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Former Industrial Spaces as Drivers of City Resilience

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Abstract

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The aim of this paper is to examine former industrial spaces as a strategic resource for urban regeneration and city resilience. The research is based on a systematic review and analysis of domestic and international literature addressing former industrial spaces, industrial heritage, and industrial brownfields. The methodology includes a comparative analysis of terminology, spatial scales, values, constraints, and regeneration models. The results reveal terminological inconsistency and conceptual overlap, while highlighting the potential of former industrial spaces to support cultural continuity, sustainable land use, social cohesion and urban development. The findings indicate that the activation and reuse of these spaces enhance city resilience by enabling multifunctionality, reducing land consumption, and supporting responses to economic, social, and environmental change. The paper concludes that interdisciplinary approaches, stakeholder participation, and context-sensitive regeneration strategies are essential for urban regeneration. This study contributes by synthesizing knowledge and positioning former industrial spaces as key assets in resilient urban planning and architectural practice.

Keywords: City Resilience; Former Industrial Spaces; Industrial Heritage; Industrial Brownfields; Urban Regeneration.

1. Introduction

Deindustrialisation across Europe, starting in late twentieth century, left a legacy of former industrial spaces, including factories, foundries, warehouses, railway complexes, mining sites, and textile mills, that remain underused or entirely neglected in many cities. These spaces represent a complex urban condition at the intersection of cultural memory, environmental challenges, and strategic development opportunity.

Cities simultaneously face mounting pressure from climate change, demographic shifts and economic restructuring. City resilience, the capacity of an urban system to absorb disturbances and adapt while maintaining essential functions, increasingly depends on the intelligent reuse of existing urban fabric rather than greenfield expansion (Meerow et al., 2016; Folke et al., 2010). Former industrial spaces occupy a distinctive position within this framework: their size, central location, infrastructural legacy, and cultural significance make them potentially powerful assets for urban resilience. Yet their full potential remains largely unrealised in transitional economies, as documented in recent comparative research addressing Central and Eastern European contexts (Koutra et al., 2023; Lorber et al., 2016; Đokić and Sumpor, 2010). In Osijek, Croatia, for instance, field research has identified 59 historical industrial areas established between 1824 and 1945, of which only 13 remain in whole or in fragments, and none has been revitalised to date (Kraus et al., 2022).

The aim of this paper is to examine former industrial spaces as a strategic resource for urban regeneration and city resilience. The paper addresses three objectives: (1) to clarify and systematise the terminology of former industrial spaces; (2) to identify values, constraints, and regeneration models of former industrial spaces; and (3) to examine how the activation and reuse of these spaces enhance city resilience by enabling multifunctionality, reducing land consumption, and supporting adequate responses to economic, social, and environmental change. These categories are not static: a site may shift from abandoned industrial space to industrial heritage following formal recognition, and subsequently to repurposed industrial space once adaptive reuse is implemented, illustrating the dynamic, time-dependent nature of the classification system adopted in this paper. This complexity is compounded in transitional economies, where Koutra et al. (2023) identify the absence of harmonised terminology and evaluation criteria as a persistent obstacle to effective brownfield policy. Clarifying these categories and their interrelations is therefore not merely a definitional exercise but a precondition for developing inventories, evaluation frameworks, and regeneration strategies capable of supporting city resilience.

2. Materials and Methods

The research is based on a systematic review and analysis of domestic and international literature addressing former industrial spaces, industrial heritage, and industrial brownfields. The methodology includes a comparative analysis of terminology, spatial scales, values, constraints, and regeneration models of former industrial spaces. The literature review encompasses scholarly works from the scientific fields of architecture, urban planning, heritage conservation, and geography, assembled through searches of Scopus, Web of Science, Google Scholar, and the HRCĀK national scientific portal. The resilience dimension is assessed using the urban resilience framework of Meerow et al. (2016), which defines urban resilience as the ability of an urban system to maintain or return to desired functions in the face of disturbance, to adapt to change, and to transform systems that limit current or future adaptive capacity. Sources were included if they addressed former industrial spaces, industrial heritage, or industrial brownfields within the disciplinary scope of architecture, urban planning, heritage conservation, or geography, and if they provided conceptual, typological, or empirical insights relevant to terminology, spatial scales, values and constraints, or regeneration models. Sources concerned exclusively with unrelated industrial sectors, purely technical engineering aspects of remediation, or non-spatial economic analyses without relevance to the built environment were excluded. The resulting corpus spans publications from 1992 to 2023, with the majority published after 2016, reflecting the recent intensification of scholarly attention to brownfield regeneration and urban resilience in Central and Eastern Europe (Koutra et al., 2023; Lorber et al., 2016; Preston et al., 2023).

