Investigating spatial patterns of green infrastructure at built heritage sites in Antwerp, Belgium

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Abstract

Green infrastructure has become a favourable solution to mitigate the effects of climate change, rapid urbanisation and the loss of biodiversity. However, historic buildings at the core of the urban fabric are often excluded from GI for reasons of conservation and the fear of plant species damaging the historic structure. There is little research and, therefore, evidence on the successful use of GI in historical contexts. This study addresses this gap by investigating different types of GI found in historical contexts. Spatial patterns found in the city centre of Antwerp in Belgium are analysed through the lens of architectural design theories and traditional heritage value assessment. This is the first step in creating an evidence base for best practices of GI in association with built heritage.

Author keywords

NbS, Heritage Value, Sustainable Development, Urban Heritage, Biophilic Design, Architecture

Introduction

In response to rapid urbanisation and global challenges like climate change and loss of biodiversity, cities are increasingly adopting nature-based solutions, which include Green Infrastructure (GI) like green open spaces, trees, green roofs and vertical greening systems. GI are strategically planned green spaces that provide numerous benefits, so-called ecosystem services (Norton et al., 2015; Tzoulas et al., 2007; Sharifi, 2021; Sturiale & Scuderi, 2019). Known benefits include improved air quality, reducing the temperature and overall urban heat island effect, contributing to (storm)water management, and increasing urban biodiversity and ecosystem health (Abdo & Huynh, 2021; Selbig et al., 2022; Ysebaert et al., 2021). In addition, GI has positive impacts on psychological and physical well-being, like reducing stress and improving attention (Kaplan & Kaplan, 1989; Ulrich, 1983). In this green transition, many historic cities have become pioneers of sustainable development and the willingness to adopt GI due to the societal and governmental acceptance of these projects (Beatley, 2012). Despite this, the compatibility of GI with historic built heritage has received little attention.

There is a common belief that GI is incompatible with built heritage as it can potentially alter the aesthetic values and physical integrity of building materials through biodegradation, plant-induced explosions, and cracks. In addition, there is a concern that integrating GI into built heritage may obstruct conservation practices by requiring additional management and maintenance activities (Ashurst & Ashurst, 1988; Coombes & Viles, 2021). However, these concerns are largely based on studies focusing on neglected and abandoned historical buildings or archaeological sites rather than representative built heritage contexts (Celesti-Grapow & Ricotta, 2021).

From a social perspective, individuals' negative perceptions of green layers on historic buildings are primarily associated with their physical and biological connections to natural and built environments (Kellert, 2008). Researches suggest that being disconnected from nature can build biphobia in the built environment (Ulrich, 1993), therefore, creating a bias against invasive and pest-attracting vegetation in public areas (Coombes & Viles, 2021). As a result, people tend to prefer manicured landscapes in urban settings because they are associated with maintenance (Hoyle et al., 2017), which could even lead to gentrification (Moore & Cooper Marcus, 2008). However, it is important to note that people may require genuine contact with nature rather than just superficial "greenwashing" (Browning et al., 2014).

To leverage the full potential of historic buildings in the greening of our cities, there is a need for evidence-based research analysing the successful and deliberate examples of GI in the context of built heritage within a framework of heritage values and spatial attributes. In this study, we focus on GI in a close relationship with historic buildings (vertical green, green roofs, and trees).

Methodology

The research uses a mixed approach involving a literature review and a field study. The literature review focuses on identifying the spatial attributes of built heritage values that can be used to analyse the compatibility of GI with built heritage. This involves reviewing cross-scale studies on urban planning, heritage value assessment, and architectural design and perception. The field study collects examples of GI applied to built heritage in Antwerp and categorises them based on their physical and perceptual attributes.

Built Heritage Value and Spatial Patterns of Urban Fabric

Determining the value of historic buildings is a central focus of many conservation doctrines and charters (de la Torre, 2013). The Nara Grid distinguishes the value and authenticity of heritage sites through different aspects, such as form and design, materials, use and function, traditions and techniques, location, and spirit and feeling, that can help to understand the artistic, historical, social, and scientific dimensions of a heritage site. Additionally, value assessment is shifting towards considering communities' involvement with heritage assets with socio-cultural associations, such as the collective memory, the spirit of the place and the identity of the place (Doğan, 2021; Kellert, 2008).

