Degradirana območja kot prostorski potencial v urbanističnem planiranju na primeru Banjaluke

Brownfields Data as a Spatial Resource for Urban Planning: A Banjaluka Case Study

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IZVLEČEK

V postindustrijski dobi so se številna mesta srečala s propadanjem tradicionalnih industrijskih panog, kar je privedlo do širokega razmaha degradiranih območij. Opuščena industrijska območja so pomemben prostorski potencial, njihova revitalizacija pa priložnost za trajnostni urbani razvoj mesta. Zato je za snovanje prostorskih strategij za trajnostno revitalizacijo degradiranih območij potrebno poglobljeno razumevanje prostorskega značaja in razporeditev degradiranih območij. Ta tematika za mesto Banjaluka (Bosna in Hercegovina) še ni bila raziskana, prav tako v njem niso identificirana ali evidentirana degradirana območja. Pri v članku opisani raziskavi so degradirana območja v Banjaluki evidentirana na podlagi zgodovinskih podatkov in znanstvene literature ter razpoložljivih GIS-podatkov. Analiza degradiranih območij je opravljena z vidika njihove prostorske razmestitve in prostorskih značilnosti. V raziskavi je ugotovljena neenakomerna razporeditev aglomeriranih in razpršenih degradiranih območij znotraj mesta ter obstoj različnih vrst degradiranih območij, ki so kategorizirane na podlagi njihovega razmerja do mesta, okolja in medsebojnih razmerij. Raziskava prispeva k prostorski opredelitvi degradiranih območij na podlagi modela prostorske analize, ki temelji na teoriji industrijske lokacije. Poleg tega raziskava podpira pomembnost vključevanja degradiranih območij v urbanistični in prostorski planski proces.

KLJUČNE BESEDE

degradirana območja, prostorska razporeditev, industrijska geografija, urbanistično načrtovanje, geografski informacijski sistem (GIS), Bosna in Hercegovina

ABSTRACT

In the post-industrial era, many cities have experienced the decline of traditional industries, leading to the widespread emergence of brownfields. Abandoned industrial sites represent a significant spatial resource, and their regeneration is considered an opportunity for sustainable urban development. Thus, spatial strategies for sustainable brownfield regeneration call for a thorough understanding of the spatial character and distribution of brownfields in a city. In the context of the City of Banjaluka (Bosnia and Herzegovina), this topic has not been researched, nor have brownfields been identified and mapped at the city level. Based on historical data and scientific literature, industrial brownfields in Banjaluka are mapped using available GIS data and further analysed to determine their spatial distribution and characteristics. This research shows an uneven distribution of agglomerated and dispersed brownfields within the city and the existence of various types of brownfields arising from their relationship with the city, their environment, and each other. The research contributes to the spatial characterisation of brownfields by defining a spatial analysis model based on the theory of industrial location. Moreover, the research affirms the need for more substantial consideration of brownfields in the urban and spatial planning process.

KEY WORDS

brownfields, spatial distribution, industrial geography, urban planning, geographical information system (GIS), Bosnia and Hercegovina

1 INTRODUCTION

The transition of the economic system and the increasing impact of globalization have led to significant changes in the territorial development of industry, which are reflected in the loss of traditional industries and leaving many industrial sites in cities abandoned. Known as brownfields, these sites tend to be concentrated in certain areas and have a profound impact on the spatial and functional urban structure (Pytel et al., 2021) and environmental configuration of urban areas. In the context of accelerated urbanization, contemporary politics of sustainable urban development have shifted from extensive urban expansion and greenfield development to intensive urban fabric renewal. Since land is scarce and a non-renewable resource (Lampič et al., 2020; Tonin & Bonifaci, 2020), regeneration of brownfields stops the expansion of built-up areas and reduces the expansion pressure on agricultural and forest land, contributing to the achievement of sustainable spatial development goals (Rebernik et al., 2023; Lampič et al., 2017; Lampič et al., 2020). Furthermore, regeneration of brownfields contributes to the improvement of the environmental quality, offers an opportunity for innovative land use strategies, alleviates the effects of urban sprawl and guides urban growth (Baing, 2010, De Sousa, 2006). The efficient regeneration of brownfields implies applying different concepts and principles within the land use and urban regeneration strategies. As an example, industrial symbiosis is an approach developed within the industrial ecology that involves the physical exchange of materials, energy and water, between different industries to achieve a competitive advantage (Cotič, 2019). The application of industrial symbiosis within urban regeneration strategies entails that brownfields are regenerated into eco-industrial parks. The results of this regeneration approach are the new green (circular) economy, economic benefits for industries and gains for the environment due to less waste and less demand for energy and raw materials (Cotič, 2019). Another recent approach is based on the capacity of natural systems to respond to a variety of social needs and refers to actions to protect, sustainably manage, and restore natural and modified ecosystems, providing benefits for human well-being and biodiversity (La Monaca, 2025). These nature-based solutions implement ecological experimentation, soil regeneration, and the incremental construction of green infrastructure within the brownfields regeneration and are considered one of the fundamental tools for guiding urban policies towards greater inclusiveness, resilience and environmental quality (La Monaca, 2025). In achieving above-mentioned goals of brownfield regeneration, policies and strategies of state authorities, local governments, and private investors play a crucial role (Pytel et al., 2021). However, the lack of robust spatial data and detailed knowledge on brownfield character may inhibit the spatial planning of brownfield redevelopment across cities. Hence, there is a need to analyze brownfields' spatial characteristics and patterns of their distribution and variations across various parts of the city, facilitating a more nuanced comprehension of industrial brownfields. A systematic understanding of brownfields, as a significant spatial resource embedded within cities, is fundamental for devising sustainable land use and regeneration strategies (Lampič et al., 2017).

Previous studies deal with a spatial analysis of differences in the spatial distribution of existing and redeveloped brownfields in cities (Frantál et al., 2013; Frantál et al., 2015; Novosák et al., 2013) and demonstrated that the regeneration of brownfield sites is significantly influenced by their intrinsic characteristics and urban location. Much research has focused on characterizing brownfield sites, analyzing natural elements (vegetation, topography and water bodies), factors of industrial location (site accessibility and proximity to city centers), and physical structure (buildings and structures) (Frantál, 2015; Špirić, 2015). It has been confirmed that location-related aspects of brownfield sites, such as geographical location, transportation

links, local socio-demographic structure, economic potential, economic activity and unemployment rate, etc., play an important role in their regeneration processes (Hercik et al., 2014; Martinát, et al., 2016; Frantál, 2015). Nevertheless, site-specific factors such as size of the brownfield, its previous use, number of buildings, ownership relations etc. are also crucial for planning brownfield redevelopment projects in administrative territory (Hercik et al., 2014; Frantál, 2015). Similarly, site-specific characteristics of brownfields, namely characteristics of the single plot, location of the plot in the local context, features of the entire national priority sites, and exogenous factors (strategies and economic factors), are considered the most important features to enhance the attractiveness of the area for redevelopment (Tonin & Bonifaci, 2020). In these studies, brownfields are researched as single sites of former industrial activities, while their tendency to cluster is neglected. Moreover, these studies mainly focus on site-specific spatial characteristics with relatively few studies addressing city-level analyses of brownfields as a single entity in the wider typology of urban land use and unused spaces. There has been limited investigation into the spatial relationships between brownfields and urban areas, as well as their underlying distribution patterns.

The phenomenon of brownfield in Banjaluka (Bosnia and Herzegovina) is not sufficiently researched, and there is no official definition or classification. They emerged as a consequence of the military operations of the civil war in Bosnia and Herzegovina (1991-1995) and loss of the market, which resulted in privatization of the state property and many bankruptcy proceedings of pre-war companies (Perić, 2016). Brownfields are not properly identified; their localities are not mapped, and there is no available information database. In general, brownfields are not valorised, their spatial potential is not sufficiently researched, and there are no brownfield redevelopment strategies and no clear attitude of local and national authorities towards this complex urban phenomenon. As in many post-socialist cities, regeneration occurs spontaneously, without a specific planning approach or strategy. In some cases, the process is carried out without adequate planning documents, spatial features are not considered, and the planning solution is driven by private interests and the favorable land price. Regeneration is planned in the short term, driven by market demand, and left to random investments by private investors (Rebernik et al., 2023). The extensive nature of the transformation of post-industrial sites is aimed at the enrichment of a small number of people under the veil of a common interest for the city and state (Perić, 2016), with no reference to social and environmental goals of sustainable development.

