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Review paper

THE GREENING OF URBAN RUINS - AN EFEECTIVE WAY FOR MULTIFUNCTIONAL REVITALIZATION OF ABANDONED URBAN SPACES

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Abstract

Greening urban ruins represents an innovative approach to the revitalization of abandoned built structures. This process merges greenery with ruins or abandoned structures, creating synergy between natural and built elements of the space. The goal of greening ruins is not only ecological but also aesthetic, as it transforms neglected buildings into green "oases" that promote biodiversity and improve microclimatic conditions in urban environments. As a part of urban green infrastructure revitalized ruins can become an effective way in adaptation cities to climate changes, especially in the terms of rainwater regulation and minimize urban heat island. Revitalization contributes to social cohesion, creating spaces that can become gathering places for various community activities. Case studies at both European and global levels provide examples of good practices that offer insights into the benefits and challenges of revitalizing abandoned structures.This paper explores the potential for revitalizing ruins through the application of plant materials, emphasizing the benefits greenery can contribute to the renewal of abandoned urban spaces, as well as analyzing various greening possibilities, including the use of different techniques such as vertical greening systems, rooftop gardens, green walls, and interior greening of buildings. Greening ruins also contributes to preserving cultural identity, through the appropriate use of plant materials, to become integral parts of contemporary urban ecosystems. The potential for revitalization depends on the structural stability of the buildings, the maintenance and care requirements for green areas, potential legal issues, and financial considerations, which highlight the need for careful planning and implementation. Further research in this area can contribute to the understanding and making practices and specific solutions for the future revitalization of urban spaces through greening.

Key words: *urban ruins, greening, abandoned urban spaces*

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1. INTRODUCTION

Intensive urbanization and demographic changes have led to the expansion of urban areas and the construction of a large number of buildings, which negatively affect existing urban green spaces. The negative impact most often results in the reduction in size and fragmentation of urban green spaces, particularly evident in central urban zones. The degradation and fragmentation of green spaces lead to the disruption of biodiversity, the loss of habitats for many plant and animal species, and the endangerment of the entire ecosystem [1]. On the other hand, urban green spaces appear to be a crucial asset that could help cities sustainably mitigate the adverse effects of rapid urbanization and urban sprawl [2]. They play a vital role in cities by reducing urban heat, decreasing air pollution, and providing significant environmental, social, and economic benefits. Unfortunately, especially in compact cities, green spaces are often undervalued in the planning and development process [3] and are seen as obstacles to development [2]. Therefore, even a minimal increase in urban green spaces is important today and often follows modern greening trends such as the construction of multifunctional small green spaces, the use of vertical greening techniques, rooftop gardens, and the revitalization of ruins and abandoned urban buildings.

Urban ruins are the result of past human activity in the urban landscape and usually refer to abandoned buildings and sites, such as remnants of wars, abandoned hospitals, unfinished buildings, disused factories, and shopping centers [4]. An urban ruin is considered an unusable, non-functional human creation when viewed in the context of functional buildings designed for a specific purpose [5]. Ruins can be previously constructed buildings that were poorly maintained or completely neglected and abandoned, and which hold value as part of culture and heritage. Additionally, ruins include buildings whose construction was never completed due to various circumstances [6].

Numerous studies show that increasing attention is being paid to abandoned urban ruins due to their diverse impacts, the emergence of relevant policies, and the real challenges cities face. People are increasingly aware of the need to reuse urban ruins, and their large-scale rehabilitation is becoming an essential component of urban resource recovery, economic development, and the promotion of sustainable urban growth [4].

The greening of abandoned city spaces, especially urban ruins are still not recognized enough and promoted in Serbia. Thus, this paper aims to emphasize the benefits of greening urban ruins and various greening methods, including vertical greening systems, rooftop gardens, green walls, indoor and outdoor greening of buildings. We present and analyze some examples of successful revitalization and reuse of urban ruins that preserve the cultural identity of buildings and places, offering an important response to the contemporary needs of the urban environment. We address the following research questions: (1) Which are the main benefits of greening urban ruins? (2) What kind of techniques can be used in context of urban ruins revitalization? (3) Can greening of urban ruins contribute to the cultural identity preservation of the structures or urban ecosystem development, and to what extent?

