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# Spatial criteria in urban renewal of industrial brownfield sites

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Professional paper

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## Spatial criteria in urban renewal of industrial brownfield sites

The paper explores the possibility of using spatial criteria for the evaluation of abandoned or underused industrial complexes (brownfields) during their urban renewal. The establishment of unique spatial criteria in the analysis and evaluation of brownfield sites is the precondition for their uniform and sustainable development. The validity of the proposed criteria is checked on the example of analysis of the former industrial complex Rudi Čajavec in Banja Luka.

### Key words:

industrial brownfields, development potential, urban renewal, spatial criteria, Rudi Čajavec

Stručni rad

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## Prostorni kriteriji u urbanoj obnovi industrijskih *braunfild* lokacija

U radu se istražuje mogućnost primjene prostornih kriterija za vrednovanje napuštenih ili nedovoljno iskorištenih industrijskih kompleksa (*braunfilda*) prilikom njihove urbane obnove. Uspostava jedinstvenih prostornih kriterija u analizi i vrednovanju braunfild lokacija pretpostavka je njihova ujednačenja i održiva razvoja. Valjanost predloženih kriterija provjerena je na primjeru analize bivšeg industrijskog kompleksa Rudi Čajavec u Banjoj Luci.

### Ključne riječi:

industrijski braunfild, razvojni potencijal, urbana obnova, prostorni kriteriji, Rudi Čajavec

Fachbericht

**Ana Špirić**

## Räumliche Kriterien in der städtischen Erneuerung industrieller Brachflächen

Die vorliegende Arbeit untersucht Möglichkeiten zur Anwendung räumlicher Kriterien in der Entwicklung verlassener und unzureichend genutzter industrieller Anlagen (Brachflächen) bei städtischen Erneuerungen. Um eine einheitliche und nachhaltige Entwicklung von Brachflächen zu ermöglichen, muss die Voraussetzung eindeutiger räumlicher Kriterien in ihrer Analyse und Bewertung erfüllt sein. Die Gültigkeit der vorgeschlagenen Kriterien wurde am Beispiel einer Analyse des ehemaligen Industriekomplexes Rudi Čajavec in Banja Luka geprüft.

### Schlüsselwörter:

industrielle Brachflächen, Entwicklungspotenzial, städtische Erneuerung, räumliche Kriterien, Rudi Čajavec

## 1. Introduction

As an effect of deindustrialisation, large areas of construction land, and many industrial facilities in urban areas, are currently underused or have been altogether abandoned. On the other hand, due to urbanisation and expansion of cities, most of these areas are now located on the periphery of urban areas or in the cities themselves, which resulted in creation of dilapidated complexes unfit for proper conduct of manufacturing activities. Such decrepit and underused areas, professionally referred to as brownfield sites, often take up attractive urban land and are characterized by a high level of contamination, which contributes to the generation of many economic, environmental and sociological problems. Brownfield sites can be defined in many ways [1, 2] but, for the purposes of this paper, a relevant definition would be the one defining such sites as the areas and structures located in urbanised areas that have lost their initial function or are currently used to a very small extent [3]. Similarly, due to demographic changes and changes in the needs of local residents, many commercial structures and land plots in urban and suburban areas have become economically unviable, and have consequently been abandoned and left in disrepair. These locations, known as greyfield sites, are in most cases not contaminated and do not require environmental improvement prior to rehabilitation.

The loss of economic value of land due to environmental system disruptions, loss of identity in city districts where dilapidated and unused sites are located, and negative psychological impacts on local residents, contribute to the further lowering of the quality of urban environments. On the other hand, due to an increase in urban population, there is a growing pressure to expand the cities toward unoccupied construction land plots, i.e. to utilise the so called greenfield locations, which places an additional emphasis on the problem of irrational use of urban land. As construction land is one of key strategic resources and factors influencing development of cities, and as it is at the same time a significant element and factor giving competitive edge to cities and contributing to the attraction of new development activities and new investors [4], the need to recycle construction land and rehabilitate abandoned and underused localities is becoming increasingly pronounced [5].

This paper is primarily concerned with the spatial aspect of renewal of the abandoned and underused industrial complexes, which are the most represented type of brownfield sites in urban areas. For many cities, industrial brownfield sites constitute significant "space reserves", and their renewal is an important mechanism for improving quality of urban areas and for reaching sustainable development goals [6-8].

Regarded as a process, the brownfield site renewal planning takes place gradually in phases that imply various activities [9]. The harmonisation of interests of various stakeholders, and an adequate renewal risk management, can hardly be regarded as a simple planning task [10]. The complexity of the process, the uncertainty and higher risks and costs related to the renewal and reuse of brownfield sites, deter private capital from direct economic interventions [8], thus making this type of renewal a long-term operation. In addition, relevant studies show that the

lack of adequate information on the development potential and downsides of brownfield sites is a factor that additionally slows down the renewal process [11]. It can therefore be said that an adequate spatial analysis of brownfield sites and the determination of possibilities for integrating brownfield sites into the urban fabric from the functional, morphological and sociological aspects, combined with the evaluation of their development potential, is of crucial significance for a sustainable renewal process [10].

The definition and assessment of the current condition of a locality in the framework of a wider socioeconomic urban context, combined with the analysis of negative impacts the locality has on its wider surroundings, is undertaken in the initial phase of a multilayer renewal planning process, which at the same time constitutes the basis for further planning activities. Based on the development potential determined for these spatial resources, it is possible to make decisions on the adoption of a plausible approach to this renewal in the scope of strategic planning. In order to make strategic brownfield-site development decisions, it is indispensable to determine special criteria for the analysis and evaluation of such sites. The intention of this paper is to establish uniform spatial criteria that can systematically be applied in the analysis of all industrial brownfield sites, which would in turn ensure compatibility and objectivity in the evaluation of their condition and development potential.

