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Brownfield regeneration – imperative for sustainable urban development

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Subject review

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Brownfield regeneration – imperative for sustainable urban development

The possibility of revitalization of abandoned or insufficiently used industrial and commercial facilities and areas in towns, known as brownfield incentives, is analyzed in the paper. These facilities and areas are most often situated in central parts of towns, and their revitalisation results in creation of new facilities which often become symbols or landmarks of such towns. The meaning of brownfield regeneration is considered on the basis of American and European experiences in the context of sustainable development of towns and cities.

Key words:

brownfield, regeneration, urban area, sustainable urban development

Pregledni rad

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Brownfield regeneracija - imperativ za održivi urbani razvoj

U radu se analizira mogućnost revitalizacije napuštenih ili nedovoljno iskorištenih industrijskih i komercijalnih građevina i površina u gradovima poznatih pod nazivom braunfeld (engl. brownfield). Navedene građevine i površine najčešće se nalaze u središnjim jezgrama gradova, a njihovom revitalizacijom dobivaju se novi sadržaji i vrlo često novi simboli gradova. Značenje braunfeld regeneracije razmatrano je na osnovi američkih i europskih iskustava u kontekstu održivog razvoja gradova.

Ključne riječi:

braunfeld, regeneracija, urbana sredina, održivi urbani razvoj

Übersichtsarbeit

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Brownfield Regeneration – Imperativ für eine nachhaltige urbane Entwicklung

In der Arbeit wird die Möglichkeit der Revitalisierung von verlassenen oder ungenügend ausgenützten Industrie- und Geschäftsbauten sowie Stadtflächen, bekannter unter dem Namen "Brownfield", analysiert. Die angeführten Bauten und Flächen befinden sich am häufigsten in zentralen Stadtkernen. Durch ihre Revitalisierung erhalten sie einen neuen Inhalt und entwickeln sich sehr häufig zu neuen Symbolen der Stadt. Die Bedeutung der Brownfield Regeneration wird auf Grund amerikanischer und europäischer Erfahrungen im Kontext der nachhaltigen Entwicklung von Städten erläutert.

Schlüsselwörter:

Brownfield, Regeneration, urbane Mitte, nachhaltige urbane Entwicklung

1. Introduction

Statistics indicate that the number of world population in cities is intensively increasing. Up to the 19th century, only 2.5% of the world population lived in urbanized areas [1]. Today, that number has increased to 50% [2]. Everything indicates that the third millennium has opted the city for mankind's living space. Although global processes encourage development of new techniques and possibilities, and bring new forms of virtual reality and wireless connections, the city still remains a key site of the civilization's existence, but also the arena of important architectural achievements. We bear full responsibility for the way in which we will deal with this increasingly dynamic and restricted living space, and for the course we will be taking in our future activities.

Increasingly frequent city image interruptions, caused by a variety of influences and social processes, show that urgent interventions are needed if we are to ensure sustainable development of our cities. In this context, compact urban forms take precedence over the policy of expanding the urban area. Pronounced practices of occupying peripheral free areas in the development of cities, lead to larger discontinuity in spatial structures, and to the dominance of aggressiveness and visual interruptions that affect human health and identity values. In addition, urban areas are increasingly faced with the lack of buildable land. Therefore, the orientation towards the existing, under-exploited surfaces (buildings and their free space), is an imperative for improving environment, and for sustainable urban development.

Most cities in the world are faced with the issue of having a significant number of unused surfaces, which often occupy attractive land but are largely environmentally unfriendly, and often characterized by high degree of contamination. However, as the rapid growth of cities has limited the quantity and size of buildable areas, the so called "greenfield" areas, municipal authorities are increasingly opting for regeneration of brownfield sites, and are creating a variety of programs and strategies for their restoration. It is only in the late 20th and the early 21st centuries that the issue of brownfield areas has gained a more prominent place in national policies, especially in those countries that are increasingly faced with the building space availability problem. Recent orientation toward new buildable areas has also contributed to the increase of brownfield projects in many cities all over the world.