2. METHODOLOGY

This paper is based on the theoretical and qualitative research, which includes collecting secondary data in the fields of landscape architecture, urban ecology and reconstruction and revitalization of abandoned buildings, in order to address the exploratory nature of the research questions. The secondary data includes relevant scientific papers and project data related to abandoned urban areas. As we emphasize, there is a lack of scientific and project-based data on urban ruins in Serbia. Therefore, our focus shifted to examples from other countries across Europe and beyond. However, a general lack of information persists globally, as the revitalization of ruins—considered a form of abandoned space—has only recently begun to emerge as a recognized approach. We aimed to identify and select examples of best practices that offer insights into the benefits and challenges of revitalizing abandoned structures. The selection of examples was based on the following criteria:

- Context and location - basic information about the location of the ruined object, the urban environment and the previous function of the built structure.
- Applied greening techniques – roof gardens, green walls, interior greening of buildings etc. and type of plant materials.
- Ecological effects - contribution to biodiversity, regulation of microclimate, stormwater management and reduction of the urban heat island effect.
- Aesthetic and ambient contribution - visual transformation of the space and visitors' experience.
- Social and cultural significance – multifunctional reuse of the space, social cohesion and cultural identity preservation.

Through discussing presented study cases we tried to highlight some guidelines including context of the location, applied greening techniques, outcomes, and observed challenges. At the end we made conclusions that can contribute to better understanding and implementation of practices as well as provided specific solutions for further research and future revitalization of urban spaces through greening.

3. ADVANTAGES OF GREENING URBAN RUINS

Major industrial cities in the United States and Europe have experienced a syndrome of abandoned urban spaces and buildings over the past 50 years, due to the decline of underlying industries [7,8]. Urban redevelopment often failed due to the inability to meet the increasing demands for both economic development and environmental improvement [9]. Trancik (1986) [10] recognized the importance of urban ruins and proposed the Lost Space Theory as a framework for understanding land and buildings left unused and unstructured in the context of urban regeneration and decline [11,12].

The negative effects of urban ruins are mainly as follows:

- high population density and low land consumption per capita make urban ruins destructive to the local tax base and wasteful of scarce land resources;
- negative impact on the overall image of the city;
- severe environmental degradation, which poses health risks and reduces the general well-being and happiness index of residents; and
- threats to public safety and an additional economic burden [13,4].

The deterioration and degradation of materials used to construct these buildings also occur naturally due to various causes (e.g., wear and chemical interactions), especially under the influence of climate change (notably temperature fluctuations). However, abandonment and lack of maintenance significantly accelerate this process.

Among the most commonly used methods of reclaiming abandoned urban spaces is their conversion into multifunctional green areas [14]. The benefits of greening abandoned spaces are numerous, with major positive effects on the building, the environment, and the people—all at once. These benefits depend on the types of plants used and the surface area they occupy.

Recognized environmental benefits include: air purification and improved air quality, retention of airborne particulates, dust, and pollutants, reduction in vertical air flow, moderation of the urban heat island effect, creation of microclimates, rainwater and stormwater retention, and the formation of new urban ecosystems.

Building-related benefits include: improved thermal performance leading to greater energy efficiency, sound insulation and noise reduction, extended roof lifespan, cost savings for commercial property owners, creation of new jobs, and opportunities for urban food production.

Sociological and psychological benefits for residents are also highly significant. Numerous cases demonstrate how transforming abandoned urban spaces into vibrant public areas positively impacts daily life and quality of life [14,15,16,17].

Several empirical studies have examined the positive mental health effects of converting abandoned spaces into green spaces [18,19], revealing reductions in residents' stress levels and increases in physical activity [20].

Hollander (2010) [21] proposed the following benefits of urban regeneration of ruins: improved physical infrastructure, enhanced community safety, better public facilities, increased walkability, and a restored sense of community. This conceptual framework shows that enhanced urban spaces can directly and indirectly improve residents' wellbeing—physically, mentally, and socially.

4. TECHNIQUES AND METHODS FOR GREENING URBAN RUINS

The restoration of ruined buildings most often aims to preserve their cultural and historical identity, leaving the stylistic and temporal characteristics from the period in which the structure was originally built intact. Additionally, many examples of building restoration show frequent changes in the land use of the site, and repurposing of revitalized ruins is almost always involved.

Contemporary greening trends for abandoned spaces and urban ruins involve the application of various techniques and methods that serve as an important strategic response to sustainable urban development and climate change. In addition to greening the structure itself through appropriate techniques (green facades, green walls, green roofs), revitalization also includes the greening of the building’s immediate surroundings, which acts as a mechanism for increasing urban green spaces (Figure 1).