## 2. Starting points in defining spatial criteria for evaluation of industrial sites

When viewed from the spatial aspect, the main objective of renewal of brownfield sites in urban areas is to integrate these sites, based on structural and functional changes, into the urban community so as to make a more efficient use of urban land, to create a better-quality urban environment complying with principles of proper urban design, and to establish optimum conditions for proper living in cities. The possibilities for integrating brownfield locations into urban space mostly depend on spatial features of the site itself. Many authors consider that main obstacles preventing investment in brownfield sites are the poor image of the site and its wider surroundings. According to Adair et al. the renewal of brownfield sites is influenced, besides social factors and an improper legal and planning framework, by the perception of the quality of such complexes, their accessibility, and transport connections [12]. Such attitudes constitute a starting point for the selection of spatial attributes of industrial brownfield sites, regarded as criteria for evaluation of their development potential. In other words, establishment of positive correlations between spatial attributes of brownfield sites and their development potentials, forms the basis for determination of spatial criteria for the analysis and evaluation of industrial sites. Two types of brownfield renewal studies are most often found in literature, and in both of them a significant role is assumed by site-specific attributes. The first group of studies is related to the spatial analysis of brownfield sites, and involves quantification of spatial attributes. The second group, covering also this study, is related to the multicriteria method for the evaluation

of development potential of brownfield sites, where spatial attributes represent evaluation criteria. The paper is oriented toward defining those spatial attributes of industrial brownfields that influence the renewal process, and that can, as such, constitute criteria for the evaluation of development potential.

In order to identify main instigators and limitations of the brownfield renewal process, authors most frequently carry out comparative analyses of spatial attributes of brownfield sites prior to and after actual renewal. Frantal et al. emphasise the significance of specific spatial factors as the renewal process instigators [13]. At that, they make a distinction between three types of factors, namely:

- a) general factors, i.e. factors that are related to the spatial macro-level of the brownfield renewal study
- b) location factors that are related to the spatial meso level of study
- c) site-specific factors that are related to the spatial micro level of study.

General factors, which are related to the economic, social and political contexts, comprise legal and economic instruments, and renewal process management instruments. Location factors are related to the brownfield complex attributes in the context of the city, i.e. its geographic position, transport connections, socio-demographic structure of local population, economic potential of the site, employment rate, and other attributes. Finally, site-specific factors are related to the size of brownfield complexes, their previous use, the number of structures/facilities within the site, presence of infrastructure, ownership rights, and contamination level [13]. Site-specific and location factors relating to spatial features of brownfield sites are of special significance to this study. They are further analysed, in their extended form and based on results of theoretical and practical investigations, as site-specific and location attributes so as to enable their selection as spatial criteria for the evaluation of industrial-brownfields development potential. Taking into account site-specific attributes, development potentials of industrial brownfields can best be differentiated according to:

- use of structures/facilities and zones within the complex,
- size of the complex,
- construction typology of the complex,
- proportion of open spaces in the total area of the complex,
- rating of the facilities,
- presence of infrastructure,
- level of contamination, and
- ownership.

These site-specific attributes are also known as internal factors and they result from the former use of the complex [14].

Taking into account location attributes, development potentials of industrial brownfields are mostly differentiated according to:

- position of brownfield within urban environment, and
- accessibility (access to transport)

Before considering the selected site-specific and location attributes, it is indispensable to explore in more detail industrial

complexes as spatial phenomena. In cities, the most represented industrial brownfields are abandoned industrial complexes, namely light industry and processing industry manufacturing sites. An industrial complex is a group of industrial plants connected to one another by functional links and, at that, they all share the same location. Their functional links can be expressed through technological, manufacturing, market-related, and other links [15]. Industrial architecture has always been characterized by a flexible structural system. Consequently, this study does not consider flexibility as a special spatial feature that influences development potential of industrial brownfields, because the basic assumption is that most industrial production plants have a structural system that is flexible enough to adjust to different urban functions.

## 2.1. Site-specific attributes

The first site-specific attribute that influences development potential of industrial brownfields is the former use of structures and zones within the complex. Most industrial complexes are most often composed of several functional zones, such as the manufacturing, administrative, infrastructural, and protective vegetation zones. The proportion of different functional zones within the complex influences their development potential as it enables change of occupancy into various urban uses. Industrial complexes are especially favourable for urban renewal due to spatial organisation of big free-standing structures within the complex, and so there are many possibilities for changing the use of such complexes, starting from the usual and most frequent ones: museums, art studios, galleries, office and residential space, schools, and to various combined, multipurpose, multifunctional uses [16].

The second site-specific attribute that influences the renewal potential of industrial brownfields is the size of the complex. According to some authors, the size of the complex is of consequence on the period of realisation of renewal projects, as it is brought into relation with the ownership structure and financing method [17]. It is considered that smaller brownfield sites exhibit a greater renewal potential [17].

Industrial facilities and complexes represent a well-rounded landscape system with streets, proper vegetation, and open spaces, as important elements of its structure. Manufacturing facilities are most often one storey structures, and the height of the storey is considerable. Some of them are of exceptional historical, social, cultural, technological, and architectural value. Such an urban structure is the result of special requirements for the planning and design of industrial structures and complexes, and it can be regarded as an advantage during evaluation of development potential. In this respect, we have selected the third site-specific attribute that influences the renewal potential, i.e. the construction typology of industrial complexes.