3. Research and Results

3.1 Terminological Framework

Former industrial space is the broadest, neutral term encompassing all spaces where industrial activity has ceased, a definition applicable to all 59 areas identified in Osijek by Kraus et al. (2022). **Abandoned industrial space** refers specifically to disused spaces resulting from factory closures or bankruptcy; Nettleingham (2019) addresses deindustrialisation as a complex set of processes that shaped and were shaped by industrial tradition, demonstrating how place identity and economic disruption are deeply intertwined. **Industrial heritage**, defined by the Nizhny Tagil Charter (TICCIH, 2003), encompasses physical remains of industrial culture with historical, technological, social, architectural, or scientific value. **Industrial brownfields** are abandoned or underutilised sites where redevelopment is complicated by actual or suspected environmental contamination (Perović and Kurtović Folić, 2012; Bartošova, 2011). Koutra et al. (2023) provide a recent synthesis of the key challenges in transitioning former industrialised areas from 'brown' to 'bright', confirming that terminological inconsistency and conceptual overlap remain persistent barriers to effective policy. These categories are not mutually exclusive, a single site may simultaneously qualify as brownfield, heritage, and repurposed space. Increasingly relevant category is the **repurposed industrial space**, denoting sites that have acquired a new function following the cessation of industrial activity. This repurposing may be temporary, where the site's potential remains only partially realised, or permanent, where adaptive reuse fully exploits the spatial and structural capacity of the original structure. Lorber (2014) frames such transformations within a holistic approach to revitalisation that integrates economic, social, environmental, and cultural dimensions, while Cizler (2012) similarly emphasises that community-oriented, integral approaches determine the long-term success of repurposing initiatives. The distinction between temporary and permanent repurposing is analytically significant: temporary uses, such as creative or cultural interim activities, can serve as a low-risk mechanism for testing new functions, generating local support, and revealing latent values before permanent investment decisions are made, whereas permanent repurposing typically requires more substantial capital investment and clearer governance arrangements. This intermediate step is consistent with the broader observation that successfully regenerated former industrial sites tend to accommodate multiple, evolving functions over time rather than a single fixed use determined at the outset of the regeneration process (Dmytryk and Urenev, 2020). In the Croatian context, where unclear ownership and limited institutional capacity often delay permanent regeneration (Đokić and Sumpor, 2010), temporary repurposing may represent a pragmatic intermediate step that preserves former industrial spaces from further deterioration while longer-term regeneration models are developed.

3.2 Spatial Scales

Former industrial spaces (FIS) operate across five spatial scales: regional, exemplified by the Ruhr region IBA Emscher Park in Germany (Božić and Gašparović, 2007); city, illustrated by Leeds, UK (Cizler, 2012) and the planned industrial towns of Raša, Borovo, and Podlabin in Croatia (Karač, 2017); district and waterfront, as seen in Canary Wharf in London (Jukić and Butina Watson (2019) and in the EXPO '98 zone in Lisbon (Petrović Krajnik et al., 2013); complex, represented by Zeche Zollverein in Essen (Cizler, 2019) and the Zsolnay Cultural Quarter in Pécs (Panyik, 2014); and single building, exemplified by Tate Modern in London (Barišić Marenčić, 2015). Table 1 summarises these spatial scales with selected international and Croatian examples. At the city scale, Osijek (Croatia) illustrates how a formerly well-developed industrial center, with 25 factories and over 2,000 workers by 1910, can lose the majority of its historical industrial fabric to demolition and abandonment within a century (Kraus et al., 2022), underscoring the urgency of context-sensitive regeneration strategies.