Areas that have been known as unified and uniform spatial components during the industrial era now have the opportunity to become, through their upgrade, new carriers of urban identity, key landmarks, areas where social processes are taking place, and visually dominant sites. The sustainability of cities is possible if it implies healthy surroundings, respects the diversity of needs, integrates all elements of systems, establishes harmony, and allows for interaction across all levels. Healthy and sustainable urban environment, and efficient use of buildable land, can be

achieved if development policies are continuously improved, if cultural innovations are adopted, and if architectural and urban intervention models are advanced and improved, all this with due regard to environmental considerations.

Although technical, technological, scientific and other advancements of civilization facilitate urban development, they are less prone to understand some objective and more humane requirements related to the life and activity of city dwellers. Diversity, new forms of communication, city as an organism, these are all characteristics of a sustainable city. Lack of construction space often leads to the loss of identity of previously recognizable city units, which are transformed into inadequate structures adapted to specific interests and needs. Brownfield developments hold a central place in architectural and urban planning incentives as they imply rehabilitation of brownfield sites and their conversion into new and healthy urban environments. These are multilayered processes involving participation of different stakeholders that combine their efforts in order to develop new and highly sustainable urban systems.

2. Brownfield: definition, types and development process

Although the term brownfield is nowadays widely used, it does not have a single widely recognized definition. Its meaning varies and is mostly formulated at the level of individual countries. However, this is a relatively new concept, and its dominant use over the past two decades in the US and Europe, has still not resulted in the definition of a precise meaning.

The term *brownfield* was used for the first time in the United States, in 1992 [3]. The most commonly cited brownfield definition comes from the Environmental Protection Agency (U.S. EPA) 1997: "Brownfields are abandoned, idled, or under-utilized industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination" [4]. This definition was complemented and partly modified in 2002 [5]. In some countries, other terms are used for *brownfield*. From a practical point of view, several brownfield classifications have been developed (Rafson, 1999, Everett, 2002) [6]. In the European context, there are many definitions and interpretations [7], [8], and the most widespread definition is the one proposed by the work group called CLARINET (Contaminated Land Rehabilitation Network for Environmental Technologies): "brownfields are sites that have been affected by the former uses of the site and surrounding land, are derelict and underused, may have real or perceived contamination problems, are mainly developed in urban areas, and require intervention to bring them back to beneficial use" [9]. This definition was complemented by the European Expert Network CABERNET (Concerted Action on Brownfield and Economic Regeneration Network) according to which this term implies surfaces that:

- Have been affected by former uses of the site or surrounding land
- Are derelict or underused
- Are mainly fully or partly developed urban areas
- Require intervention to bring them back to beneficial use and
- May have real or perceived contamination problems [10]

Brownfields may vary from very small spots in mixed urban areas to large military complexes, industrial sites, public spaces, airports, and coastal areas. Although industrial complexes are dominant, areas destined for other occupancies, in which the primary activity is no longer operated, can also be regarded as brownfield sites. A good example is a military site where, due to transformation of military contents and reduced need for military activities, many facilities are no longer used. The identification of existing and potential brownfield sites, and their classification, are important for their proper treatment. There are several types, and they can be classified according to appropriate criteria. Three typical brownfield types can be differentiated according to their position within an urban community:

- In the central area
- On the city's periphery
- In historic areas

According to their purposes, typical brownfields are:

- Industrial zones
- Military complexes
- Mining installations
- Railway complexes
- Coastal areas
- Municipal public service facilities

In general terms, according to the U.S. EPA Types of Brownfields Sites, potential environmental pollutants include [11]:

a) Oil and petroleum facilities

- Natural gas manufacturing (byproducts and waste products can enter groundwater and surface waters...)
- Gas stations (possible contamination of soil and groundwater due to spills or leaks...)
- Oil production, distribution and recycling (contamination of soil due to: drilling, processing, storage, transport and recycling of oil; soil can be polluted with a number of substances used in oil refining)

b) Manufacturing

- Chemical and dye manufacturing (possible contamination by chemicals...)
- Ordnance sites (possible water and soil pollution by waste products, toxic gases, liquids, metals)
- Cement plants, electronics manufacturing, iron and steel manufacturing, machine tool industries, pesticides facilities, plastics facilities, pulp and paper mills, and textile mills.