The complex construction typology is related to the proportion of open spaces in the total area, which is the fourth site-specific attribute that has been selected. If we take into account that the availability of public open and green spaces belongs to the basic indicators of sustainable development of cities, it can

rightfully be said that a great proportion of open spaces is a significant attribute of industrial complexes. The most represented open spaces in industrial complexes are the streets, pedestrian zones, handling areas, parking spaces, park areas, and protective vegetation. The professional community has recognized a long time ago the potential of brownfield sites for the "greenification" of cities, through planning of new parks, playgrounds and other developed open spaces for public use [18]. Therefore, the existence of greater open spaces in industrial brownfield sites positively influences their development potential, as such sites can be converted into public pedestrian spaces, squares etc. with a very small investment.

The rating was selected as the fifth site-specific attribute because of significance of the physical condition and level of preservation of architectural manufacturing and non-manufacturing facilities, and architectural-ambient values of industrial complexes for the realization of renewal processes. The rating of facilities influences development potential of complexes because the funding needed for the renewal is related to the estimation of rating of facilities. Consequently, well preserved complexes have a greater development potential, as they can be renewed at lower cost.

The availability of infrastructure is the sixth significant site-specific attribute of industrial brownfield sites that is of significance for the renewal process. All industrial complexes usually have municipal and service facilities, water supply systems, evacuation of waste water and other waste, electricity and thermal energy connections, and telecommunication systems. Considering this well developed infrastructure the development potential of industrial sites is related to the condition of infrastructure. The condition of infrastructure facilities greatly influences the raising of funding needed for their renewal.

The level of contamination of a brownfield site and its wider surroundings is the result of its previous function and of the way in which the site was used, and it represents one of basic obstacles preventing successful renewal [19]. A manufacturing activity may result in contamination of land, air and water. Renewal projects often imply the use of decontamination measures, which greatly increases the costs of such projects. It often happens that, due to contamination, the repair costs exceed the market value of the land. Such an increase in funding often slows down the renewal process and extends the project realisation time.

However, the key barrier to investment in brownfield sites is the complex ownership structure [20]. A great number of owners makes it hard to harmonize various interests. On the other hand, some owners are not interested in the renewal, and very often they even do not wish to sell because they expect that the value of the land will be higher in the future. All this extends the renewal realisation time.

## 2.2. Location attributes

The so called *location attributes* or *external factors* [14] are highly significant for the successful renewal of industrial brownfields. Here, the most significant is the position of the brownfield site in urban environment. Many studies have shown that brownfield sites in city

centres have a much greater development potential compared to other sites [13, 14]. After analysis of brownfield sites that have been renewed in England, Longo and Campbell conclude that brownfields situated in developed areas have a greater development potential compared to sites situated in less developed areas [17].

The second significant location attribute, important for the development potential of industrial brownfield sites, is the accessibility (access to transport). Studies that consider the role of accessibility in the renewal process show that brownfield sites in the vicinity of airports, city centres and railway terminals exhibit a greater potential for renewal [21]. According to Novosak et al., brownfield sites near motorways can be great instigators of development of large brownfields that have a complex ownership structure [22].

## 3. Determination of spatial criteria in evaluation of industrial sites

The following spatial criteria for evaluation of industrial brownfield sites were determined based on the presented research dealing with spatial attributes of brownfield locations that influence the efficiency of the renewal process:

- site-specific attribute criteria,
- location attribute criteria.

A total of ten criteria were defined. Out of that number, the first eight (1-8) belong to the site-specific attribute criteria and the remaining two (9-10) to the location attribute criteria. They are described below in the mentioned order, always with explanation of their potential values.

**First criterion** – the way in which structures and zones are used within the complex.

According to their use, the structures and zones in industrial complexes can be [23]:

- manufacturing zone or workshop areas with technological work flows,
- warehouse zone, areas for storing materials, products, or fuel,
- power-supply zone, boiler rooms, power plants, heating plants, etc.,
- zone of accessory services, administration quarters, canteens, recreation zones, garages, health clinics, etc.,
- vegetative barriers facing transport routes.

Manufacturing zones, warehouse zones, power-supply zones, and accessory services zone, are not favourable for conversion into similar types of urban amenities. The growing trend of change of use has been noted worldwide already twenty years ago. Thus abandoned port warehouses, docks, factories, mills, bus/train stations or power plants have mostly been converted into galleries and art museums but also to hypermarkets, shopping centres, and hotels. This variety of possible uses has been made possible because of the flexibility of industrial, manufacturing, storage and workshop buildings, i.e. because of the use of specific reinforced-concrete or steel-glass structures with large open spaces such

structures are able to offer. On the other side, accessory structures situated in such complexes, such as administration quarters, canteens, recreation zones, garages, health clinics, etc. can be adapted, with modest technical interventions, into health care facilities, schools, preschool facilities, community centres, culture and science centres, sporting & recreation facilities, food and tourism establishments, municipal and other services. Power-supply zones do not usually change their initial uses, and require only appropriate modifications and improvements. This shows that abandoned complexes in post-industrial cities constitute ideal locations for the creation of urban areas with concentrated public-use services and facilities [24, 25], and that there are almost endless possibilities for the long-term development of post-industrial cities.

#### Second criterion – size of the complex.

The size of industrial complexes can be expressed as [22]:

- small (less than 5 ha),
- medium (5-10 ha),
- large (more than 10 ha).

Industrial brownfields belong to the group of medium and big sized brownfields and, less often, to the group of small brownfields. Less time is needed to realize small-sized brownfield renewal projects because it is assumed that the ownership structure is less complex, and that the renewal costs are lower. That is why smaller brownfields have a greater development potential compared to medium sized and big brownfields. With adequate plot plan changes, conditions can be created for gradual resolution of complex ownership structures, and for acquiring financing for the renewal of big-sized industrial complexes.