Table 1: Former industrial spaces by spatial scale – selected international and Croatian examples. Source: compiled by the authors.

Spatial scale	International / Croatian examples	Key sources
Regional	Ruhr Region — IBA Emscher Park (Germany)	<i>Božić & Gašparović (2007)</i>
City / Town	Leeds (UK); Raša, Borovo, Podlabin (Croatia)	<i>Cizler (2012); Karač (2017)</i>
District / waterfront	EXPO '98 zone (Lisbon); Canary Wharf (London)	<i>Petrović Krajnik et al. (2013); Jukić & Butina Watson (2019)</i>
Complex / Block	Zeche Zollverein (Essen); Zsolnay Cultural Quarter (Pécs)	<i>Cizler (2019); Panyik (2014)</i>
Single building	Tate Modern (London); Lauba (Zagreb)	<i>Barišić Marenčić (2015)</i>

3.3 Values and Constraints

Former industrial spaces carry cultural and social value as repositories of collective memory and local identity, key foundations of cultural continuity and social cohesion (Arčabić, 2007; Cizler et al., 2014). Their architectural value derives from spatial distinctiveness (Jacobs, 1992), while their economic value as catalysts for new commercial and cultural activity is realised through adaptive reuse (Fisher-Gewirtzman, 2016). Environmental value is ambivalent: the reuse of brownfield land supports sustainable land use and reduces pressure on undeveloped greenfield sites, while heavy-metal soil contamination poses risks to public health (Cai et al., 2019; Del Giudice et al., 2020). Kuzior et al. (2022), in a comparative study of post-industrial facility revitalisation in Poland and the USA, demonstrate that successful regeneration delivers measurable economic and socio-cultural benefits, but requires sustained institutional commitment and clear governance frameworks. The Osijek case illustrates the cost of inaction: the Karolina Steam Mill was demolished in 2005 and replaced by a generic shopping centre, permanently erasing the spatial identity of that urban quarter (Kraus et al., 2022). Principal constraints include contamination, structural obsolescence, unclear ownership — particularly acute in post-socialist contexts — absence of national inventories, and limited institutional capacity (Perović and Kurtović Folić, 2012; Lorber et al., 2016). Preston et al. (2023) further demonstrate that brownfield typologies are highly heterogeneous, underscoring the need for site-specific, context-sensitive evaluation frameworks. Dmytryk and Urenev (2020) further distinguish between historically significant structures, recognised as monuments of industrial architecture and history even where not formally heritage-listed, and typical structures, which lack aesthetic value but offer favourable architectural, planning, and structural indicators for reuse within urban areas. This distinction provides a practical basis for prioritising conservation-led intervention versus adaptive transformation. Perović and Kurtović Folić (2012) further frame brownfield sites as neglected industrial heritage with significant potential for generating new social spaces and attractive physical structures, underscoring that regeneration value extends beyond mere environmental remediation. Bartošova (2011) observes that planning authorities often fail to adequately emphasise the importance of brownfield reuse, while developers frequently find it easier to build on greenfield sites outside the city, a pattern that exacerbates urban sprawl, reduces settlement density, and places additional pressure on undeveloped land.