c) Recycling

- Automobile salvage and metal recycling (possible soil contamination by recycling heavy metals, asbestos, PCB oils, hydraulic fluids, lubricating oils, fuels, solvents)
- Tank/drum recycling (Many different chemicals are stored in drums, including acids, bases, corrosive liquids, reactive chemicals, flammable compounds, and oils)

d) Treatment and repair facilities

- Metal plating and finishing (process vats can spill, leak, or overflow, contaminating soils and groundwater with heavy metals, solvents, and cyanide).
- Paint shops and automobile body repair (paint shops and auto body repair shops can produce contaminants such as toluene, acetone, perchlorethylene, xylene, gasoline, diesel fuel, carbon tetrachloride, and hydrochloric and phosphoric acids)
- Wood preserver facilities (chemicals for wood treatment and disinfection may contaminate soil and water surfaces)

e) Miscellaneous

- Agri-business (fertilizers, pesticides, and herbicides can reach the soil, groundwater and surface waters)
- Asbestos piles (asbestos can cause health problems such as cancer when inhaled)
- Landfills and dumps (older and newer landfills can have oils, paints, solvents, corrosive cleaners, batteries, and gardening products. These substances can contaminate soils and groundwater, especially when the landfills are poorly built)
- Rail Yards (include networks of railway tracks, storage areas, fueling stations, and maintenance sites. Diesel fuel, paint, solvents, degreasing agents, PCB oils, and creosote are used at rail yards and can leak or be spilled or dumped, polluting soils and groundwater)
- meat packaging plants, mining sites and wastes, power generating facilities and utilities, quarries, print shops, and radiation mining, refining, and research sites.

In addition to contamination, brownfields also degrade the environment in the visual, aesthetic, sociological, economic, psychological and other terms, and their neglect often leads to human health hazards, which is especially due to neglect and poor state of repair of such facilities. Industrial revolution has caused intensification of urbanization processes. The growth of cities due to development of industrial centres is dominant in more developed areas, and is more often concentrated in peripheral zones of cities. The orientation to industrial production has caused demographic changes and intensive development of industrial complexes in cities, construction of sterile workers' districts with poor sanitation facilities, and erection of assembly plants, but also the construction of new urban landmarks of public and cultural character. The evolution of economy and technological capabilities has

spurred economic development of the society. Cities have become economic, political, and administrative centres. An intensive technological development has caused a general decline in the socio-economic and cultural spheres of the society. Many cities have been unable to keep up with the rapid population growth.

The fall in industrial production has caused liquidation of certain enterprises, degradation of industrial facilities, and new forms of organization in industrial production. Innovations in transport, construction and manufacturing, negative impact on the environment, global climate change, the abolition of industrial zones from the structure of cities, etc., have resulted in the process of brownfield formation, and have also imposed the need for radical transformation of physical urban structures.

3. Brownfield regeneration and its role in sustainable development of cities

According to (ODPM, 2003) [12], the main criteria for determining a sustainable or unsustainable community are:

- Economic Growth
- Citizenship
- Governance
- Community Characteristics
- Urban Design
- Environmental Dimensions
- Quality of Life
- Identity, Belonging and Safety

Sustainable community, among other, implies blossoming of the economic base, a balanced community, diverse architecture (availability of public space, a wide range of amenities, buildings that meet diverse needs), attractive surroundings, and a high quality of life. [12]

The primary goal of urban regeneration is to respond to the complex dynamics of contemporary urban life, and to revitalization of economic, environmental and cultural functions. The social cohesion and diversity hold a primary role in the process. The process begins with the analysis of urban problems. The urban regeneration process may be spurred by various factors:

- Social stimulants may be positive or negative in the context of altering the needs and lifestyles or solving social problems (natural disasters, poverty)
- Environmental causes also provide an incentive for urban regeneration and are generally of negative nature: environmental degradation, environmental risks, and others
- Political reasons may initiate urban regeneration through changes in government or legal regimes, or adoption of new planning instruments.
- The urban regeneration is sometimes delayed or limited due to the following factors [13]:

- Lack of interaction between stakeholders, decision makers, users and designers
- Financial constraints
- Inadequate criteria and development policies
- Discrepancy between sustainable development goals and actual needs
- Insufficient cooperation between public and private partners
- Inadequate role of users in the decision making process