Vertical greening (green facades, green walls, green roofs) is an essential method used in the revitalization of ruins. It consists of systems in which vegetation grows vertically upward or along wall and roof surfaces, with plant growth and development occurring in limited space [22].

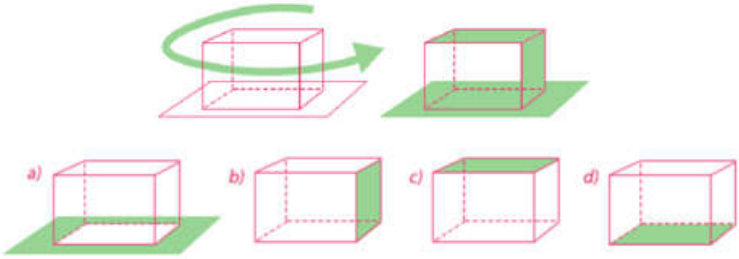

Figure 1: Possibilities for greening urban ruins (a) greening of the surrounding space, (b) wall greening, (c) roof greening, (d) interior greening of the building, Source: authors

Greening the vertical surfaces of buildings involves the use of various categories of plant material and different plant taxa, along with accompanying structural solutions. There are several ways to classify vertical greening systems, but they can essentially be divided into two basic categories: green facades and green walls. Green facades involve the use of climbing plants that gradually cover the wall surface as they grow. Green facades can be: direct, where the vegetation is attached directly to the wall, or indirect, where plants climb along structural support elements.

Green walls, on the other hand, involve more complex structural components that allow for a uniform appearance of greenery, with various plant taxa used in the design. Green walls are further classified into: continuous green walls, which consist of lightweight and permeable panels that allow for individual plantings, and modular green walls, which contain substrate and containers in which plants grow on a vertically constructed surface [23]. Although aesthetic value is often the initial requirement set by investors when selecting plant species for vertical greening systems, priority should be given to the water requirements of the plants. Succulent plants are a good choice due to their drought resistance, though their small height makes them more suitable for small spaces. Agricultural crops and aromatic plants are also commonly used in vertical greening systems, especially in green walls [24,25].

Using green roofs as a greening technique involves creating a limited green space on top of a man-made structure [26]. Green roofs can be classified as extensive or intensive, according to their purpose and characteristics. There is also a semi-intensive category, which represents a combination of the previous two types, where no more than 25% of the surface should be an extensive garden [27]. An extensive green roof has a thin substrate layer with a shallow vegetation layer, typically consisting of succulents, mosses, grass, or a combination of these. Intensive green roofs have a thicker substrate layer that allows better root development and typically supports the growth of woody plant species (trees and shrubs). Maintenance of intensive green roofs is both important and necessary, requiring the implementation of various and often complex measures and operations, carried out according to a defined plan and schedule (Figure 2).

Vertical greening systems on buildings are not part of natural urban ecosystems; they are anthropogenic in nature and purposefully designed to suit the specific type of building on which they are implemented. The clear spatial boundaries of these green surfaces are a key feature that distinguishes them from other urban ecosystems [28]. Buildings where these greening techniques are applied gain additional functions—besides ecological—such as social and aesthetic roles.

It is important to underline that using vertical greenery or roof greening cannot replace the complexity and species diversity of the habitat established on the ground. But certain benefits compared to the "ground-level" ecosystem exist and are as follows [29]:

- they are undisturbed,
- they have no predators,
- they create the conditions for the desired type of vegetation and the animal type whose population is stimulated.

