elements in the database we can find the most have been reported or in the case studies is coming up with green roof infrastructure and then the water element like rain garden.

Concerning four most popular BGI elements,from various BGI solutions reported in the literature, the four most popular BGI elements were selected for detailed analyses: rain gardens, green roofs, VGS, and permeable pavements. According to Versini et al. (2018), these four elements were the most important and popular due to a number of benefits for urban spaces. The description of each solution com-prised a definition, types, and classification criteria. The importance of each element was presented in the relation to its role for water management [Versini et al. 2018: 60-63].

Among the various solutions of BGI, the highlights would be given to four elements, which combine and design solutions used in water management systems: rain gardens, green roofs, vertical greening systems, and permeable pavements. Below provide their characteristics, types and features that enable effective support for water management in the cities. It should be noted that their potential results from the possibility of installation in a dispersed manner, tailored to the individual characteristics of a given area.

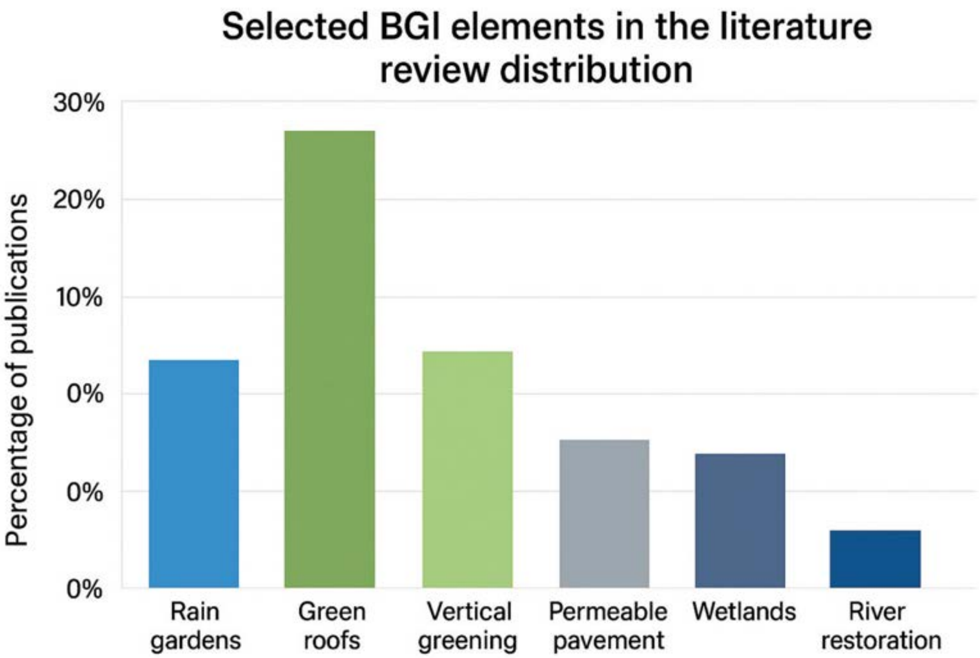

Fig. 1. The publications research distribution percentage on selected the key elements in BGI solution in Landscape Architecture application [own study based on web of science core collection]

3. BLUE GREEN INFRASTRUCTURE APPLICATION IN LANDSCAPE ARCHITECTURE – CASE STUDIES

3.1. Adaptation flood management and incorporating green infrastructure – smart solution BGI – case study from Germany

These large-scale urban projects highlight the importance of adapting the climate challenges while promoting ecological solutions and social well-being. HafenCity from Germany is a large-scale urban development project in Hamburg, Germany, transforming a former port area into a vibrant, mixed-use neighborhood. By implementing green architecture, revitalizing the Elbe waterfront, and balancing residential, commercial, and cultural uses,the project aims to create a vibrant and friendly neighborhood. By integrating flexible flood protection measures that adapt to changing water levels, incorporating green roofs, green walls, and extensive parks to improve air quality, manage storm-water, and enhance urban biodiversity. combine historical preservation with contemporary architecture and sustainable urban planning. Converting an industrial port area into a residential and commercial district presented significant challenges, including environmental remediation, infrastructure development, traffic management, and preserving the area's historical character. Smart to use the Blue green infrastructure, the urban regeneration project focuses on sustainability, public space, and cultural integration by preserving historic buildings and urban context.

The Master plan as shown fig. 2 which defines the basic elements of Hafencity developments was conceived from the outset as a flexible, updated concept, designed to be refined and firmed up over the course of the planning and development process. The basic Blue green infrastructure elements had been clarified as the fig.2 shown below.