Theorists of architecture and urban planning have various approaches when it comes to determining spatial forms and elements. This involves considering various attributes, including ordering principles and qualities of space (such as texture, colour, and size) (Ching, 2014), categorising elements based on their form, function, and construction (Krier, 1991), creating an "urban vocabulary" based on a mental map (Lynch, 1960), and studying spatial patterns of built environments across scales (Alexander et al., 1977).

Field Study

The field study carried out in Antwerp aimed to establish a framework for subsequent research stages by conducting a preliminary analysis of several case studies where GI was implemented on built heritage sites. Antwerp was selected as the case study location because of the presence of projects that support the integration of GI into the built environment and the historical context. The study was conducted during the spring and summer seasons in 2022. The data collected through photo documentation of evergreen and deciduous GI was analysed qualitatively to investigate the spatial relationship between architectural patterns and GI using a set of attributes based on the built heritage values and spatial patterns of the urban fabric (Table 1). The attributes were grouped into three scales: building scale, neighbourhood scale, and city scale. The building scale analysis focused on the direct impact of GI on the historic building. Neighbourhood scale analysis examined the spatial relationships within building blocks and streets, which shape the collective identity of the built environment. Finally, the city scale analysis involved the examination of different districts with different historical and social characteristics.

Table 1. The attributes used for analysing perceptual and spatial attributes of GI in a built heritage context.

Scale	Attributes	Description
Building	Heritage Status	It encompasses the features that define buildings' identity, such as function, uniqueness, age and condition and historical value.
	Form and design	Analyses the spatial and physical elements of buildings where GI is applied, such as the façade, roof, and courtyard.
	Materials	Examines the visual impact of GI on the surface qualities of building materials.
	Support structures	Refers to the support structures used to maintain and guide the growth of GI, such as planters, wire structures, and trellises.
Neighbourhood	Street Morphology	Examines the physical characteristics of the street and building facades, including the height-to-width ratio of buildings and the alignment of buildings and setbacks
	Spirit of the space	Considers the meanings linked to a place, including its collective memory and cultural-ecological identity
City	District Characteristics	Analyses the correlations between social and historical characteristics of districts and the level of support for GI implementation
	Land availability	Evaluates the availability of urban morphology for implementing GI.

Results

The results of the study represent the examples of GI implemented in various built heritage sites at different scales. These spatial patterns were determined through a field study according to the attributes outlined in Table 1.

In the building scale, it has been observed that there is a connection between the function of a building and the way GI was used. For example, GI is often used at the entrances of retail buildings to create an inviting atmosphere (see Figure 1a), while educational buildings may use GI in courtyards to benefit students. Another finding is that the buildings that draw inspiration from nature in their unique architectural style also tend to use GI to highlight this inspiration. The Cogels-Osylei district is one example, featuring Art Nouveau and Neoclassical buildings that are accentuated by adding greenery (see Figure 1b).

Another relationship observed on the building scale is between the form and design of buildings, where GI is implemented, and how it impacts the building materials. For example, evergreen climbing plants tend to grow on flat surfaces such as blind facades (see Figure 1c), while flowering plants like trumpet vines are used for shading or highlighting architectural elements like windows and gates (see Figure 1d). Recessed or extended forms such as window sills, balconies, and bay windows are typically used for potted plants like flowers, herbs, and small trees. It has also been observed that flat roofs tend to allow for green roofs in historic buildings (see Figure 1e). Furthermore, It has been observed that the choice of plant species for courtyards may be connected to the building's function and the courtyard's location. Front gardens of residential buildings tend to have large trees or shrubs to provide privacy, while inner or side courtyards are used for gardening and horticultural activities (as shown in Figures 1b and 1f). In spatial limitations, metal wire or wooden trellises are utilised to guide the growth of vertical greenery in a controlled direction which also prevents direct contact between GI and the building façade (see Figure 1g). Subsequently, the interaction between vertical greenery and various building materials, including terracotta, natural stone, exterior rendering, and metal cladding, has been examined. Some surface alterations were observed due to direct contact, but those attached to metal wires did not exhibit such alterations. This is also observed concerning the age and condition of the building. In buildings that have been recently restored or are regularly maintained, fewer surface changes are observed due to the use of GI, based on the analysed samples (see Figure 1h).