#### Third criterion – construction type of industrial complexes.

According to construction type, industrial complexes can be [23]:

- separate pavilion systems in which all buildings are realised as separate units,
- block systems in which all amenities/units are situated in a single common space,
- mixed systems which are in fact a combination of the previous two systems.

The attributes of the type of construction of industrial complexes are defined by the position and size of structural elements, i.e. by the number of storeys, horizontal dimensions, position of structures within the plot, relationship between neighbouring structures, relationship between structures and the street, position of open spaces compared to structures, street, etc. Separate pavilion and mixed systems, as related to block systems, most often have a greater development potential as they can adapt easier to a number of urban functions. On the other hand, such construction typologies enable staged realisation of complex renewal projects, which greatly facilitates the way in which the renewal is financed.

#### Fourth criterion – proportion of open spaces in the total area.

Although dependant on the position of the industrial site within

the city, an average value of proportion of open spaces in industrial brownfields can be expressed as:

- small: less than 50 % of the total area,
- medium: 50-70 % of the total area,
- large: more than 70 % of the total area.

The attributes of this criterion are influenced by the plot coverage ratio. The plot coverage ratio depends on the position of the industrial site within the urban environment, size of the complex, construction type, organisation of transport, space occupancy, environmental protection conditions, etc. [26]. The plot coverage, investigated on theoretical models of industrial plots in urban areas, amounts to no more than 0.5. In practice, one can find examples of industrial plots in urban areas where the plot coverage amounts to as much as 0.8, which would mean that the proportion of open spaces in relation to the total area is 20 % only. This space use form is most often due to gradual extension of industrial structures. In rural areas, the maximum plot coverage is 0.3 [26].

#### Fifth criterion – Rating of structures

The rating of structures can be expressed as follows:

- good: physical condition of structures does not require implementation of various renewal or remedial measures,
- fair: physical condition of structures requires partial implementation of various renewal or remedial measures,
- poor: physical condition of structures requires implementation of various renewal or remedial measures.

The rating of architectural structures is defined by the type, physical condition and level of preservation of the structural system, roof structure, roof cover, and façade system. The rating attributes are also influenced by the year of construction and renewal of structures, and by their property-rights status.

#### Sixth criterion – condition of infrastructure

The condition of infrastructure at industrial complexes can be expressed as follows:

- good: condition of infrastructure does not require implementation of various renewal or remedial measures,
- fair: condition of infrastructure requires partial implementation of various renewal or remedial measures,
- poor: condition of infrastructure requires implementation of various renewal or remedial measures.

The condition of infrastructure is affected by the level of preservation, maintenance method, year of construction, and repair of infrastructure facilities.

#### Seventh criterion – brownfield contamination level.

The level of contamination of former industrial complexes can be expressed as follows [19]:

- low,
- intermediate,
- high, and
- extremely high.

The attributes of this criterion are influenced by the presence of various contaminants. In practical terms, the level of contamination is determined by measurements conducted according to various criteria. In many cases, due to lack of funding, the contamination levels are simply assumed based on the analysis of previous function of the complex [27]. Depending on the type of contaminants, various industrial activities generate varied contamination hazards. Decontamination measures must be taken if it is estimated that the contamination risk is so high that it could be detrimental to the future use of the complex. Sites with high levels of contamination are not attractive to private investors, unless significant funding from the local or even national budget is provided to improve the situation. Nevertheless, some studies show that contamination is not a limiting factor for the renewal process if a brownfield site is situated in an attractive urban zone [13].

**Eighth criterion – ownership structure**

The ownership structure of former industrial complexes can be expressed as follows [22]:

- simple,
- complex,
- highly complex.

The complexity of ownership structure arises from the number of owners, their stake in the total area of the complex, and the possibilities for harmonising their interests. Industrial brownfields characterized by simple ownership structure have a greater renewal potential [13]. However, the issue of ownership of abandoned industrial complexes is quite unclear in the majority of cases. Some companies have been privatised and the city or the state has no competence over them, but there are legal successors to the companies. The owners of abandoned locations are often not interested for their renewal. In such cases, if the good will of the owner exists, the state or the municipality can purchase such buildings, renovate them and offer them to individuals or institutions, the objective being to stimulate local economic development. Municipalities are most often not capable to finance renewal projects from their own sources of funding [28]. In such cases, private-public partnerships are likely to provide an efficient financing model [29].

**Ninth criterion – position of brownfields in urban setting.**

The position of brownfields in urban environments can be expressed based on the categorisation provided by the research network called CABERNET (Concerted Action on Brownfield and Economic Regeneration Network) which, according to this criterion, differentiates three categories of brownfields [2]:

**Table 1. Spatial criteria for evaluating development potential of industrial brownfields and their value**

Spatial criteria		Criteria values
Site-specific attributes	use of structures and zones within the complex	manufacturing zone or workshop area; warehouse zone; power supply zone; accessory services zone; vegetative barrier [23]
	size of the complex	small- less than 5h; medium- 5-10 ha; large- in excess of 10 ha [22]
	construction typology	separate pavilion systems in which all buildings are realised as separate units block systems in which all amenities/units are situated in a single common space mixed systems which are in fact a combination of the previous two systems [23]
	proportion of open spaces in total area	small – less than 50% of the total area medium – 50-70% of the total area large – more than 70% of the total area
	rating of structures	good: physical condition of structures does not require implementation of various renewal or remedial measures fair: physical condition of structures requires partial implementation of various renewal or remedial measures poor: physical condition of structures requires implementation of various renewal or remedial measures
	condition of infrastructure	good: condition of infrastructure does not require implementation of various renewal or remedial measures fair: condition of infrastructure requires partial implementation of various renewal or remedial measures poor: condition of infrastructure requires implementation of various renewal or remedial measures
	level of contamination	low, intermediate, high, and extremely high [19]
	ownership structure	simple, complex, and highly complex [22]
Location attributes	position of brownfields in urban settings	in central urban zones (Category A) in the periphery of urban zones (Category B) in rural areas (Category C) [2]
	transport accessibility	very good: direct link to express roads (motorways, major roads), good: direct link to first category roads (regional roads, main roads), poor: direct link to the second and third category roads (local roads), very poor: other (lower category roads) [22]