This research deals with the spatial distribution of industrial brownfields in Banjaluka and the analysis of their spatial characteristics that extend beyond their immediate spatial context, promoting a shift towards a *city-based approach* as opposed to the conventional *site-based approach*. Thus, brownfields are considered a network of spaces that is an integral part of the city, and not isolated sites. The research is structured to address the following key questions: How are brownfields spatially distributed in Banjaluka, and what are the factors affecting their spatial distribution across the city? What are the spatial characteristics of brownfields, and are there significant differences between them? Based on these questions, this research first identified brownfields in Banjaluka, using desktop research, literature review and field research. Subsequently, the industrial geography approach was applied in the research to analyze the spatial distribution of brownfields within the city and understand their spatial characteristics. Specifically, the theory of industrial location provides concepts that allow understanding of the location of former industrial sites and defines a multi-criteria analytical tool for spatial analysis of brownfields. The analysis encompassed the patterns of spatial distribution of brownfields and the interrelationship between brownfields, their

immediate environment and the city. Finally, the study examined the types of brownfields based on their spatial characteristics. The research elaborates on the imbalanced spatial distribution of agglomerated and dispersed brownfields. Eventually, the research demonstrates the existence of diverse types of brownfields arising from their relationship with the city, their environment, and each other.

Ignorance of the uneven disposition of agglomerated and dispersed brownfields and the existence of brownfields with different spatial characteristics prevents the application of targeted strategies that facilitate local and regional sustainable development goals. The research contributes to the methodological model of spatial characterization of brownfields, based on the theory of industrial location. Its general aim is to contribute to a body of knowledge for creating spatial strategies for brownfield redevelopment corresponding to the character of their disposition within the city and their unique character arising from their industrial location. These strategies could focus on the problem of developing brownfields as isolated sites or part of the agglomerated sites, the suitability of the site for achieving local and regional development goals, and the harmonization of the brownfield development with the development of its immediate environment. Moreover, the research affirms a more sustainable consideration of brownfields in spatial planning, which implies integration of the theory of industrial geography and methodology of multi-criteria spatial analysis in the spatial planning realm.

2 METHODOLOGY

2.1 Study area

The case study city, Banjaluka, is the largest city in the western part of Bosnia and Herzegovina and part of the largest urban agglomeration in the western part of the Republic of Srpska. Banjaluka has approximately 185,000 inhabitants who live in 1,209 km^2 of the city's administrative area. According to the Spatial plan of City of Banjaluka (GBL et al., 2014), the city territory is divided into an urban area, which consists of the city core and its surrounding belt, and a non-urban area. Seventy-five per cent of the population lives in an urban area. The city center is located in the north-eastern part of the city's territory. Historically, urban development of Banjaluka was determined by the process of industrialization. Industrial development promoted the expansion of Banjaluka and brought about reforms in urban planning and scale.

The beginnings of industrialization can be traced back to the period before Austro-Hungarian rule, when the development of industry was laid by the monks of the Trappist Monastery. The Austro-Hungarian period was characterized by the exploitation and processing of raw materials and the arrival of modernity in Banjaluka. Transport infrastructure made Banjaluka connected with the European centers of the time (UZBL, 1975). In the period between the two world wars (1918-1941), the development of Banjaluka's economy and urbanization was very slow. However, after World War II, there was a rapid development of the industrial economy. The post-war spatial development of Banjaluka was influenced by the spatial concentration of industry, the creation of new jobs, the position of the residential areas around the industrial zones, and the concentration of city functions and services. The compact urban structure consisted of several settlements with the concentration of housing, work, central functions and services (UZBL, 1975). The most developed industrial branches were the pulp and paper industry, metal industry, electrical industry, wood and food industry (UZBL, 1975). The development of industry and modern industrial branches such as electronics, electromechanics, chemistry and mechanical engineering contributed to economic development (UZBL, 1975). The most important factories of the second half of the 20th

century were: the electrical engineering industry "Rudi Čajavec", the wood, cellulose, paper and wood fiber industry "Incel", the wood industry "Vrbas", the machine factory and foundry "Jelšingrad" and the leather, footwear and leather goods factory "Bosna". The urban planning policy applied the principle of zoning of housing, work and recreation, which are integrated into a single spatial entity.

This situation in the industry lasted until the civil war in Bosnia and Herzegovina (1991-1995) and the collapse of Yugoslavia, when the existing economy was destroyed, i.e., when there was a decline in industrial production, income and technological backwardness, a decline in employment and loss of workforce. At the same time, the economic transition process took place, and a new economic model based on private initiative and private ownership was developed. Due to the privatization of the state property in the 2000s, which resulted in bankruptcy proceedings of pre-war companies, many abandoned and devastated industrial sites from the socialist period are present in Banjaluka. The concept of spatial organization and industrial development has changed, and today is based on entrepreneurial infrastructure, with a special emphasis on business and industrial zones.

2.2 Brownfields definition, identification and data collection

The definition of brownfield is determined by complex social, economic, political, cultural and historical local context. There are differences in the general definition of brownfields in different post-socialist countries (Rebernik et al., 2023). The meaning of brownfields in academic and professional discourse is not uniform and is based on the purpose of individual research on that spatial phenomenon. However, in most European Union countries, brownfield refers to each abandoned or neglected built space. For example, in Slovenia, brownfields are defined as not fully utilized or disused areas with a visible impact of their former uses and of lower utility value, that needs to be regenerated (Lampič et al., 2017). In the Czech Republic, brownfields are properties (lands, objects, areas), that are underused, neglected, and can be contaminated. They are relics of industrial, agricultural, residential, military or other activities, and they cannot be appropriately and effectively utilized without the regeneration process (Frantál et al., 2012). Similarly, in Croatia, brownfields are areas, land, real estate or buildings that are inadequately used, neglected or abandoned and can be contaminated (Matković & Jakovčić, 2019). Brownfields in Romania are geographically defined areas, bounded by surface and depth, polluted with biological or chemical substances (Frantál et al., 2012). Eventually, in Poland, they are specified as areas designed for recultivation that include degraded or desolated grounds, such as closed dumps, dumping grounds, depressions (hollows), post-industrial areas, post-mining areas, post-military training grounds, for which the administrative bodies approved recultivation projects (Frantál et al., 2012).

The US Environmental Protection Agency defined brownfield sites as abandoned or underutilized industrial and commercial property where expansion or redevelopment is complicated by real or suspected contamination (USEPA, 2002). However, the most common and comprehensive definition is given by the Concerted Action on Brownfields and Economic Regeneration NETwork (CABERNET). Brownfields are defined as sites that have been affected by the former uses of the site and the surrounding land, are derelict or underused, have real or perceived contamination problems, are mainly in developed urban areas, and require intervention to bring them back to beneficial use (CABERNET, 2006). According to the previous function, there are several categories of brownfields such as: industrial, commercial, storage, municipal facilities, transportation facilities and mining.

There is no official definition of brownfields in Bosnia and Herzegovina. In professional and scientific fields, brownfields are recognized as previously developed and/or built areas with an evident state of neglect and inefficient use, which have the potential for regeneration and sustainable development (Đukić, Vujičić, 2014). There are eight categories: industrial brownfields, military brownfields, communal and transport brownfields, residential, cultural and social brownfields, commercial brownfields, sports and recreational brownfields and agricultural brownfields (Đukić, Vujičić, 2014). In the urban area of Banjaluka, brownfield sites are mostly represented in the form of abandoned or unused industrial complexes and military complexes and warehouses. In the non-urban area, brownfields are represented in the form of abandoned industrial complexes, abandoned complexes of former agricultural and farming cooperatives, and military complexes and military economy facilities that are not relevant for the defense system. The most common type of brownfield sites in urban areas is industrial, and it is generally accepted that brownfield sites are most often considered abandoned or underutilized industrial sites (Stojkov, 2008; Tonin & Bonifaci, 2020). Based on the above-mentioned definition and purpose and objectives of this study, brownfields are defined as previously developed industrial built areas that are partly or completely abandoned, inefficiently used, with the potential for regeneration.