Fig. 2. The masterplan of Hafencity, which defines the basic objectives of HafenCity development [https://www.hafencity.com/en/overview/masterplan @KCAP/ASTOC]

3.2. BGI soultion in design a raingarden case study from Pekin University Campus

Due to the suffering from the waterlogged in the southern part of the campus of Pekin University, the campus was constructed with high intensity, which has led to severe waterlogging and runoff pollution. The lawns between the buildings are not for the social activities and has no effect to reduce surface rainwater runoff.

The rain garden project had been designed in this campus and the designer team from University Design and biuld Association of Pekin University had selected a typical green space of 300 m^2 in the dormitory area as the pilot.

The most used sidewalks on both sides of the site had been retained asa well as all the high greenery had been maximally retained on the site. A small square of 5 m by 5 m is defined by the odd persimmon and walnut trees. The square divides the long and narrow green space into a larger and a smaller bioretention. Therefore some of retention ponds had been to reduce in order to provide some space for bikes parking in the campus nearby the dormitory.

In terms of collection and reuse of rainwater, the rain garden can manage the runoff generated by the surrounding impervious surface of 572 square meters, reducing up to 16 cubic meters of rainwater for the dormitory area (https://mooool.com/harvesting).

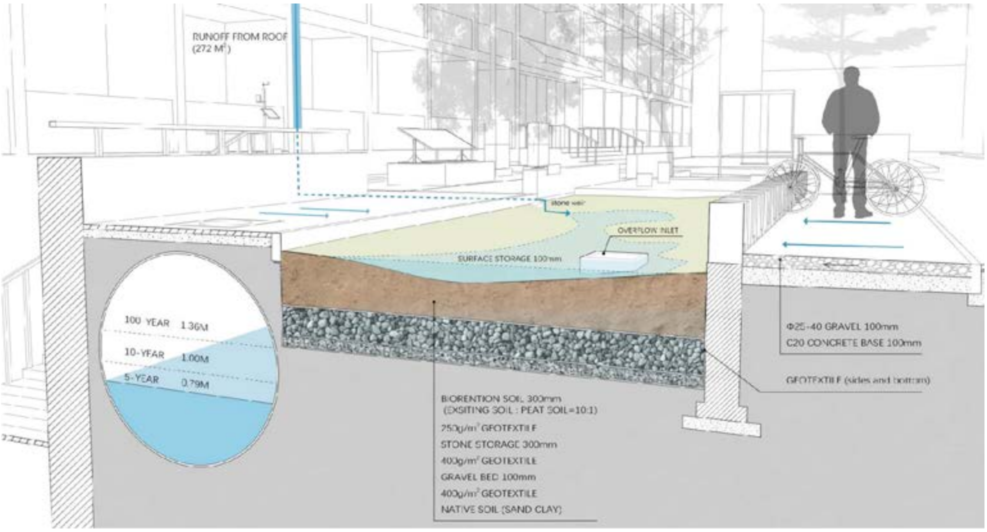

Fig. 3. The rainwater garden collection in order to reduce the waterlogging problem in Pekin UNiverity Campus provided from Hao Zhang, Kangfu Zhuo [https://mooool.com/harvesting]

3.3. The Blue green infrastructure solution applied in landscape architecture design – a case study from campus space design modeling

This project was aimed to regenerating the campus Warta and to create the future green campus and the tasks were given to students during the landscape Architectural classes as the exercises. This project was based on the sector between two high teaching buildings in the campus. The main function is adapting the green surface and maximally use the rainwater collection to enrich the limited open space ir order to provide the pace for students for social activities.

The landscape design emphasizes a balanced integration of natural elements and campus infrastructures. Maple and fir trees are used to create diverse textures, seasonal colors, and natural sound barriers. Tree-lined paths and green zones visually and functionally connect various areas of the campus, ensuring an inviting and cohesive environment. As shown in fig. 4 the project focuses on enhancing both the functionality and aesthetics of the space, with recreational zones, green corridors, and plantings designed to provide a harmonious blend of usability and nature. Sustainable measures like rainwater systems and drought-resistant vegetation further contribute to the ecological vision of the campus.