- Category A: sites in central urban zones where the value of recycled land increases considerably after transformation, which makes them sufficiently attractive for private investors. Brownfields belonging to this category have the highest development potential.
- Category B: sites in peripheral areas of urban communities that are characterized by smaller value of land, which is why participation of public sector is indispensable for attracting potential investors.
- Category C: sites outside of the cities and in rural areas where the value of recycled soil is negative, which requires a significant financial backing of public sector, through direct subsidies and tax reliefs.

#### Tenth criterion – access to transport infrastructure.

Transport accessibility of industrial complexes can be expressed as follows [22]:

- very good: direct link to express roads (motorways, major roads),
- good: direct link to first category roads (regional roads, main roads),
- poor: direct link to the second and third category roads (local roads),
- very poor: other (lower category roads).

Attributes of the access-to-transport criterion are influenced by the significance and type of roads leading to the site. Brownfields with good transport accessibility have a greater development potential compared to brownfields with poor access. Consequently, in case of good connections with other cities, their development can be of regional significance.

The selected spatial criteria and their attributes – as shown in Table - can be used to create a general framework for evaluating development potential of industrial brownfields.

## 4. Selected examples of urban renewal of industrial complexes

The renewal of brownfield sites is a highly complex process, even for the economically developed countries. Many European cities, faced with brownfield problems in urban areas, implement innovative approaches for the renewal of these zones. Many

projects facilitating these approaches and contributing to the sustainable urban development have been developed in countries undergoing the transition process [4].

The heterogeneity of industrial brownfield sites does not allow establishment of a single renewal model. Although no universally applicable brownfield-renewal recommendations can be given, the experience of European countries can be useful for analysing the influence of various spatial attributes of abandoned sites on the renewal process. In current circumstances when the number of investments is still low compared to the need for boosting economic growth and social development, it would be advisable to use experience of other countries that have successfully converted industrial brownfield sites into cultural centres, educational institutions, or public spaces, thus increasing the quality of urban life. It is of special significance to analyse and present examples of good practice, i.e. successful brownfield renewal cases in various geographical contexts [13]. Cases of industrial brownfield renewal projects completed in the wider region, which have contributed to creation of a greater potential for the development of wider urban areas, are presented below, with a special emphasis on location and site-specific attributes that have influenced the renewal process.

### 4.1. Gasometer complex in Vienna, Austria

The Gasometer Complex, occupying an area of 22 ha, is located in the Vienna's eleventh district of Simmering, and it is the site previously used as a four-part gas storage area. When it was initially built, this gas storage facility was the biggest storage of this type in Europe and, in 1981, it was placed on the list of outstanding examples of industrial architecture. In the period from 1899 to 1984, these storage units were used for gas storage. With the introduction of modern gas storage technologies, involving storage under pressure, these storage capacities became too big for maintenance and use and so, in 1978, they were dismantled and abandoned. Only the brick walls and parts of the roof have been preserved and these remains have in modern times become an attraction, a cultural curiosity, and a distinctive characteristic of Vienna.

In 1995, Vienna authorities initiated renewal of the abandoned industrial complex in order to create a new residential area. Four



Figure 1. Conversion of gas storage facilities into a multifunctional space in Vienna

renowned architects were engaged for this purpose: Jean Nouvel for the gas storage unit A, Coop Himmelblau for the gas storage unit B, Manfred Wehdorn for the gas storage unit C, and Wilhelm Holzbauer for the gas storage unit D. Himmelblau proposed construction of a single new facility for the entire complex. Storage units were renovated and converted into several residential zones – apartments on higher storeys, offices on intermediate storeys, and various cultural and amusement amenities and shopping centres at lower storeys. In addition to apartments, these spaces now accommodate a concert hall for 2000-3000 spectators, a theatre, student dormitory, municipal archives, and various other amenities. The entire Gasometer renewal and regeneration process was completed in 2001. Such a great number of new amenities has also provided a significant number of new workplaces. As a result of this urban renewal effort, the quality of space in this formerly industrial zone was brought to a higher level, hence positively influencing the living standard of local residents.

Many spatial attributes of this extensive industrial complex influenced the planning and implementation of the renewal process. Prior to renewal, this complex belonged to the brownfield category B, as it is situated in the peripheral eleventh district of Vienna, which is why it was indispensable to seek participation of public sector to attract potential investors. However, the properly solved ownership issue and the possibility of securing financing through a private-public partnership, contributed significantly to the success of this renewal project. A good transport accessibility of the site, and appropriate links with the centre of the city, were enabled through appropriate public transport lines. In this respect, prior to complex renewal, a north-eastern part of the motorway was built, and one metro line was extended. A characteristic typology involving structures of an outstanding industrial architecture represented a good potential for the renewal of these facilities and for creation of a new landmark in this city.