The following approach was adopted to identify and select relevant brownfields. Based on the definition, this research identifies sites with different levels of abandonment, i.e., sites that are not used, sites of partial reuse and partial adaptive reuse. Partial reuse refers to the functional continuation and maintenance the industrial production on some part of a site, while the rest is not used. Partial adaptive reuse refers to the partial functional and physical change of some parts of an existing brownfield site (for a purpose other than original industrial production).

Regenerated brownfields are excluded from the research. Nevertheless, they were identified, mapped, and data about them were collected to provide a basis for a better understanding of the spatial characterization of brownfields and their distribution within the city. Spatial distribution of brownfields needs to be analysed in the context of all former industrial sites, which form a network of places whose location was influenced by the same factors of industrial production. The network of these sites is an integral part of the city and extensively affects spatial urban development. Besides, the spatial characteristics of all former industrial sites, whether regenerated or not, stem from their location and mutual relationship. Regenerated brownfields were also considered to identify the transformation directions and functional changes of sites and determine the area and location they occupy. This additionally facilitates creating targeted strategies for the sustainable regeneration of different brownfields. Moreover, identifying regenerated sites helps to determine whether the spatial phenomenon of brownfields is being reduced, and to what extent brownfields as a spatial resource have been redeveloped to reduce the irrational land use and prevent urban sprawl. Finally, these sites differ according to different functional and physical changes and can be described as sites of reuse and adaptive reuse. Reuse refers to changes that involve functional continuation and maintaining the original industrial function. Adaptive reuse refers to changes that involve both a functional and a physical component, whereby the change in function of the site does not necessarily mean a radical change, but it can be more subtle (Plevoets & Cleempoel, 2019). Further, the minimum length of the period without any level of site usage was set to one year so that regeneration could be differentiated from reconstruction.

The research method includes (1) desktop research and literature review, (2) fieldwork and database creation, and (3) cartography.

(1) Data were collected on the period of construction of industrial sites, previous industrial activity, current use, cultural heritage and implemented regeneration measures. The existing sources were used to identify existing and regenerated brownfields in Banjaluka: the catalog of pre-war business entities, national and entity heritage lists, academic articles related to the industrial development of Banjaluka and Bosnia and Herzegovina, a strategic document (GBL et al., 2014) and internet sources on the decline of industry after the collapse of Yugoslavia. The institutions that the data were collected from are the Banjaluka City Administration and the Republic Institute for the Protection of Cultural, Historical and Natural Heritage of the Republic of Srpska.

(2) The field work and creation of existing and regenerated brownfields inventory with all necessary data for further spatial analysis were carried out to corroborate information gathered beforehand, namely, to investigate current land use and to determine the level of site abandonment.

(3) To accurately analyze the spatial distribution of brownfields and their characteristics, the data were processed, transformed into a visual narrative, and visually presented using the QGIS platform. The maps aid in analyzing the spatial patterns of brownfields within the city and determining their clustering status. Characterization of the spatial distribution of brownfields was done by in-depth reading of visually presented data.

2.3 Spatial characterisation of brownfields, spatial analysis of the data

The study focuses on brownfield characteristics based on their mutual spatial relationship and relation to their host city and surrounding area. The analytical theory that enables the spatial characterisation of former industrial sites based on their geographic location is the theory of industrial location introduced by Alfred Weber. This theory indicates that industries tend to locate where maximum profit can be achieved by minimal cost, especially minimizing the transportation cost of raw material and final product (Hayter, 1997; Smith, 1966; Weber, 1929). Normative approach involves locating industry in places that allow the lowest costs of production based on three basic factors: transport, labour, and agglomeration and deglomeration (Weber, 1929). In this regard, an important locational factor is the transport connection of the industry with the market and resources. Besides, access to labour constitutes an important determinant for the location of labour-intensive industry. According to Weber (1929), labour-intensive industries gravitate to central locations, where the labour force is available, while capital-intensive industries gravitate to suburban locations with a lower land price.

Classical and modern location theories have emphasized the agglomeration and clustering tendency of industries (Marshall, 1920; Porter, 1990). Industries tend to locate near existing industries that supply them with raw materials or industries that demand their final products. Weber (1929) defines agglomeration factors as those that lead to the concentration of industry to facilitate technical improvement, specialization of production facilities, and the establishment of cooperation between actors within the same industrial branch. Besides functional, clusters have spatial complexity in terms of size as well. Their boundaries are not limited to the city, but also to regions and even states. They are expanding due to technological changes and market demands. However, agglomeration of production activities is always accompanied by agglomeration of population (Semevskiy, 1978). The labour

force is located near the place of work, that is, in the immediate environment of the industrial sites (Scott, 1982). Finally, the concept of industrial decentralization denotes a general social process that involves a relative change in the ratio between capital and labour and the displacement of production activity from the city centre to the periphery (Scott, 1982). The main factor that affects the dispersion of industrial activities is higher land rent and labour cost in the city centre. In addition, industries will decentralize as they mature and move from innovative to standardized production processes, and become less dependent on the main market, more skilled labour force and availability of the specialized goods and services (Barkley, 1988).

Based on the above theoretical concepts, qualitative spatial criteria for analysis of brownfields and descriptive classification indicators are defined and employed in the research (Table 1). In a preliminary desktop and field survey of Banjaluka's brownfields, for each criterion, different categories are identified (Table 1). Spatial characterization of brownfields was done by in-depth reading and analysis of visually presented data using the QGIS platform. Finally, based on the recognised spatial characteristics according to which brownfields differ the most, a typology was created.

Table 1: Spatial criteria for analysis of brownfields and their classification into categories.

No.	Theoretical framework	Criteria	Indicator	Categories
1.	Industrial decentralization and agglomeration of population	Location of the brownfield in the city	Position of the brownfield in relation to the city centre	*The city core* *Surrounding belt* *Non-urban area*
2.	Industrial agglomeration and deglomeration	Brownfield spatial patterns	Distance between brownfields and geometry of their distribution	*Dispersed pattern* (multiple scattered sites with equal and/or different mutual distances) *Agglomerated pattern* (linear agglomeration along important roads, river and railroad)
3.	Industrial agglomeration boundaries	Brownfield size	Number of industrial buildings and structures that makes up the former functional unity and the area they occupy	*Industrial building (very small area site):* standalone factory, warehouse or structure *Industrial block (small, medium and large area sites):* a group of industrial buildings and/or structures (buildings for production, storage, workspace, catering) which form a functional unit, all sharing a common location. *Industrial zones (large area sites):* large independent industrial compound, a group of industrial blocks.
4.	Transport as a factor of industrial location	Accessibility to the brownfield	Transportation links and the distance to the roads of different categories	*Very good*: direct link to express roads (regional roads, main roads, railroads), *Good*: direct link to first category roads (main city road, first class city road, second class city road, collector street), *Average*: direct link to the second and third category roads (access road, first class local road)
5.	Labor as a factor of industrial location and agglomeration of population	Brownfield environment	Surrounding land use	*Mixed-use* *Residential area* *Industrial and business area* *Non-built-up area*

3 RESULTS

3.1 Spatial distribution of brownfields in Banjaluka

According to the data gained from the research, there are 36 existing and regenerated brownfield sites in Banjaluka. In relation to the spatial structure of the city, 28 former industrial sites are located in the city core, 6 in the surrounding belt and 2 in a non-urban area. Out of 36 sites, 19 are regenerated (10 reuse and 9 adaptive reuse), and 17 are partially regenerated or completely abandoned (5 not in use, 9 partial adaptive reuse, 3 partial reuse) (Figure 1). Out of 17 brownfield sites, 13 are in the city core, 3 in the surrounding belt and 1 in a non-urban area (Figure 1). Study results indicate that brownfields cover 150 ha or 1.15% of the total city core and surrounding area.

Results of the analysis of the former production activities in Banjaluka have shown that the largest number of locations was occupied by the food industry (9 sites). However, the most prevalent industrial activities which covered the largest area of the city were the pulp and paper industry (60 ha), black metallurgy (30 ha), wood industry (30 ha), food industry (22,1 ha), machine construction (20 ha), metal industry (19 ha) and electrical industry (9,5 ha). The majority of these industries are located in the city core. Regarding heritage values, 7 sites out of the total number (19%) are institutionally protected as cultural heritage, 3 of which are located in the city core, 3 in the surrounding area and 1 in a non-urban area. Although the industrial past of Banjaluka dates to the Austro-Hungarian period, only 5 sites from that period exist. The construction period of the mills (4 sites) is unknown, and the rest of the sites (27 sites) were built after World War II, accounting for 72% of all former industrial locations.