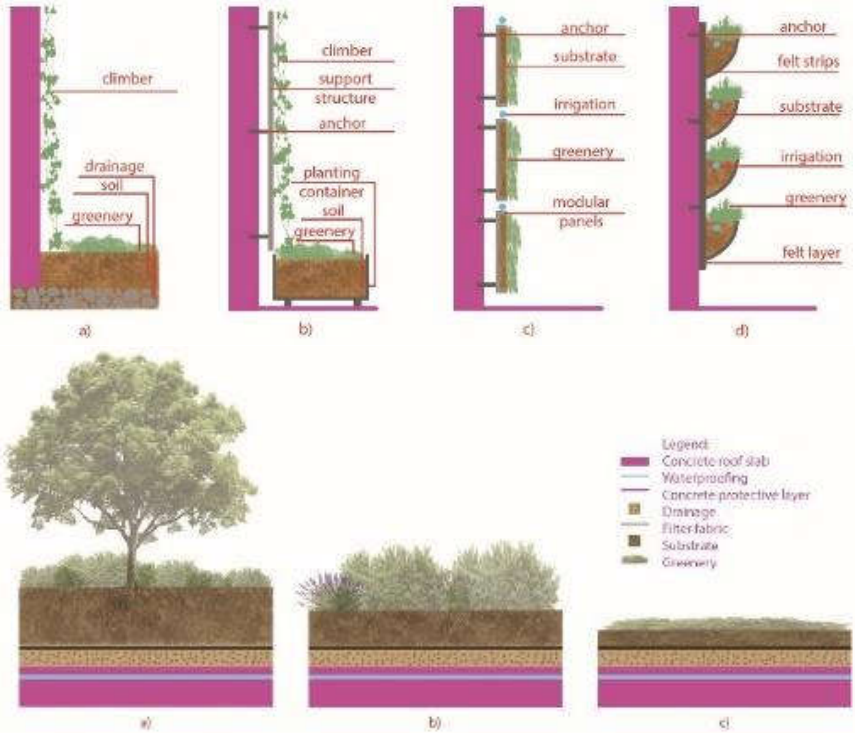

Figure 2: Schematic representation of the categorization of vertical greening systems, green walls, and green roofs (a – direct green facade; b – indirect green facade; c – modular green wall; d – continuous green wall; (a – intensive; b – semi-intensive; c – extensive green roof) [30]

The interior space of a ruin can also be greened. Vertical surfaces within the building (such as load-bearing walls, partition walls, panels, various shelves, etc.), the floor surface, and even the ceiling can become segments of the structure that can be greened using a wide range of techniques and methods. The application of a specific greening technique depends on the building's structure, the investor's preferences, and the available budget.

The application of different methods and techniques for greening ruined structures can be analyzed in the context of large abandoned complexes (e.g. industrial complexes) or individual buildings and urban quarters. In both cases, the ruined space is almost always distinguished either as a separate point in space with a specific identity or as an independent point, categorized as part of micro-greening initiatives. At the European and global levels, there are notable examples of good practice that illustrate diverse approaches to the revitalization of abandoned urban spaces. Through the application of appropriate greening methods and techniques, these projects have led to the integration of cultural heritage within the framework of the ecological and social needs of contemporary cities.

5. SELECTED EXAMPLES OF MULTIFUNCTIONAL REVITALIZATION OF URBAN RUINS

Among the examples of successful revitalization of abandoned industrial complexes in Europe, one standout project is the former weapons manufacturing and testing facility in Zurich, Switzerland – Maschinenfabrik Oerlikon (MFO), which has been transformed into a public urban space that has significantly enhanced the quality of life for the city's residents. The structure, which symbolizes the former industrial building, is located in the city center and has been greened using vertical greening systems—indirect green facades applied to three double-walled exterior sides of the building. Those double-walled structures of the building were covered with wire mesh where numerous climbing plants were planted. The project includes more than 100 different plant species, mostly ornamental cultivars of climbing plants, such as species from genera Wisteria Nutt., Clematis L. and Parthenocissus Planch. as a key landscape architecture element. The climbing plants are in the direct contact with the ground or, on the upper stairs, they are in the containers fulfilled with substrate of adequate depth. Towards the rear of this spacious hall structure, four wire chalices were placed also with the climbing plants. Shrubs in a form of hedges were used as a technique to direct the visitors and by spreading outside of the building they made a connection between inner and outer side of the building. Social cohesion is encouraged by the following:

- a central spot around an embedded pool of water designed for sitting and enjoying,
- numerus staircases, walkways and cantilevered loggias emerging in the spaces between the double walls,
- a deck on the roof for sunbathing and providing a panoramic vista of the surrounding area and
- the large hall which can be used for a variety of purposes.

The fourth facade is characterized by an open concept, offering a visual connection to the outer section of the building. The building does not have a closed roof; instead, it features a steel grid structure serving two functions: to provide sufficient light, humidity, and ventilation for the plant material located inside the structure, and to act as a supporting framework for the further growth of vegetation, allowing the plants—once they overgrow the side facades - to continue spreading over the fifth facade (roof). The installation of open-frame staircases leading to seating platforms and balconies encourages exploration of the interior from different height levels, introducing additional spatial dynamics to the use of the space (Figure 3a).