Figure 1. Demonstrates the use of GI in building scale: a) Retail Function, b) Building from Cogels-Osylei district, c)Vertical greening on the blind facade, d) Vertical greening around the windows, e) Green roof, f) Inner courtyard of the Rubens House g) GI support structures, g) Implementations of GI in different materials

The analysis of GI on a neighbourhood scale considers the street morphology and spirit of the space in the built heritage context. Concerning the street morphology, the influence of building height, road width, and building alignment on GI selection is analysed. In narrow street canyons with limited sky views, trees are not commonly used due to the potential for blocking sunlight and obstructing views of historic buildings. Instead, vertical greening supported by metal wires across the street is often preferred. On the other hand, wide canyons have trees planted in rows to provide shade and cooling without disrupting the aesthetic perception of historic buildings (see Figure 2a). Also, in many cases, the alignment of buildings has impacted the selection of GI types. Trees are often planted in buildings with setbacks from the road or a garden, while climbing plants may cover blind facades or garden walls in detached buildings. Row houses use vertical greening in a continuous order along horizontal divisions (see Figure 2b).

Regarding the spirit of the space, the cases in which collective memory and cultural-ecological identity are influential in the use of GI are observed. For example, there are many cases where trees are planted along historical streets, such as the Meir in Antwerp, to frame significant monuments like the central station (see Figure 2c). Furthermore, it was noted that cultural-ecological identity played a significant role in GI adaptation through urban agriculture in the case of PAKT (PAKT Antwerpen, n.d.) (see Figure 2d) and through the botanical gardens of museums, as in the cases of Rubes Huis and Snijders & Rockoxhuis (see Figure 1f).

On a city scale, districts with different historical and social characteristics are analysed, considering the level of support for green initiatives. Residential areas like Borgerhout and Zurenborg (see Figure 3a) have numerous examples of green streets shaped by the initiative of local participants. Meanwhile, the historical city centre of Antwerp has top-down initiatives such as the green street project in Lange Riddersstraat (stad Antwerpen, 2020), which was systematically handled with the support of the municipality (see Figure 3b). Although there are some examples of participatory initiatives in the historical centre, they are more common in residential areas. Additionally, the availability of land is a significant challenge for implementing GI. However, there are examples at the city

Figure 2. Demonstrates the use of GI on a Neighbourhood scale: a) Trees along the wide and narrow street canyons, b) Vertical green along row houses, c) View of the central train station from Meir street, d) PAKT

Figure 3. Demonstrates the use of GI on a City scale: a) Schorpioen street in Zurenborg, b) Lange Riddersstraat in the historic centre of Antwerp, c) Utilising the node point as the garden at Marnixplaats, d) Google Earth view of courtyards defined within building block in Marnixplaats

scale that have overcome this issue. For instance, greenery surrounds the node points of crossroads, as seen in the case of Marnixplaats, and open spaces within building blocks are used as communal gardens (as shown in Figures 3c and 3d).

Conclusion

This study proposes a framework to study types of GI at or near historic buildings by linking different forms of greenery with different attributes of built heritage sites. The preliminary field study brought forward numerous examples where types of GI integrate with built heritage environments. From this, different spatial patterns were identified.

In the field study, it has been noted that different forms of GI are used at buildings with different functions, designs, ages, and conservation statuses. Façade patterns like vertical and horizontal divisions or blind facades provide a surface for the growth of climbing plants. At the same time, recessed or extended forms such as window sills, balconies, and bay windows are used for pot plants like flowers, herbs, and small trees. The use of GI in neighbourhoods is also influenced by street morphology, alignment of buildings, and the cultural-ecological identity of the area. The main challenges in implementing GI into built heritage at the city scale are the regulations within the urban conservation areas and finding adequate space. However, several examples have been observed that have overcome these challenges, such as green street initiatives and using open spaces inside building blocks as common gardens. Overall, observations have provided creative solutions to overcome regulatory and spatial limitations.

These examples could serve as best practices and guide the integration of GI into built heritage environments in a way that is both functional and respectful of their cultural significance. The findings of this study invite a further in-depth study. In the next phase of our research, we will conduct a comprehensive study in Antwerp's historic centre to further assess the compatibility of GI in heritage environments. This study will include quantitative data analysis using QGIS and QField and gathering feedback from the general public and experts. Through this combination of approaches, we aim to understand what factors contribute to successfully integrating GI in historical contexts.

Acknowledgements
The authors gratefully acknowledge BOF Research grants for funding this project (44623) and Research Foundation – Flanders (FWO) for funding this project (43365). We thank all the peers who commented and helped us to develop this paper.

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