The results of the spatial analysis have shown that the distribution of brownfields is spatially uneven, and that brownfields are showing a tendency for clustering (Figure 1). They are predominantly concentrated in the city core (13 sites), while notably sparse in the surrounding belt (3 sites) and non-urban area (1 site). Out of 13 brownfields in the city core, 10 are located along the inner border of the city core, while 3 are located in the centre of the city core. The map indicates a significant agglomeration of 8 brownfields along the east inner edge of the city core. This concentration of former food industry (13,03 ha), machine construction (4,61 ha), metal processing industry (14,40 ha) and pulp and paper industry (60 ha) has a linear structure that follows the course of the river and railroad. Further, 5 brownfields with different mutual distances are positioned in the central and southern part of the city core, suggesting a dispersed distribution of former mainly metal processing industry (4,61 ha), graphic arts (1,06 ha) and leather industry (1,6 ha). 3 out of 9 brownfields of dispersed pattern come out from the city core and fit into the surrounding belt, while 1 site is located in a non-urban area. The spatial disposition of regenerated brownfields follows the same logic of dispersed and agglomerated patterns. 4 out of 12 former industrial sites of an agglomerated pattern are regenerated into new industrial and business use, whereby 3 sites maintain industrial function. Additionally, 15 out of 24 former industrial sites of dispersed pattern are regenerated, whereby 7 sites maintained their previous function and the rest changed into industrial and business use (Figure 1, Figure 2).