#### 4.2. Am Borsigturm in Berlin, Germany

The industrial complex Am Borsigturm, spreading over 15 ha in area, is situated in the north-eastern part of the city of Berlin,

and it is the oldest industrial zone in Germany. The first industry of locomotives in this area was initiated as early as in 1837 and it soon became the main instigator of economic development of the region. The continuous development lasted until 1930 when the production of locomotives was stopped for economic reasons. The similar destiny awaited other industries and companies at the same location, which moved to less expensive countries or simply went bankrupt. As a result of this situation, many areas and buildings remained unused and abandoned.

In the early 1920s, very rapid structural changes were initiated in this area, and the industry had to adjust to new market conditions. Big companies became increasingly interested in these locations, as they expected development of the market and the start of a lucrative business. In 1992, the industrial complex was bought by the company involved in production of office furniture and equipment. This purchase marked the start of regeneration of the entire complex.

According to the development strategy of the city of Berlin, the first renewal concept, based on the mixed functions principle, was proposed in 1993. The project was financed according to the private-public partnership model. The basic idea was to keep industry in the city, and to improve living conditions. Thus the heavy industry was replaced with the light environment-friendly industry, service occupations, and with residential buildings and recreation areas. The basic motive behind this renewal was to create a new centre of economic development in the north-western part of Berlin. Existing structures were in a very poor conditions, and some of them were classified as a part of the historical and cultural heritage, and so the intention was to preserve most of them. Eighty percent of the planned renewal work was completed by 2003. Respecting the mixed functions principle in the course of this renewal, the complex Am Borsigturm was reintegrated into the urban tissue, thus completely meeting the needs of the city's population.

Although contaminated, the site of the former industrial complex did have a significant development potential. Location and site-specific attributes that mostly influenced the development potential of this complex are: position of complex within the city of Berlin, transport accessibility, and solved ownership issues.



Figure 2. Industrial complex Am Borsigturm in Berlin after renovation





Figure 3. Lisbon based industrial brownfield transforms into the Park of Nations

Prior to the renewal this complex belonged to the brownfield category B, and so the participation of the private sector had to be partly backed by public sector. Good transport accessibility of the site is enabled by direct links to motorway, railway and metro lines.

#### 4.3. Park of Nations (Parque das Nações) in Lisbon, Portugal

The Park of Nations, occupying an area of 330 ha, is situated in the eastern part of the city of Lisbon. Before renewal, this used to be a completely inaccessible oil refinery site with tens of tanks and extensive areas destined for various petrochemical activities. The site also accommodated a slaughterhouse, explosive depots, and ship repair facilities. Environmental protection measures were not respected during construction of the industrial complex, and so the land was contaminated. Considering its industrial occupancy, the site was used only by workers employed in this complex.

The first phase of renewal of this complex was initiated in 1992 and the project was completed in 1998 by construction of the park for the world Expo exhibit, while the second phases started in 2009 and is still in progress. The intention of the city of Lisbon was to create an exposition park with mixed-use spaces, destined for visitors from all over the world. The public Expo company purchased privately owned areas as needed for the construction of the park. In the initial phase of the renewal process, the existing structures – which were in a very poor condition – were demolished and their material remains were recycled, the land was decontaminated and appropriate environmental protection measures were taken. The city engaged several internationally famous architects to work on the renewal of this complex, which was divided, according to the master plan, into six sections. In the period from 1994 and 1998 numerous structures greatly varying in occupancy were built: residential and office buildings, sporting and cultural facilities, and spaces destined to free-time and leisure activities. The design resulted in creation of a multifunctional urban environment of mixed use, with as many as 110 ha of green spaces. Five km long riverfront was also built, and it has

become a favoured area for prospective residents, investors and visitors. A special pedestrian communications design was made, and an emphasis was placed on the use of public transport. A new infrastructure, appropriately backed by modern technologies, was created. The renewal project also focused on establishment of a new link between the city and the river, on the modernisation of the complex, but also on the preservation of its existing characteristics. The renewal resulted in a completely new urban community that has completely changed the Lisbon image. The selection of the renewal location, i.e. its positioning in the eastern part of Lisbon, which had by that time been only partly developed, was conditioned by the need for extensive areas. Considering the size of the complex, a considerable proportion of private capital was needed for this renewal. The realisation of the project enabled integration of this location into the city space, as well as a considerable influx of capital from various investors. Many big companies chose to move their headquarters to this attractive location. Timely solution of property right issues speeded up realization of this complex renewal and construction project.

In the light of the previously described renewal of industrial brownfield locations in Vienna, Berlin and Lisbon, it can rightfully be said that spatial attributes of such complexes play a significant role in the process of their renewal. The following attributes have mostly influenced the planning and implementation of renewal projects: favourable location within the urban community, good transport accessibility, and solved ownership issues, all this combined with the use of appropriate financing models.

#### 5. Verification of criteria on the example of a former industrial complex Rudi Čajavec in Banja Luka

The site formerly occupied by the Rudi Čajavec factory in Banja Luka was selected for the purposes of this paper as a test site for verification of the previously selected criteria. Rudi Čajavec is an ex-manufacturer of military electronic equipment and devices, and it started operating in 1950. This factory later on started to expand its activities to general-purpose electronic devices such as guitar amplifiers, TV sets, and PA systems. The factory was finally closed