3.4 Activation Models

The activation and reuse of former industrial spaces is documented through several regeneration strategies. Adaptive reuse, the conversion of industrial buildings to new functions while retaining their spatial and structural character, is the most widely documented approach (Cizler et al., 2014). Sironić and Obad Šćitaroci (2017) propose models for the transformation of urban blocks with former industrial use. Multifunctionality, accommodating several distinct uses simultaneously, is identified as a key characteristic of successfully regenerated industrial objects that enables resilience by reducing dependence on a single function (Dmytryk and Urenev, 2020; Lorber, 2014). Arbab and Alborzi (2022) propose a sustainable regeneration framework for urban industrial heritage that integrates conservation objectives with socio-economic development goals, emphasising the importance of community participation. Klušáček et al. (2023), drawing on brownfield regeneration experience in a shrinking Central European region, demonstrate that successful revitalisation depends critically on local development potential, location attractiveness, and the complexity of ownership relations. Holistic, interdisciplinary, and community-oriented approaches integrating economic, social, environmental, and cultural dimensions are most effective (Lorber, 2014; Cizler, 2012), while market-driven projects risk gentrification and loss of heritage value. Sironić and Šćitaroci (2017) distinguish between two principal models for transforming urban blocks containing former industrial uses: partial block revitalisation and full block revitalisation. Jukić and Butina Watson (2019) further propose transformation models centred on ownership structures and the functional repurposing of buildings and urban areas, alongside strategic planning mechanisms for shaping brownfield sites and the potential value of public–private partnership financing arrangements. Karač (2017) illustrates how revitalisation models must be tailored to local conditions: in Borovo, factory transformation builds on the site's port potential and border location, whereas in Uble, on the island of Lastovo, tourism-oriented reuse emerges as the only viable model. Hospers (2002) similarly documents a wide range of activation outcomes, including shopping centres, business premises, studios, and designer workspaces,

enabled by the open-span structures typical of former industrial buildings, which accommodate a broad spectrum of new functions.

3.5 Former Industrial Spaces and City Resilience

The findings indicate that the activation and reuse of former industrial spaces enhance city resilience across five dimensions. Ecologically, adaptive reuse reduces land consumption and eliminates greenfield pressure; Preston et al. (2023) confirm that urban brownfields offer substantial ecological co-benefits when sustainably redeveloped, directly supporting sustainable land use. Functionally, multifunctional regenerated sites increase the redundancy and flexibility of the urban system, core attributes of resilience that enable responses to economic, social, and environmental change (Meerow et al., 2016). Socially, the preservation of industrial heritage reinforces local identity and social cohesion following economic disruption (Folke et al., 2010; Kraus et al., 2022). Culturally, Swensen (2023) demonstrates that resilience thinking in industrial heritage museums, integrating curators' historical insights, urban planners' visions, and citizens' views, constitutes a replicable model for cultural continuity in regenerating post-industrial areas; the awareness of industrial heritage as a cultural resource and identity of urban space further underscores this dimension (Arčabić, 2007). Economically, regeneration catalyses broader urban development and restructuring in post-industrial cities (Hospers, 2002; Jukić and Butina Watson, 2019). Together, these five dimensions position former industrial spaces as key assets in resilient urban planning and architectural practice.

In Osijek, the resilience cost of non-intervention is clearly documented. The demolition of the Karolina Steam Mill in 2005 represents a permanent loss of resilience potential across all five dimensions. The Tannery and the Drava Match Factory retain regeneration capacity, but only if context-sensitive planning instruments, reformed governance, and stakeholder participation are put in place (Kraus et al., 2022). Such conditions reflect the broader governance challenges identified across Central and Eastern European brownfield contexts (Koutra et al., 2023). Table 2 synthesises these five resilience dimensions, their mechanisms, and illustrative examples.

Table 2: Former industrial spaces as drivers of city resilience — five dimensions. Source: authors, based on Meerow et al. (2016) and Folke et al. (2010).

Resilience dimension	Mechanism linking FIS to resilience	Documented examples	Key sources
Ecological resilience	Adaptive reuse eliminates greenfield consumption; remediation of contaminated brownfields reduces environmental impact	IBA Emscher Park (Ruhr); brownfield remediation across CEE	<i>Cai et al. (2019); Preston et al. (2023)</i>
Functional resilience	Multifunctional sites increase redundancy and flexibility of the urban system	Zeche Zollverein — museum, design school, events; Tabakfabrik — creative hub	<i>Meerow et al. (2016); Dmytryk & Urenev (2020)</i>
Social resilience	Preservation of industrial heritage reinforces local identity and social cohesion after economic disruption	Ruhr region — heritage tourism; Zagreb — Lauba cultural center	<i>Folke et al. (2010); Arčabić (2007)</i>
Cultural resilience	Safeguarding collective memory and working-class narratives embedded in industrial fabric	Zsolnay (Pécs)	<i>Cizler et al. (2014); TICCIH (2003); Panyik (2014)</i>
Economic resilience	Regeneration catalyses broader economic recovery and urban restructuring in post-industrial cities	Canary Wharf (London)	<i>Hospers (2002); Jukić & Butina Watson (2019)</i>