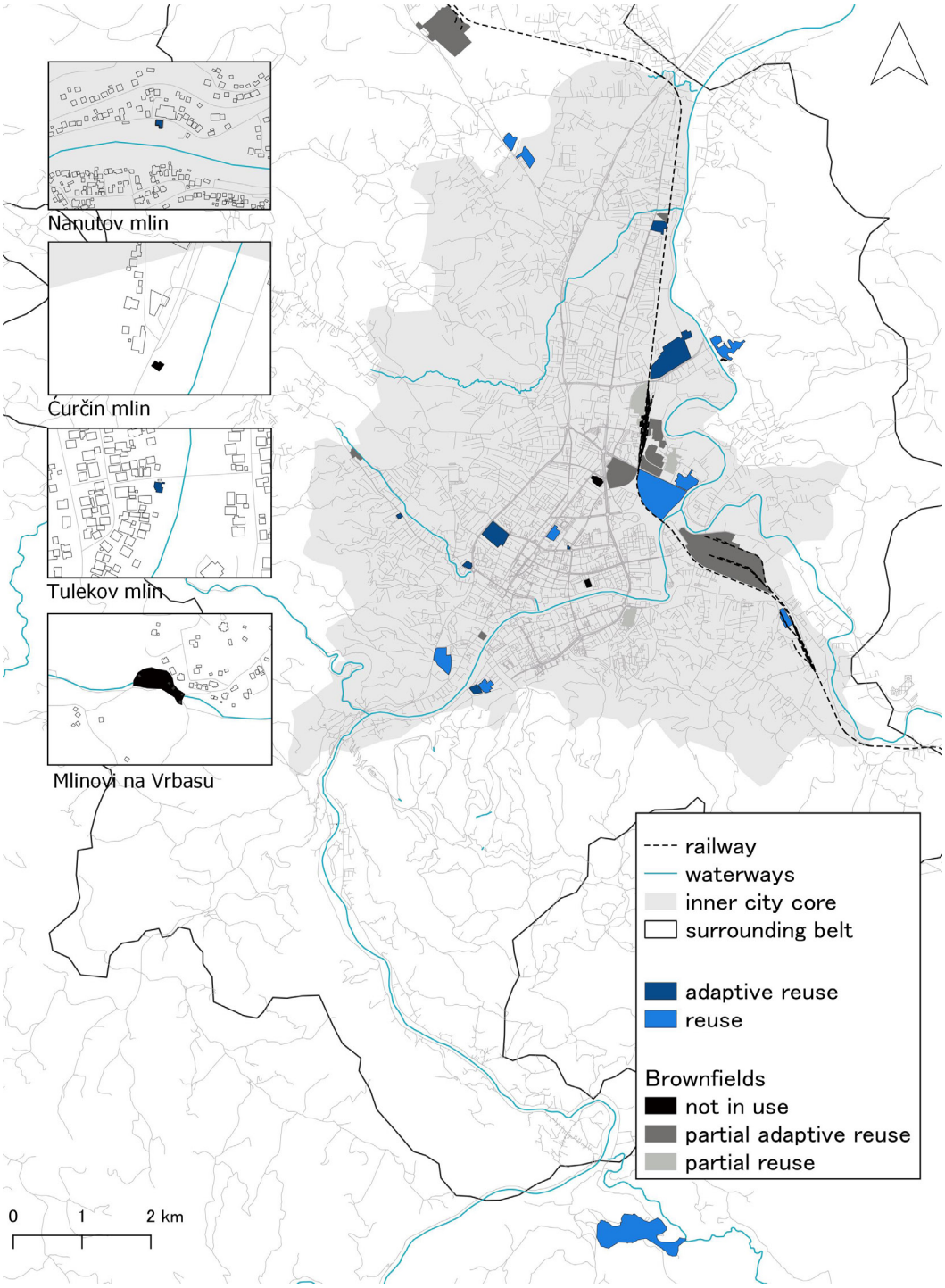

Figure 1: Distribution of existing and regenerated brownfields in Banjaluka

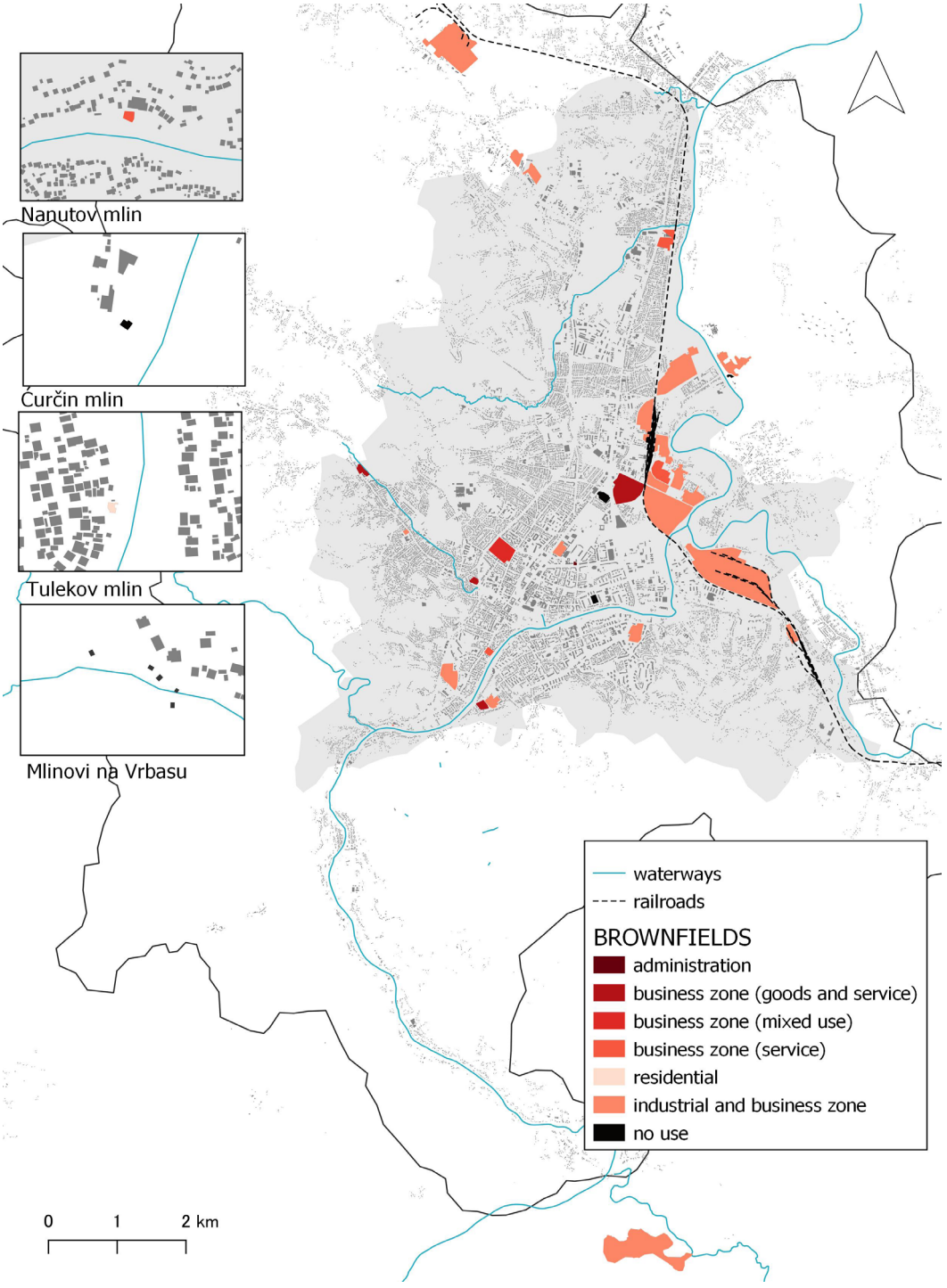

Figure 2: Distribution of new functions of regenerated brownfields in Banjaluka

3.2 Spatial characteristics of brownfields in Banjaluka

The map indicates that the 17 identified brownfields embody three different sizes (Figure 3): a) industrial buildings- very small sites (up to 1 ha); b) industrial blocks- small sites (1- 5 ha), medium sites (5- 10 ha), and large sites (more than 10 ha); and c) industrial zones (more than 10 ha). All identified brownfields are dominated by industrial blocks (13 sites), followed by industrial buildings (2 sites) and industrial zones (2 sites) (Figure 3). Within the city core, two different sizes of brownfields are identified, namely 12 blocks (7 small sites with the area ranging between 1 ha and 4,60 ha, 5 medium sites with the area ranging between 5,2 ha and 9,70 ha and 1 large site with an area of 14,40 ha) and 1 zone with the area of 60 ha. The average number of buildings in industrial blocks in the city core is 14, with the number of buildings varying from 4 to 43, while the number of buildings in a single zone is 84. Within the surrounding belt, the distribution of selected brownfields is less balanced, with 2 buildings (0,01 ha and 0,35 ha) and 1 zone (30 ha). The number of buildings in the industrial zone is 36. In a non-urban area, only 1 industrial block composed of 6 buildings (0,45 ha) is covered.

By observing the transportation links and the distance of brownfields to the roads of different categories, namely regional and main roads and railroad, primary roads and secondary and tertiary roads (Figure 3), it can be concluded that almost all brownfields have very good and good accessibility, with only 1 site in a non-urban area of average accessibility. Finally, analysing the immediate environment of the brownfields, it is observed that brownfields in the urban core are integrated into the built-up area, which is mainly a mixed-use, business, industrial and residential area. Contrary to this, the immediate surroundings of the brownfields in the surrounding and non-urban area is non-built and residential area (Figure 3).

3.3 Typology of brownfields in Banjaluka

Typology of the brownfields is based on defined criteria and conducted field and map research. The key classification criteria were location, spatial pattern of brownfields, brownfield size, accessibility, and surrounding environment. The principal typological classification was made based on brownfields location within the city, that is, distance to the city core centre (Krajina Square, the central square of the City of Banjaluka), which puts brownfields into three basic categories, namely, those overlapping with the city centre, adjacent to the city centre and distant from the city centre (Figure 4, Table 2). Spatial pattern of brownfields, brownfield size, accessibility, and surrounding environment were additional criteria to describe the three types in greater detail, which also made division into subtypes possible.

Table 2: Typology of brownfields in Banjaluka.

TYPE 1	**TYPE 2**		**TYPE 3**
Brownfields overlapping with the city centre	**Brownfields adjacent to the city centre**		**Brownfields distant from the city centre**
Centre of the city core	**Along the inner border of the city core**		**Surrounding belt and non-urban area**
	Subtype 2A	**Subtype 2B**	
Dispersed pattern	Dispersed pattern	Agglomerated pattern	Dispersed pattern
Industrial blocks (Small sites: 1- 5 ha)	Industrial blocks (Small sites: 1- 5 ha)	Industrial blocks and zone (Small sites: 1- 5 ha; Medium sites: 5- 10 ha; Large sites: > 10 ha)	Industrial buildings, blocks and zone (Very small sites: < 1 ha; Large sites: > 10 ha)

TYPE 1	TYPE 2		TYPE 3
Very good and good accessibility	Very good accessibility	Very good and good accessibility	Very good, good and average accessibility
Mixed-use and residential area	Business and residential area	Industrial, business and residential area	Non-built-up area and residential area
3 brownfields	2 brownfields	8 brownfields	4 brownfields
Total area: 6,6 ha	Total area: 3,0 ha	Total area: 108,5 ha	Total area: 31,8 ha
Average area of the site: 2,20 ha	Average area of the site: 1,5 ha	Average area of the site: 13,50 ha	Average area of the site: 7,95 ha

4 DISCUSSION

Brownfields in Banjaluka are unequally distributed and largely concentrated in the built-up urban core (Figure 1). Out of 17 brownfields, 13 sites (78%) covering 118,10 ha are located in the city core area, 3 sites (17%) covering 31,35 ha in the surrounding belt and 1 site (5%) covering 0,45 ha in a non-urban area. This ratio of brownfields is very similar to many other post-industrial cities (De Sousa, 2003; Frantál et al., 2013; Longo & Campbell, 2017; Sorin & Pompei, 2012). The highly represented brownfields in the city core support existing evidence that for many cities, brownfields are significant "space reserves", and their regeneration is an important mechanism for improving the quality of urban environments and principles of compact city (Grimski, Ferber, 2001; Dorsey, 2003). Additionally, the proportion of 19 regenerated brownfields in Banjaluka is the same. 15 sites (78%) covering 90 ha are in the city core, 3 sites (16%) covering 10,20 ha in the surrounding belt and 1 site (6%) covering 38 ha in a non-urban area. This result complies with the research confirming that location is an important factor of urban regeneration and claiming that brownfields in city centres are more likely to be regenerated than those on the periphery (Frantál et al., 2013). However, almost an equal number and area of existing brownfields (ca. 150 ha) and those that are regenerated (ca. 140 ha) indicate that the process of brownfield regeneration is going on very slowly. This dynamic, in which no more than half of the brownfields are regenerated, is present in other post-socialist cities (Kunc et al., 2023). The reasons are mainly found in the complex ownership, lack of finance, environmental burden, and lack of efficient tools for the management of the process of brownfield regeneration and educated brownfield managers (Cotič, 2009).

Brownfields in Banjaluka are mainly located in the urban core and are small-scale with an average area of 6,30 ha. However, 3 large sites along the border of the city core cover an area of 105 ha, which makes up 69% of the total area of all brownfields. This could be because large brownfields in Banjaluka are not attractive to investors or are more complex to redevelop in terms of time and finances. Furthermore, the average area of regenerated brownfields is slightly larger and is 8,10 ha. In the structure of regenerated sites, 4 industrial buildings, 8 small industrial blocks (1- 5 ha) and 4 medium blocks (5- 10 ha) predominate, covering 49,30 ha, which makes over 35 % of all regenerated sites. The remaining 90 ha are occupied by 3 large sites. This result confirms that the smaller the area, the greater the probability of brownfield regeneration.