The revitalization of urban ruins in Prado Park in Medellín, Colombia (South America) is a representative example of how an old, neglected element of grey infrastructure can be successfully integrated into park design (Figure 3b). It is located in a dense area close to the city center on a sloping parcel. The challenge of height difference of almost 7 meters was overcome using terraces like a technique of landscape design. The applied concept is based on the principles of preserving the existing structure in order to maintain traditional construction practices and the identity of the building, as well as to save materials and reduce construction waste [31]. Only facades of the urban ruin were kept and greening was done using indirect green facade as a technique whereas plants are in the direct contact with the ground. New steel structures were added to support climbers such as blue

skyflowers (*Thunbergia grandiflora* Roxb.) which are gradually taking over the ruin. It is important to underline that the landscape design included the preservation of existing greenery along with the planting of new native plant species. The main advantage of the revitalization of urban ruins in Prado Park is greening of the surrounding space and its transformation in a multifunctional urban green space. All plant categories are used in landscape design with the intension to repair and enhance an urban ecosystem: ornamental grasses such as middle-size fountain grasses (*Pennisetum setaceum* (Forssk.) Chiov.) and taros (*Colocasia esculenta* (L.) Schott) enclose smaller spaces, while trumpet trees (*Handroanthus chrysanthus* (Jacq.) S.O. Grose) and kapok trees (*Pseudobombax septenatum* (Jacq.) Dugand) provide shade in open areas. Ground cover such as pinto peanuts (*Arachis pintoi* Krapov. & W.C. Greg.) as well as different types of shrubs are used to attract insects and birds. Maintenance savings were achieved through the implementation of an efficient stormwater management system, which is used for irrigating the vegetation [31].

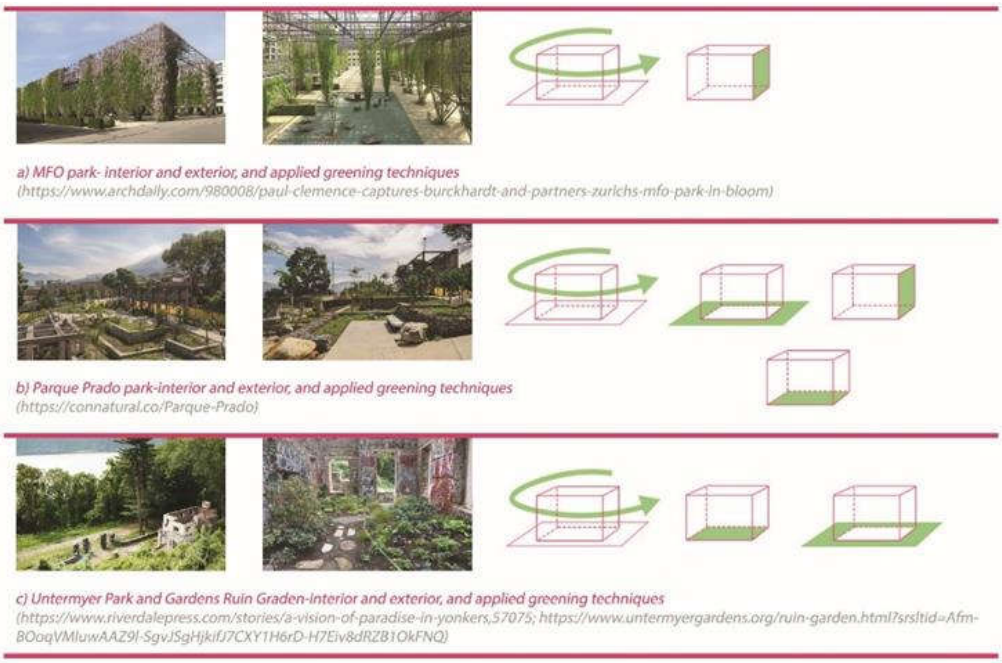

Figure 3: Case studies of urban ruin greening and applied greening techniques

Within the public urban park Untermyer Park and Gardens in Yonkers (New York, USA) lies the Ruin Garden (Figure 3c). The old, ruined Gate House, located at the park's entrance, has been reconstructed and repurposed. The building was restored while preserving its original characteristics, including the graffiti on the walls and the aesthetic of decay. The landscape design included greening of the building's interior and its immediate surroundings. The interior of the ruin lacks a roof and floor slabs, allowing plants to grow under natural sunlight and moisture conditions, covering the entire ground floor of the structure. The greening was achieved using foliage- and flower-decorative plant species, herbaceous and shrubs, including: *Pulmolaria* 'Raspberry Splash', *Helleborus* x *ballardiae* cultivars, *Tiarella* 'Candy Striper', *Heuchera villosa* 'Black Pearl', *Geranium maculatum* 'Espresso', *Hydrangea anomala* subsp. petiolaris 'Miranda', *Polystichum luctuosum*