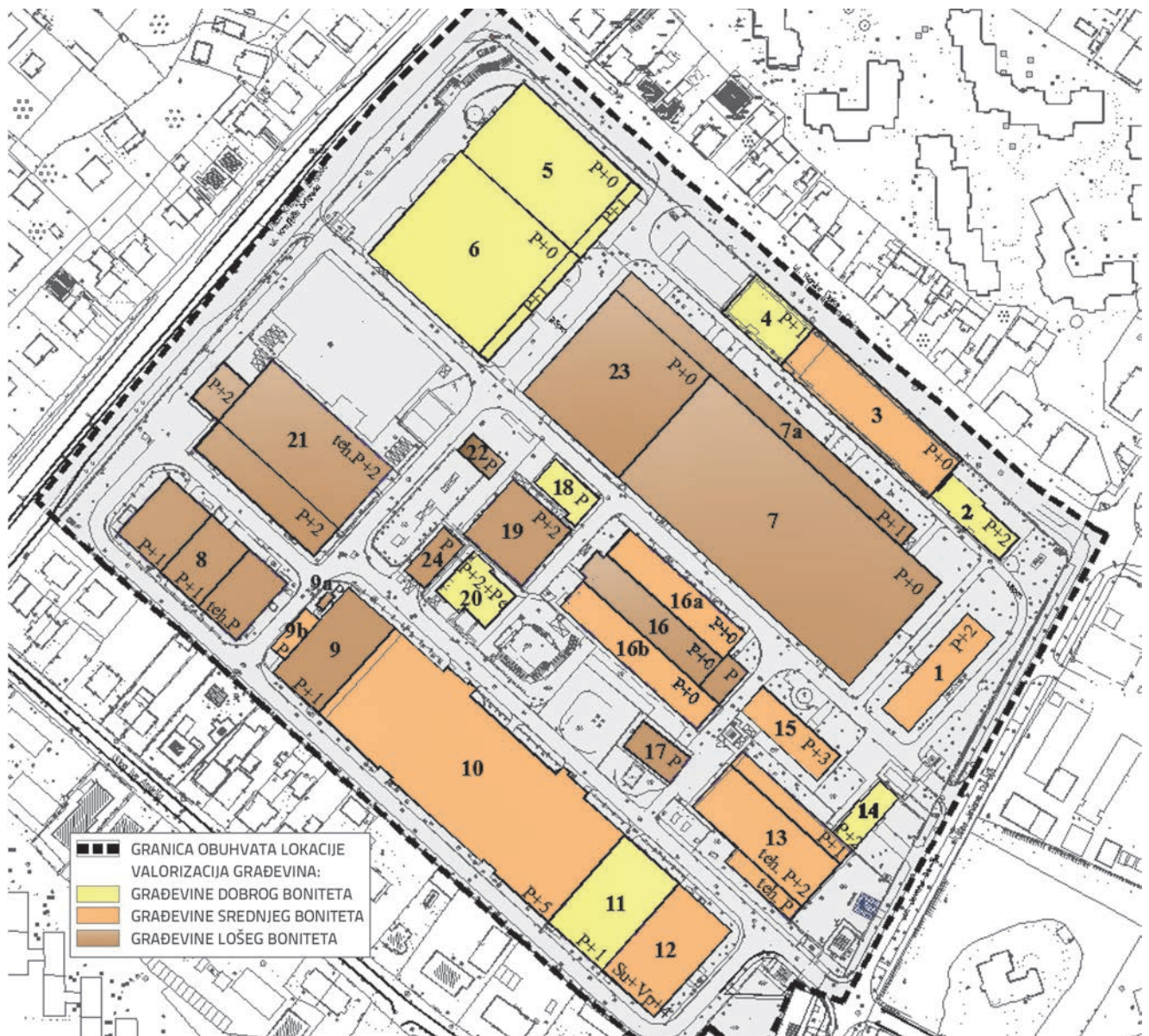


Figure 4. Spatial organisation of Rudi Čajavec complex – current condition

down due to changes in economic structure in the post-war period. Since that time, Rudi Čajavec went through several development stages, and each of them was followed by ownership change and, accordingly, by renovation of some of its structures.

### 5.1. Analysis of Rudi Čajavec industrial complex based on predefined spatial criteria

The aim of the Rudi Čajavec spatial analysis was not only to verify acceptability of predefined criteria, but also to determine possible development potential of this complex. To this end, a detailed analysis of the existing built and unbuilt parts was made based on the predefined criteria. Some results of this analysis are presented in this text.

#### *Use of structures and zones within the complex*

The former industrial complex is composed of the manufacturing and workshop areas, warehouses, power supply zones, accessory zones, and a smaller area with high-standing vegetation.

Most manufacturing structures are currently unused, while some facilities in the accessory structures have been repaired. The current use of these facilities is business related, mostly involving service providing activities. The initial and present-day function of structures is presented in Table 2.

#### *Size of the complex*

The total area occupied by the complex is 9,29 ha, and so it can be classified as a medium-sized brownfield site.

Table 2. Former and present use of structures

Structure No.	Number of storeys	Use of structures	
		Former	Current
1	P+2	business - (administration building "FELMA")	business - office space with appropriate amenities (education)
2	P+2	business - (former "RAS")	business - office space with appropriate amenities (education)
3	P+0	business – food service establishment	business – food service establishment and commercial outlet
4	P+1	business – administration	business- cultural and sporting amenities
5	P+0, P+1	manufacturing – galvanising plant	business- commercial outlet
6	P, P+1	manufacturing – galvanising plant	business- commercial outlet
7 i 7a	P+0, P+1	manufacturing – FELME hall	not in use
8	P, P+1	manufacturing- "precision cast" in the scope of the Čajavec plant	not in use
9	P+1	manufacturing	not in use
9a	P	technical block	not in use
9b	P	accessory structure	warehouse
10	P+5	business – offices in a part of the "Main Building"	business- administration (structure partly in use)
11	P+1	business – administration	business- services
12	Su+P+4	business – administration	business- administration, services, education
13	P, P+1, P+2	manufacturing -"Tool room" in the scope of the Čajavec plant	business - manufacturing (structure partly in use)
14	P+2	business – administration building	business- administration and commercial activity
15	P+3	business – administration building	business- services, commercial activity
16	P+0, P	manufacturing- "nterim hall" with an accessory factory building	business- services, commercial activity
16a	P+0	manufacturing- power plant – tool room	business- services, commercial activity
16b	P+0	business – manufacturing	business – manufacturing
17	P	technical block – services	warehouse
18	P	warehouse and transformer station	warehouse and transformer station
19	P	manufacturing– casting hall	not in use
20	P+2+Pe	manufacturing	business- services
21	P+2	manufacturing	not in use
22	P	gas station next to casting hall	not in use
23	P	shed located between the FELME hall and galvanisation	not in use
24	P	manufacturing	business- services