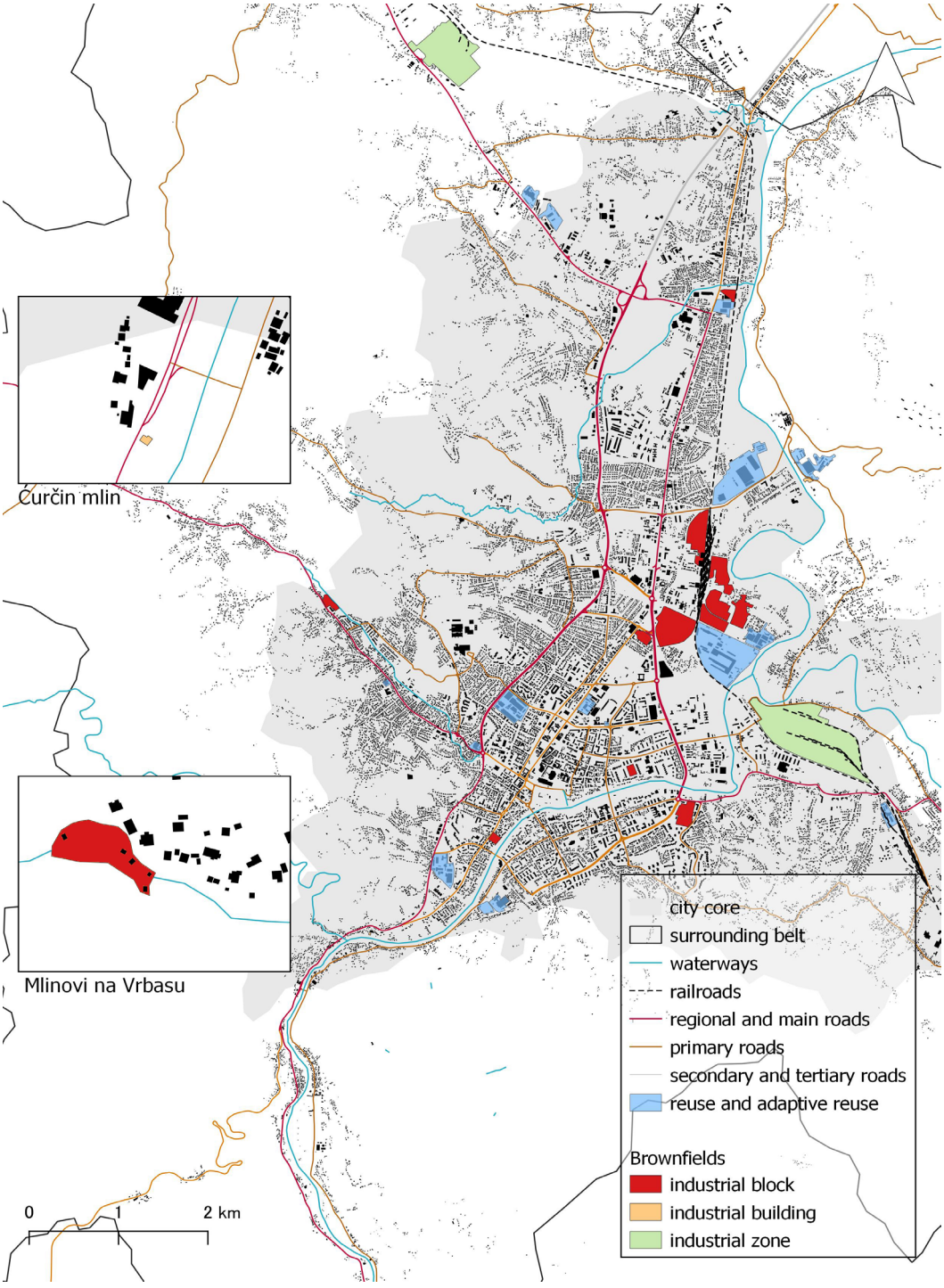

Figure 3: Distribution of spatial characteristics of brownfields in Banjaluka

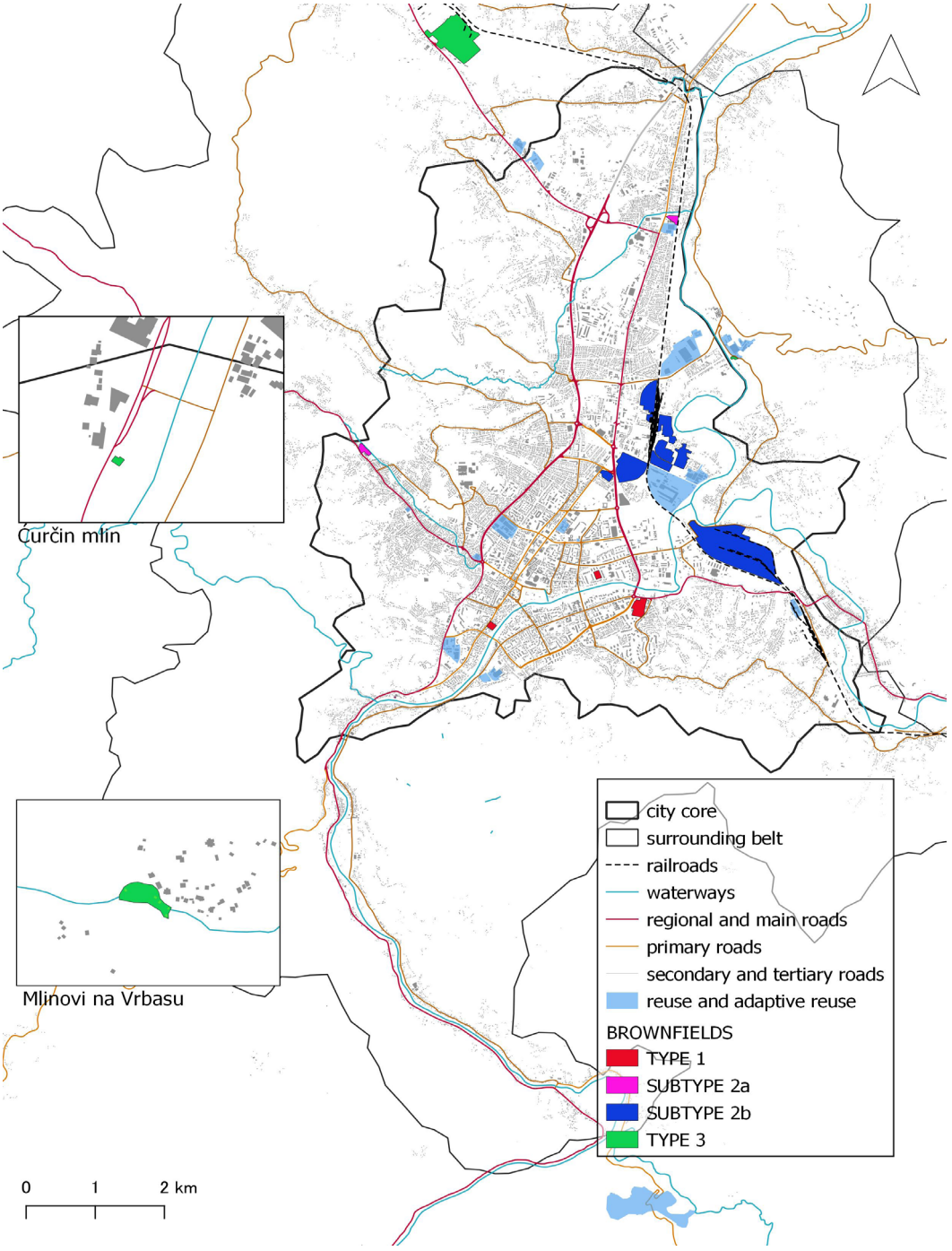

Figure 4: Typology of brownfields in Banjaluka. Type 1: Brownfields overlapping with the city centre; Type 2: Brownfields adjacent to the city centre (Subtype 2A: dispersed pattern and Subtype 2B: agglomerated pattern); and Type 3: Brownfields distant from the city centre.

Two different spatial patterns of brownfields are identified, namely dispersed and agglomerated distribution, which are underpinned by the rationale of the city's internal and external transportation network. Historical development of industry in Banjaluka, connected with the construction of the railway from the north-west and Prijedor, and its continuation via the city core towards the southeast along the river Vrbas, created an important linear agglomeration of industrial sites along the eastern border of the city core. These industries used a large amount of electricity and water, had a greater need for storage and open spaces, and were dependent on the rail transport. Thus, this phenomenon of brownfield clusters can largely be attributed to their previous industrial land use and transportation facilities. Similar patterns of brownfields are also identified in other post-socialist cities as dispersed spatial patterns characterised by the insular distribution of brownfield sites within the urban system, occasionally grouped into brownfield clusters, which dominate the urban area and generate a specific urban fabric (Sorin & Pompei, 2012). Eventually, the tendency for industrial linear clustering at intersections of railway lines, along rivers, or near energy plants is already proven in literature (Frantál et al., 2015), which strongly complies with critical factors of agglomeration, including industrial commonality, transportation costs, raw material availability, fuel supply, and water conditions (Porter, 1990). This research showed that the smallest number of regenerated brownfields belongs to an agglomerated spatial pattern, which can be explained by the larger average area of the sites.