(Kunze) T. Moore, *Polygonatum odoratum* 'Variegatum', among others [32, 33]. Vertical greenery is presented in a form of direct green fasades which extend along inner walls. Climbers are in the direct contact with the ground and their growth and extension along the wall are spontaneous (without supporting construction). The landscape design of the space around the ruin follows the aesthetics of the interior that evoke a feeling of being in a ruined and abandoned place. The revitalized ruin is created as a place that encourages more private activities and a closer connection with plants and history. The revitalization of this ruin serves as an example of how neglected spaces can be transformed into attractive spot, which in turn support local economic development and attract curious visitors of Untermyer Park and Gardens and wider.

Table1. Overview of significant characteristics of selected examples of greening urban ruins

Urban ruins	MFO Park	Prado Park	Ruin Garden
Location	City center	City center	In the suburb
Applied greening techniques	Indirect green facades; Surrounding greening Plant hedges	Surrounding greening; Interior greening; Indirect green facades Direct green fasades	Surrounding greening; Interior greening; Direct green fasades Sponatenous greening
Used plant category	Climbings; shrubs	Woody species (trees and shrubs); Herbicious species; Climbers; Ground covers	Herbicious species; Climbers
Facilities	Exist, added and made of new materials	Exist, added and made of recycled materials	Inheritable and made of stone
Part of larger complex	No	Part of an urban park	Part of a historical complex
Publicity and opening time	Public and always open	Public and always open	Public with opening hours
Design style	Post-industrial	The ruin aesthetic	The ruin aesthetic
Outcomes	Aesthetical and ambiental benefits; Social coehesion; Ecological site-specific benefits	Wide ecological benefits; Aesthetical and ambiental benefits; Social coehesion; Psychological benefits	Hystorical and cultural benefits; Aesthetical and ambiental benefits
Challenges in terms of greening	Preserve the identity of the object; Avoid a sense of empty space; Provides a counterbalance to the urban surrounding maintenance	Reuse of existing demolish material; usage of recycled materials in landscape design; Avoid a sense of chaotic space; maintenance	Preserve the hystorical and cultural identity; Preserve the aesthetic of ruin

6. DISCUSSION

The analyzed examples highlight the importance of greening urban ruins, as reconstructed and revitalized spaces become multifunctional, environmentally efficient, and possess ambient and aesthetic value. They are accessible for public use and contribute to social cohesion. The presented cases of greening urban ruins, realized over the past two decades, demonstrate various approaches in terms of greening methods, techniques applied, materials used, plant selection, site-specific conditions, and the outcomes and challenges of revitalization (Table 1).

Green facades represent the most commonly used greening technique in urban ruins. Depending on the structure, the degree of decay and stability of the object, as well as the complexity of the design, the choice between direct or indirect green facades is determined. Although green roofs are a highly effective technique offering numerous benefits for both the building and its surroundings, their implementation in the context of urban ruins is either absent or limited (typically applied to only part of the roof). This is largely due to the use of open-roof concepts during the revitalization of ruins, aimed at ensuring optimal conditions for plant growth within the interior—such as sufficient light, humidity, and ventilation.

Ensuring adequate natural lighting and ventilation greatly enhances both the aesthetic and ambient qualities of the space. In addition to interior greening, greening the immediate surroundings of the building—when and where feasible—is of critical importance, as the structure and its context should be viewed as an integrated whole. Greening the broader environment around a ruined structure is particularly relevant in responding to the modern demand for expanding green spaces in urban areas and achieving the full spectrum of benefits that greening abandoned sites can provide—primarily ecological, but also aesthetic, social, psychological, and economic.