Urban regeneration is quite present in national urban policies. The process depends on the level of development of a country. In highly developed countries, the primary objective is to promote the "return to the city" and improvement of living environment. The need for urban regeneration can occur for many reasons. These reasons are [13]:

- Economic: limited private investments, unemployment, decline of urban economies, economic mono-culture, declining entrepreneurship, etc.;
- Social: declining and aging population, poverty, deteriorating services and infrastructure, etc.;
- Spatial: high-density residential areas, illegal residential development, etc.;
- Environmental: loss of open spaces, air pollution, increased noise levels, degradation of urban landscape, destruction of cultural sites and monuments etc.;
- Institutional: complex and outdated urban management framework, poor implementation, overlapping responsibilities.

The "Urban Regeneration: A Handbook" [14] is a significant publication containing a comprehensive analysis of urban regeneration, and an overview of major theoretical and practical issues.

Brownfield regeneration is a key aspect of urban regeneration. In degraded urban areas, the goal is to develop a physical environment that will attract new residents and improve quality of living, which is why it is especially important to establish a clear connection between economic development and physical regeneration. "Sustainable brownfield regeneration is the management, rehabilitation and return to beneficial use of brownfield base of land resources in such a way to ensure the implementation and continuity of satisfying peoples' needs for present and future generations in a non-degrading, environmentally friendly, economically viable, institutionally robust and socially acceptable manner" [15].

The sustainable brownfield regeneration combines three pillars of sustainable urban development [16]:

- Economic - generating development and employment
- Ecological - environmental improvement
- Social - a new life in urban environments, offering new opportunities for the community

The sustainable brownfield regeneration transforms devastated surfaces and landscapes into new attractive, inclusive, and multifunctional environments, enhancing the character of the place and respecting the specificity of local community. The devastated industrial heritage has been recognized as having great potential for development of new places for generation of social processes, and for erection of attractive physical structures of high ecological, cultural and visual value. Objectives of brownfield regeneration are to develop new opportunities, fostering economic growth, community strengthening, environmental improvement, cultural prosperity, promotion of new values at the local community level, etc.

Brownfield regeneration involves definition of sustainability goals, sustainability indicators for the management of contamination and re-use of land, management of existing projects and infrastructure, urban design, planning and methods for citizen participation, as well as proper management of brownfield projects. [15]

The promotion of public-private partnership is essential for strengthening urban efficiency and brownfield regeneration programs, as such partnership encourages communication and builds trust and cooperation between relevant stakeholders [17, 18].

The effectiveness of brownfield regeneration is mostly dependent on the overall vision, which includes a variety of disciplines, then on the promotion of public-private partnerships, and also on adequate control mechanisms [19, 20].

An increasing number of successful brownfield interventions/projects has revealed numerous advantages of brownfield regeneration incentives [21]:

- Protection of public health and living environment: cleanup of contaminated areas that would otherwise continue to threaten our living environment
- Location benefits: brownfields are often placed on strategic locations near the coast, central city zones, railways and transport routes
- Infrastructure advantages: locations have an already developed infrastructure network
- Economic / tax base development
- Profitable investments
- Job creation
- Prevention of uncontrolled growth of urban/industrial zones

3.1. Architectural and urban planning and design of brownfield projects

The planning and design of space in the context of brownfield regeneration plays a key role in the sustainable development of cities. The objectives of sustainable urbanism (town planning) are: to create a space characterized by care for human values and a city able to recognize needs of its users, to recover and

rehabilitate the existing city structure, to increase quality of urban living, and to promote new authentic and recognizable functional and identity-related values of the city.