The most prevalent new use of the regenerated brownfields is industrial and business use, regardless of the city location (Figure 2). This is consistent with the research proving that the most popular new functions of the former industrial sites in post-socialist cities are production and services, which probably results from the ease of using the existing infrastructure and passage from the old to the new function (Pytel et al., 2021; Rebernik et al., 2023). On the contrary, there is research confirming that only a small number of cases of regenerated brownfields in the city correspond to the development of activities similar to former industrial activities, while most of them are associated with the development of business areas (shopping centres) (Sorin & Pompei, 2012). Contrary to these uniform approaches to regeneration, after 2000, the transformation of brownfields became more planned and sensitive, as the interest and awareness of the public towards the industrial heritage and sustainable development increased. The focus is on new residential functions, services, commerce, administration and mix zones (Kunc et al., 2023).

The research shows that brownfields in Banjaluka have different spatial relationships with the main built-up area of the city centre and each other and different spatial characteristics, based on which a novel typology was defined (Figure 4). Brownfields overlapping with the city centre (type 1) are characterised by a dispersed pattern, small-scale industrial blocks with an average area of 2,20 ha and a direct link to regional roads, main roads, railroad, and primary city roads. Regeneration of these brownfields should be closely integrated with strategies for urban renewal. Since these sites are integrated into a mainly mixed-used city environment, their development needs to enhance urban vitality and reach a balance between social and economic values.

Brownfields adjacent to the city centre (type 2) are characterised by small, medium and large industrial blocks with an average area of 7,50 ha and direct link to regional roads, main roads and railroad, as

well as primary city roads. Therefore, regeneration of these sites could be relatively independent of the city's strategies, offering more possibilities for large-scale and regional projects. These sites are integrated into industrial, business and residential environments, and therefore strategies should focus on further economic development, but not threaten the quality of housing. Moreover, dispersed small industrial blocks (subtype 2A) could be treated independently within regional strategies. Besides, agglomerated small, medium and large industrial blocks and zones (subtype 2B) exert a significant spatial impact on urban areas due to their size and complexity. This research showed that there are more brownfields of this type, and they occupy more than 70% of the brownfield area with an average area of 13,56 ha. This is the reason why a holistic strategy for agglomerated sites is required, and regeneration should not be isolated. However, it is crucial to avoid homogenization of planning proposals and enhance the distinctiveness of each regeneration project. Moreover, unique characteristics of each site, contributing to the originality of the local structure of inhabitants and users, should be considered (Pytel et al., 2021). Since these sites are closely tied to the natural environmental conditions of their locations along the river, regeneration approaches need to consider their environmental impacts and contribution of brownfield land to urban green infrastructure and ecosystem services (Preston et al., 2023). Besides, there is a convenient link between individual brownfields due to the transportation factors of agglomeration, which allows future complementary new functions on brownfields to support each other.

Brownfields distant from the city centre (type 3), located in the surrounding belt and non-urban area of Banjaluka, are characterised by a dispersed pattern of industrial buildings and a large industrial zone with an average area of 7,95 ha, direct link to express roads and first, second and third category roads, and a non-built up and residential environment. Regeneration of these brownfields should be closely integrated with strategies for activation of non-urban areas and a polycentric model of development of non-urban settlements, as well as improving economic, tourist and public service capacities. Development of tourism and entrepreneurial and public functions, along with implementation of incentives for living and working in the non-urban area, should be in focus of these strategies. In this way, regeneration of these brownfields contributes to the coordinated urban and rural development goals (GBL et al., 2014). Eventually, sites valued as industrial heritage, which are most prevalent in this type, should be the subject of strategies for industrial heritage protection at the local and regional level. Further, values of industrial heritage should be an integral part of brownfields regeneration strategies, because cultural heritage plays an important role in the spatial, social and economic aspects of the regeneration process (Pytel et al., 2021). Industrial brownfields are remnants of past industrial processes as well as evidence of the unique identity that industrial landscapes have acquired over the years, becoming integral components of cultural and architectural heritage (Arbab & Alborzi, 2022).

5 CONCLUSION

Brownfields are a significant spatial resource of the city of Banjaluka. Thus, a thorough understanding of the spatial character and disposition of brownfields within the city should be considered for creating spatial strategies for sustainable brownfields regeneration. More precisely, strategies should consider the qualities and potentials of brownfields coming from their urban location, mainly their spatial relation-

ship with the city, environment, and each other. Otherwise, neglecting different types of brownfields and their uneven agglomerated and dispersed patterns within the city will not enable comprehensive brownfields development. On the contrary, it could make homogenized regeneration solutions with no reference to integral urban development goals. Meanwhile, the practice of regeneration that has been going on for the last two decades will continue. Ignoring this practice in the context of spatial strategies of the entire city is a crucial omission in planning.

The model used for the multi-criteria spatial analysis is a tool for considering brownfields as a network of spatial spaces within the city and understanding the spatial aspect of urban regeneration. The model enables identifying brownfields with different spatial characteristics; that is, it offers the possibility of their future reintegration into the city territory. The analysis results, i.e., different spatial relationship of brownfields with the city, their environment, and each other, show the importance of brownfield location as a determinant of its spatial character. Precisely, they enable reflection on the brownfield stock through the lenses of industrial geography that is not based on sites as isolated spatial units, but a single entity determined by the factors of industrial location.

The brownfield database and typology can inform spatial planning by offering opportunities for differentiated strategies and targeted measures for brownfield regeneration and facilitating the achievement of local and regional sustainable development goals. Different types of brownfields should be carefully considered for creating spatial strategies for balancing between urban expansion, optimization of space, and development of small-scale and large-scale urban projects. This would complement the urban spatial strategies based on efficient land use. Secondly, the typology may be useful for initial site investigation to identify constraints or hindrances to brownfield development (e.g., size of the site, accessibility, environment, etc.), along with other relevant studies. Precisely, it can help governments and investors have more detailed information on land resources and prioritize brownfield redevelopment. The analysis model employed in the research can be improved in the context of research techniques through software and geodetic databases for spatial mapping and analysis. The method used to create brownfield typology in this single case study research is transferable to other post-industrial cities to be tested for further improvements. By offering a comprehensive and profound perspective on the status of brownfields in Banjaluka, this research endeavours to lay the groundwork for subsequent comparative studies with other cities.

Literature and references:

Arbab, P. & Alborzi, G. (2022). Toward developing a sustainable regeneration framework for urban industrial heritage. Journal of Cultural Heritage Management and Sustainable Development, 12(3), 263-274. https://doi.org/10.1108/JCHMSD-04-2020-0059.

Baing, A. S. (2010). Containing Urban Sprawl? Comparing Brownfield Reuse Policies in England and Germany. International Planning Studies, 15(1), 25–35. https://doi.org/10.1080/13563471003736910.

Barkley, D. L. (1988). The Decentralization of High-Technology Manufacturing to Nonmetropolitan Areas. Growth and Change, 19(1), 13–30. https://doi.org/10.1111/j.1468-2257.1988.tb00459.x.

CABERNET, 2006. Sustainable Brownfield Regeneration: CABERNET Network Report. University of Nottingham Land Quality Management Report. https://sig.urbanismosevilla.org/sevilla.art/sevlab/m004UEb_files/m004_UE.pdf, accessed 11. 3. 2025.

Cotič, B. (2009). COBRAMAN – Manager coordinating brownfield redevelopment activities. Urbani Izziv 20(1). https://urbaniizziv.uirs.si/Portals/urbaniizziv/Clanki/2009/urbani-izziv-en-2009-20-01-012.pdf, accessed 15. 9. 2025.

Cotič, B. (2019). Industrial Symbiosis in Brownfields in Kranj,Slovenia. IOP Conf. Ser.: Mater. Sci. Eng. 471 112073. DOI 10.1088/1757-899X/471/11/112073.

De Sousa, C. A. (2003). Turning brownfields into green space in the City of Toronto. Landscape and Urban Planning, 62(4), 181–198. https://doi.org/10.1016/S0169-2046(02)00149-4.