The choice of plant material depends on the characteristics of the structure itself, its surroundings, and the desired effect. All plant categories and a wide range of species may be used (e.g., Prado Park), while in other cases the palette is deliberately more limited (e.g., Ruin Garden). Climbers are almost always included, as they play a key role in emphasizing the aesthetic of ruination and in symbolically linking the structure to its past (e.g., ruins overgrown with vines). However, using a large number of plant species and categories does not necessarily result in the desired visual effect; on the contrary, it can lead to a sense of spatial overcrowding and visual chaos. Due to the typically limited space of urban ruins and specific microclimatic conditions in urban cores, it is recommended to use native plant material and limit the number of species. Richness and diversity can be achieved through the use of a larger number of cultivars within a single species.

MFO Park is a good example of this approach, demonstrating that it is possible to create an urban oasis in the city center using only two plant categories and a limited number of species.

The examined cases of greened urban ruins reveal a wide range of positive outcomes: enhancement of aesthetic and ambient values of the site and its surroundings, preservation of historical and cultural heritage, stimulation of social interaction and cohesion, and improvement of ecological conditions within the urban environment. These outcomes largely depend on the size of the site, the extent of greening, and the possibility of greening the immediate or wider surroundings. The greater the level of greening and the larger the greened area around the ruined object are (e.g., Prado Park), the more significant the positive impact on the environment is—and vice versa (e.g., Ruin Garden).

Thus, the outcome of greening urban ruins, in terms of environmental benefits, can range from being site-specific (e.g., MFO Park) to having a wider urban impact (e.g., Prado Park). Accordingly, we can refer to these as site-specific project impacts and outcomes or broader-scale project impacts and outcomes.

The fundamental characteristic of greening urban ruins is the individual and often site-specific approach unique to each building and location. Every structure undergoing greening, as well as the site it occupies, is defined by its own cultural, social, and economic values, along with microclimatic conditions. Therefore, it is difficult to generalize the practices related to greening buildings or adapting cultural heritage to meet contemporary urban needs. Although each structure and site requires an individual approach, certain conceptual similarities can be identified across various examples:

- the existing built structure is viewed as cultural heritage;
- the buildings either lack a roof or have a permeable/grid-like structure to allow light penetration and support the survival and care of plant material;
- multiple greening techniques are typically applied;
- there is a preference for using native plant species;
- the projects aim for ecological and economic sustainability;
- they seek to encourage social interaction among the population.

Greening urban ruins also comes with certain challenges. First and foremost, it is necessary to assess the structural stability of the existing building and the load-bearing capacity of the structure, which requires the involvement of experts to ensure the safe implementation of the project. This assessment defines the possibility of reusing existing materials and the need to reinforce the load-bearing structure. Additionally, since these are typically abandoned and old urban buildings, it is essential to determine property ownership of the parcel and land, and to obtain all necessary permits for the changes proposed by the project. The selection of plant material must be suited to site conditions and local microclimate, and the maintenance requirements of the green areas must also be considered. Contemporary trends favor the use of resilient plant taxa with low water needs, as well as native species, which contribute to self-sustainability. It is also crucial to allocate the project budget efficiently and define priorities during the design and reconstruction phases. To ensure that the overall solution aligns with urban development policy, careful planning and implementation are required.

7. CONCLUSION

Greening urban ruins represents a strategy for revitalizing abandoned urban spaces, which not only contributes to environmental protection and the development of green infrastructure, but also provides social, psychological, economic, and aesthetic benefits. Such projects enhance the characteristics of the structures themselves, improve the microclimatic conditions of the site, promote the development of urban biodiversity, play a role in adapting cities to climate change, and foster social cohesion. As multifunctional spaces, they serve as areas for rest and recreation for urban residents, helping to reduce stress and promote well-being. Through the use of vertical greening techniques, green roofs, interior greening, and greening of surrounding areas, as well as adaptive reuse of ruins, it is possible to create sustainable and multifunctional environments that improve the

quality of urban life. The revitalization of ruins also plays a role in preserving cultural heritage and spatial identity, linking the past with contemporary urban needs. The potential for revitalization depends on factors such as the structural integrity of the building, plant care requirements, investment value, and the resolution of legal issues related to ownership and management—emphasizing the need for careful planning and implementation. Although there is no universal approach to greening ruins and abandoned urban spaces, developing criteria for selecting structures and forming a priority list would be beneficial. The evaluation of site or building suitability for revitalization, the design process, implementation, and long-term maintenance and management require a multidisciplinary approach, involving engineers and experts from various fields.

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