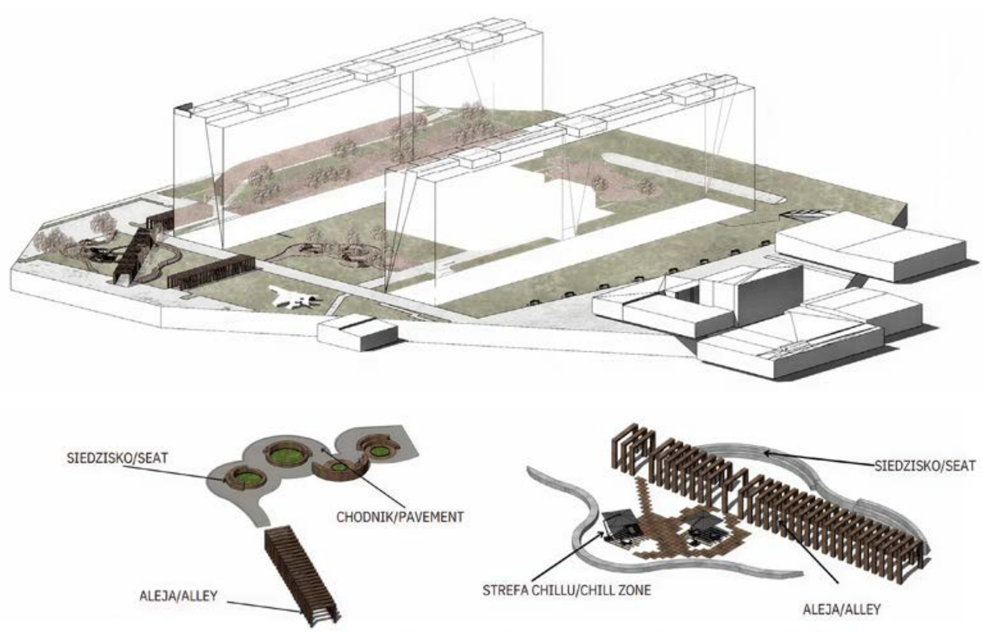

Fig. 4. The AXONOMETRY, and the concept development of a sector space between teaching buildings in Campus Warta from Poznan University of Technology [drawn from K. Plewa, J. Stępniewska, M. Szymanek, E. Szymanowska, W. Szyszka. Supervised by M. Zhou]

4. CONCLUSIONS

The Blue-Green Infrastructure approach represents a transformative opportunity for landscape architecture to contribute to urban resilience and ecological restoration. By embedding water-sensitive design and ecosystem services into urban fabrics, landscape architects can lead the transition toward regenerative cities. Future research should focus on quantitative performance assessment, climate adaptation modeling, and community-driven design methodologies.

In terms of biodiversity, green infrastructure can provide habitats for plants and animals and promote ecological restoration. Measures such as wetland restoration and ecological corridor construction provide more habitats for urban ecosystems, enhance the connectivity of ecosystems, and thus promote the diversity and stability of biological populations. Through these measures, not only has the local ecological environment been improved, but urban residents have also been provided with more opportunities to get close to nature, and people's ecological awareness and environmental protection actions have been enhanced.

LITERATURE

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WDRAŻANIE PODEJŚCIA NIEBIESKO-ZIELONEJ INFRASTRUKTURY W ARCHITEKTURZE KRAJOBRAZU

Streszczenie

Koncept błękitno-zielonej infrastruktury (BZI) prezentuje innowacyjne i zintegrowane podejście w architekturze krajobrazu, łącząc funkcjonowanie systemów wodnych i roślinnych w celu stworzenia trwalszego, bardziej odpornego i wielofunkcyjnego środowiska miejskiego. Niniejsze badanie analizuje rolę BZI w zapewnianiu zrównoważonego rozwoju, podkreślając możliwość zarządzania wodami opadowymi i zwiększania bioróżnorodności oraz poprawy mikroklimatu miejskiego.

Poprzez interwencje architektoniczne, takie jak zielone dachy, ogrody deszczowe, pionowe systemy zieleni i przepuszczalne nawierzchnie, w dynamiczne sieci ekologiczne, które wspierają korzyści środowiskowe i społeczne.

Analiza wybranych studiów przypadków przestrzeni miejskich i kampusów wykazała, że integracja procesów ekologicznych i wartości społecznych odgrywa kluczową rolę w projektowaniu architektury krajobrazu. Uzyskane wyniki potwierdzają, że koncepcja BZI może stanowić fundament wspierający zrównoważony rozwój oraz tworzenie przyjaznych mieszkańcom miast. BZI przekształca konwencjonalną szarą infrastrukturę. Projekt ramowy infrastruktury niebiesko-zielonej (BGI) integruje systemy wodne i roślinne w celu tworzenia wielofunkcyjnych, odpornych i połączonych środowisk miejskich.

Wdrożenie konceptu błękitno-zielonej infrastruktury pomaga tworzyć bardziej inkluzywne miasta poprzez integrację ludzi z naturą, a także wspierać adaptację do zmian klimatu.

Słowa kluczowe: błękitno-zielona infrastruktura (BZI), architektura krajobrazu, rozwój zrównoważony, korzyści społeczne, różnorodność biologiczna