4. Discussion

The results reveal terminological inconsistency and conceptual overlap across the four principal categories of former industrial spaces, a finding that is not merely academic. Without clear definitional frameworks, it is difficult to develop consistent policy, compile reliable inventories, or apply standardised evaluation criteria, as the Croatian context demonstrates (Kraus et al., 2022; Đokić and Sumpor, 2010).

The principal contribution of this paper is a synthesis of knowledge positioning former industrial spaces as key assets in resilient urban planning and architectural practice. The paper demonstrates that interdisciplinary approaches, stakeholder participation, and context-sensitive regeneration strategies are essential for realising this potential — conclusions consistent with the convergent findings of Swensen (2023), Kuzior et al. (2022), and Klusáček et al. (2023). At the policy level, findings support the further development and systematic completion of the existing national brownfield register, which does not yet comprehensively cover former industrial spaces across Croatia, alongside systematic heritage evaluation aligned with resilience objectives (Koutra et al., 2023; Lorber et al., 2016). The risk of gentrification in market-driven regeneration processes must also be explicitly addressed in policy frameworks (Lorber, 2014).

Đokić and Sumpor (2010) attribute the slow pace of brownfield redevelopment in Croatia to the absence of a systematic approach and a clear definition of such spaces, fragmented and outdated land-registry data, unresolved ownership structures, the lack of a standardised brownfield-regeneration methodology, and limited institutional and fiscal capacity at the local level. Lorber et al. (2016) similarly note that, compared with Slovakia and Slovenia, brownfield regeneration

has received comparatively little research attention in Croatia, placing the country at a relative disadvantage in developing context-specific regeneration knowledge.

Beyond the policy level, the findings carry direct implications for architectural and urban design practice. Fisher-Gewirtzman (2016) demonstrates that combining new and historic architectural elements can preserve the authentic character of former industrial buildings while accommodating contemporary functional requirements, an approach that is particularly relevant where structures retain distinctive spatial qualities, such as large open floor plates or expressive structural systems. For architects and urban planners working in Croatian cities, this suggests that early-stage feasibility studies for former industrial sites should systematically assess heritage, structural, and spatial potential alongside market demand, using the five-dimensional resilience framework proposed in Section 3.5 as an evaluative lens.

The principal limitation of this study is its reliance on secondary sources. Empirical validation through site surveys, stakeholder interviews, and GIS-based spatial analyses is required to substantiate the framework proposed here in specific Croatian and regional urban contexts.

5. Conclusions

Through a systematic literature review, this paper examines former industrial spaces as a strategic resource for urban regeneration and city resilience. The systematic review and comparative analysis of the relevant literature reveal terminological inconsistency and conceptual overlap across four principal categories, a wide range of spatial scales with distinct planning implications, and significant cultural, social, architectural, economic, and environmental values alongside substantial constraints.

The findings indicate that the activation and reuse of former industrial spaces enhance city resilience by enabling multifunctionality, reducing land consumption, and supporting responses to economic, social, and environmental change. The study concludes that interdisciplinary approaches, stakeholder participation, and context-sensitive regeneration strategies are essential for urban regeneration. This study contributes by synthesising knowledge and positioning former industrial spaces as key assets in resilient urban planning and architectural practice.

Future research should: (1) further develop and systematically complete the existing national inventory of former industrial spaces in Croatia; (2) conduct empirical resilience assessments of surviving sites in Osijek and other Croatian cities; (3) develop and test evaluation frameworks that integrate resilience criteria alongside heritage, architectural, economic, and social dimensions; and (4) examine the governance and ownership structures that currently decrease the realisation of the resilience potential of former industrial spaces.

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Conflicts of Interest

The author(s) report no conflicts of interest.

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