De Sousa, C. A. (2006). Unearthing the benefits of brownfield to green space projects: An examination of project use and quality of life impacts. Local Environment, 11(5), 577–600. https://doi.org/10.1080/13549830600853510.

Dorsey, J. W. (2003). Brownfields and Greenfields: The Intersection of Sustainable Development and Environmental Stewardship. Environmental Practice, 5 (1), 69–76. https://doi.org/10.1017/S1466046603030187.

Đukić, A., & Vujičić, T. (Eds.) (2014). Browninfo, Priručnik za uspostavljanje interaktivne baze podataka braunfild lokacija [Browninfo, A manual for establishing an interactive database of brownfield sites]. Banja Luka: Univerzitet u Banjoj Luci, Arhitektonsko-građevinsko-geodetski fakultet, Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH i INOVA informatički inženjering, d.o.o.

Frantál, B., Greer-Wootten, B., Klusáček, P., Krejčí, T., Kunc, J., & Martinát, S. (2015). Exploring spatial patterns of urban brownfields regeneration: The case of Brno, Czech Republic. Cities, 44, 9–18. https://doi.org/10.1016/j.cities.2014.12.007.

Frantál, B., Klusáček, P., Kunc, J. & Martinát, S., (2012), Report on Results of Survey on Brownfields Regeneration. https://www.researchgate.net/publication/306152657_Report_on_Results_of_Survey_on_Brownfield_Regeneration_and_Statistical_Analysis_Information. accessed 27. 8. 2025.

Frantál, B., Kunc, J., Nováková, E., Klusáček, P., Martinát, S., & Osman, R. (2013). Location matters! exploring brownfields regeneration in a spatial context (A case study of the South Moravian Region, Czech Republic). Moravian Geographical Reports, 21(2), 5–19. DOI: 10.2478/mgr-2013-0007.

Grad Banja Luka (GBL), Projekt a.d. Banja Luka, & Institut za građevinarstvo "IG", d.o.o. (2014). Prostorni plan Grada Banja Luka [Spatial plan of City of Banja Luka].

Grimski, D. & Ferber, U. (2001). Urban Brownfields in Europe. Land Contamination & Reclamation, 9 (1), 143–148.

Hayter, R. (1997). The dynamics of industrial location: The factory, the firm and the production system. New York: John Wiley & Sons.

Hercik, J., Šimáček, P., Szczyrba, Z., & Smolová, I. (2014). Military brownfields in the Czech Republic and the potential for their revitalisation, focused on their residential function. Quaestiones Geographicae, 33(2), 127-138.

Kunc, J., Sikorski, D., Novotná, M., Brezdeń, P., Ilnicki, D., Tonev, P. & Marek, A. (2023). Industrial legacy towards modern urban environment: a comparative study of Wroclaw and Brno. Bulletin of Geography. Socio-economic Series, 61(61): 71-92. http://doi.org/10.12775/bgss-2023-0026.

La Monaca, F. (2025). The Construction Site as Ecological Laboratory: Integrating Nature-Based Solutions into Architectural Practice. International Theory and Practice in Humanities and Social Sciences, 2(7), 155–169. https://doi.org/10.70693/itphss.v2i7.1096.

Lampič, B., Bobovnik, N. & Rebernik, L. (2020). Tools for sustainable and smart land use: Slovenian approach for land regeneration support. Geographical Review. 42, 101-115. DOI:10.35666/23038950.2020.42.101.

Lampič, B., Kušar, S. & Zavodnik Lamovšek, A. (2017). A model of comprehensive assessment of derelict land as a support for sustainable spatial and development planning in Slovenia. Dela, 48, 33-59. https://doi.org/10.4312/dela.48.33-59.

Longo, A. & Campbell, D. (2017) The determinants of brownfields redevelopment in England. Environmental and Resource Economics, 67(2), 261-283. https://doi.org/10.1007/s10640-015-9985-y

Marshall, A. (1920). Principles of economics. https://eet.pixel-online.org/files/etranslation/original/Marshall,%20Principles%20of%20Economics.pdf. accessed 11. 3. 2025.

Martinát, S., Dvorak, P., Frantal, B., Klusacek, P., Kunc, J., Navratil, J., Osman, R., Tureckova, K., & Reed, M. (2016). Sustainable urban development in a city affected by heavy industry and mining? Case study of brownfields in Karvina, Czech Republic. Journal of Cleaner Production, 118, 78-87. https://doi.org/10.1016/j.jclepro.2016.01.029.

Matković, I. & Jakovčić, M. (2019). Brownfield prostori i njihova regeneracija; Definicije i pristupi. Prostor, 27 (2(58)), 348-359. https://doi.org/10.31522/p.27.2(58).13

Novosák, J., Hájek, O., Nekolová, J. & Bednář, P. (2013). The Spatial Pattern of Brownfields and Characteristics of Redeveloped Sites in the Ostrava Metropolitan Area (Czech Republic). Moravian Geographical Reports. 21(2), 36-45.

Perić, A. (2016). Institutional Cooperation in the Brownfield Regeneration Process: Experiences from Central and Eastern European Countries. European Spatial Research and Policy, 23(1), 21–46. https://doi.org/10.1515/esrp-2016-0002.

Plevoets, B. & Cleempoel, K. V. (2019). Adaptive reuse of the built heritage – Concepts and cases of an emerging discipline. London: Routledge.

Porter, M. E. (1990). The competitive advantage of nations. New York: Free Press

Preston, P. D., Dunk R. M., Smith, G.R. & Cavan, G. (2023). Not all brownfields are equal: A typological assessment reveals hidden green space in the city. Landscape and Urban Planning, 229. 1-13. https://doi.org/10.1016/j.landurbplan.2022.104590.

Pytel, S., Sitek, S., Chmielewska, M., Zuzańska-Żyśko, E., Runge, A., & Markiewicz-Patkowska, J. (2021). Transformation Directions of Brownfields: The Case of the Górnośląsko-Zagłębiowska Metropolis. Sustainability, 13(4), 2075. https://doi.org/10.3390/su13042075.

Rebernik, L., Vojvodíková, B., & Lampič, B. (2023). Brownfield Data and Database Management—The Key to Address Land Recycling. Land, 12(1), 252-272. https://doi.org/10.3390/land12010252.

Scott, A.J. (1982). Locational patterns and dynamics of industrial activity in the modern metropolis. Urban Studies, 19, 111–42.

Semevskiy, B. (1978). The principle of agglomeration and its role in the process of urbanization. Geographia Polonica, 39, 9-16.

Smith, D. (1966). A theoretical framework for geographical studies in industrial location. Economic Geography, 42(2), 95–113.

Sorin, F. & Pompei, C. (2012). Urban industrial brownfields: Constraints and opportunities in Romania. Carpathian Journal of Earth and Environmental Sciences. 7(4), 155-164.

Špirić, A. (2015). Spatial criteria in urban renewal of industrial brownfield sites, GRAĐEVINAR, 67 (9), 865-877, doi: https://doi.org/10.14256/JCE.1011.2014.

Stojkov, B. (Ed.) (2008). Strategija razvoja grada Beograda - ciljevi, koncepcija i strateški prioriteti održivog razvoja – nacrt [Development strategy of the city of Belgrade - goals, concept and strategic priorities of sustainable development - draft]. Beograd: PALGO centar.

Tonin, S., Bonifaci, P (2020). Assessment of brownfield redevelopment opportunities using a multi-tiered approach: A case in Italy. Socio-Economic Planning Sciences, 71 (9). 100812. https://doi.org/10.1016/j.seps.2020.100812.

Urbanistički zavod Banja Luka (UZBL). (1975). Urbanistički plan Banje Luke [Urban plan of Banja Luka].

USEPA (United States Environmental Protection Agency) (2002). Brownfields Road Map to Understanding Options for Site Investigation and Cleanup, Sixth Edition. https://www.epa.gov/system/files/documents/2024-06/brownfieldsroadmapepa542-r-12-001.pdf, accessed 12. 3. 2025.

Weber, A. (1929). Theory of the Location of industries. Chicago: The University of Chicago Press.

Špirić A., Đukić A., Ikalović V. (2025). Brownfields Data as a Spatial Resource for Urban Planning: A Banjaluka Case Study. Geodetski vestnik, 69 (3), 366-385.
DOI: https://doi.org/10.15292/geodetski-vestnik.2025.03.366-385

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