#### Construction typology

The industrial complex is of mixed composition, i.e. it is a combination of a separate pavilion system and block system. Manufacturing halls, in the sense of their vertical dimensions, are single storey structures, while the non-manufacturing structures are maximum 5 storeys in height (ground storey + 5). The number of storeys of individual structures is presented in Table 2, while their organisation in plan is shown in Figure 4.

#### Proportion of open spaces in the total area of the complex

The proportion of open spaces can be classified as average. Open spaces account for 5.05 ha, which is 54 % of the total area of the complex. Open spaces in the complex are composed of streets, pedestrian zones, handling areas, parking spaces, and vegetative barriers. The proportion of open spaces can be visualised through spatial organisation of the complex shown in Figure 4.

*Rating of structures*

The complex is in poor state of repair. The structures were built in 1950s, 1960s and 1970s. Some of the structures, i.e. the privately owned ones, have been renovated and repaired, while the remaining ones are in a very poor condition. The valorisation of the existing building stock is shown in Figure 4.

*Condition of infrastructure*

The condition of infrastructure can be classified as average. The complex is equipped with the utility and service facilities, water supply, drainage of waste water and other waste, electric power and thermal energy supply, and telecommunications system.

*Level of contamination*

It is assumed that the complex has a low level of contamination. A detailed analysis of the contamination of land, water and air has not been made for this locality, nor has the study of influence of the locality on the surrounding residential community been conducted. The assumption is based on the analysis of former use of structures and the complex, and possible contaminants.

*Ownership structure*

The ownership structure of the complex is complicated. Some companies were privatized, structures were sold to various owners or are under lease, while other companies went bankrupt.

*Position of brownfield in urban settings*

According to administrative division of the town of Banja Luka, the complex is located in the town's first zone. The locality is situated to the central urban area of Banja Luka. According to brownfield classification presented by CABERNET group [2], the complex belongs to category A.

*Transport accessibility*

The transport accessibility is very good. A major road follows the north-western border of the complex, while the main street runs along the north-eastern periphery of the site. This proper accessibility has been enabled due to existence of an appropriate public transport and pedestrian traffic network.

**5.2. Conclusion of the analysis**

The analysis of the existing condition of the Rudi Čajavec industrial complex, in the light of the selected spatial criteria, has enabled determination of attributes for each criterion used in the analysis. Considering the presented values of site-specific and location attributes, it can reasonably be stated that the complex of the former Rudi Čajavec factory has a good development potential, and that it constitutes a significant urban resource of Banja Luka. However, in order to enable rational use of this resource, it is indispensable to conduct remedial measures for some of the architectural and infrastructure facilities, and to solve ownership issues.

The potential for the use of this highly valuable urban locality in the process of local economic development has not as yet

been fully recognised. The preparation of regulation plan for this complex, calling for construction of a business zone, was initiated in 2008 but the plan has not been adopted to this date, which is slowing down the renewal process considerably. In this context, it can be stated that the renewal of the Rudi Čajavec industrial complex has already been initiated, but the process is conducted partially and in an unplanned manner.

**6. Conclusion**

Dilapidated and unused industrial sites, known in literature as industrial brownfield sites, constitute a significant urban resource for the present-day cities confronted with an increasing need to improve the quality of urban living. The renewal of such sites is an important mechanism for achieving sustainable development.

One of the most significant obstacles hindering such renewal is the lack of adequate spatial data about brownfield sites, and the lack of objectivity in the analysis of their development potential. As foundations for planning activities, an adequate spatial analysis of brownfields, and the determination of possibilities for their integration in the urban tissue from the functional, morphological and sociological aspects, are of crucial significance for the conduct of a sustainable renewal process. Therefore, to make strategic decisions on the development of brownfield sites, it is indispensable to determine spatial criteria for the analysis of such sites. The objective of this paper was to establish uniform spatial criteria that can systematically be used in the analysis of all industrial brownfield sites, which would ensure compatibility and objectivity in the evaluation of their condition and development potential. Based on theoretical and practical research on the influence of spatial attributes of industrial brownfields on the efficiency of renewal processes, the site-specific attribute criteria and location attribute criteria have been selected as relevant spatial criteria. The significance and role of spatial attributes in the renewal process have been confirmed in the good practice examples from Vienna, Berlin, and Lisbon.

The space occupied by the former industrial complex Rudi Čajavec, situated in Banja Luka, was selected as the test site for verification of the selected criteria, namely in the sense of checking their applicability in the analysis, and determination of development potential of industrial brownfields. The analysis of the current condition of the complex in the light of site-specific attribute criteria and location attribute criteria has enabled the evaluation of criteria and development potential of the former industrial complex, and hence the validity of the criteria was confirmed. However, the criteria determined are general in character and they should be used only as a basis for determination of development potential of industrial brownfields, while a more detailed analysis would also involve other spatial criteria such as: position of structures within the plot, dimensions and sizes of structures situated within the complex, etc. This study can further be oriented toward creation of the methodology for evaluating development potential of industrial sites, and toward strategic decision-making with regard to their development.

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