An intensive urbanization in many parts of the world, combined with other global issues such as production, environmental pollution, energy, lack of resources, has influenced the shaping of physical structure of cities, which are increasingly characterized by unification tendencies and lowering of values. It is interesting to mention several statements related to design: a) It is time to stop designing in the image of the machine and start designing in a way that honours the complexity of life itself" (S. Cowan [22]) and b) "art of relationship that aims to take all the elements that go to create the built environment: buildings, trees, nature, water, traffic, advertisements, and so on, and to weave them in such a way that drama is released," (G. Cullen) [23]. The city space requires fulfilment of living conditions, which are complex, but at the same time existential. Various elements of the spatial system should act in concert to develop a city properly adapted to its users. By establishing balance and harmony between elements of a whole, we can achieve compactness of a city, which is essential for sustainable development [24]. Under the city's physical structure we imply "a complex set of built elements, spaces and settings, units and components that, connected in an integrated urban system, create an environment and surrounding for implementation of complex processes of urban life" [25]. City implies the harmony and unity of all elements in space, and interaction of all functions operated in space: work, housing, and leisure. The concept of integrality implies decentralization, development of a polycentric and multi-functional city, centre-periphery connection, harmony and coherence between natural and developed, existing and new, internal and external space, vertical and horizontal regulation, and technical and technological systems. The integral concept involves interaction in the sense of forming important centres as places where various functions overlap. In this spirit, a movement based on interaction and humanity, the so called New Urbanism [26], was established in America, while the New Athens Charter, which promotes dialogue and connection [27], was created on the European level.

The "transdisciplinary research" has become a term known as a research model for initiating processes aimed at solving real world problems [28]. The transdisciplinarity is directed from the central to sustainable development, and it implies a balanced approach to action taking, as an indispensable tool for proper understanding of urban space. Interventions through urban plans and projects imply synergy of scientific knowledge, professional knowledge and knowledge held by all members of the society, in public and private sectors alike. Some studies describe typological methods of spatial planning for sustainable development with an emphasis on transdisciplinary planning. These include: theoretical

orientation, resources, interdisciplinary and transdisciplinary orientation, strategic orientation, and spatial concept [29]. The urban expansion and global processes point to the importance of selecting an appropriate method for the analysis, research and specific intervention in urban space. The choice of methodology for examining and understanding the city, and for selecting directions of its development, opens a path towards a sustainable urban system. Due to specificity of each space and local community, it is advisable to develop a specific approach for solving every individual problem and challenge. Brownfield facilities are often equipped with infrastructure, and with solid and stable structural systems, and can be transformed into highly modern architectural structures and buildings with various occupancies and visual values. Often positioned in central cores of cities, they may give new impulses to urban areas and develop new forms of connections.

The reconstruction, revitalization, transformation, renewal and improvement of existing public spaces and physical structures require a well thought-out engagement in all phases. It is of viable importance to raise awareness about sustainable development to a higher level, encourage more ideas and practical methods, and develop research approaches and experimental studies of spatial and physical aspects of the developed environment and urban development.

The growing need for "sustainable" and "green" construction in the 21st century setting has resulted in adoption of a number of legal provisions and models that are meant to encourage and promote sustainable development of cities. For example, international standards for "green building" were formed in the late 20th century, when USGBC (U.S. Green Building Council) and LEED certificates were awarded to buildings which were designed and constructed using technologies and materials that ensure: saving energy and water, improvement of air quality, resource management, and reduction in CO₂ emissions. Some of the cities with a high percentage of "green building" are: Vancouver, Newcastle, Bristol, London, etc.

3.2. Brownfield zones in historic context

The architectural heritage and historical context are a particularly sensitive issue in terms of brownfield regeneration. Brownfield sites are sometimes a part of historical heritage and are protected as cultural-historical monuments but, due to lowering of their structural/architectural qualities, they are increasingly viewed as threatening to the context and the surrounding. In such situations, it is very important to make adequate assessment of strategic approach to be adopted in reconstruction of these areas, and in definition of their future role in the historic context. A systematic holistic approach is the basis for developing cities of the future, on the existing platform of present-day cities. Historic context has a special place in this process. There are several examples where

brownfield sites take up much space in historical centres, and this fact constitutes a special challenge for transformation and improvement in such a sensitive setting. A significant issue is how to adapt these non-functional areas to new cultural, commercial, residential and other requirements, and how to improve the space and context without disturbing the existing identity and inherited value of the space. Most cities in the world have historical cores that are protected and that accept minimum transformation, which is why the issue of brownfields is so highly sensitive. However, new facilities could improve the existing architectural heritage and prove highly responsive to the needs of modern society and local communities.

4. Brownfield experience in the US and Europe

The urban regeneration in the world has played an important role in the development of cities, especially in the period of their degradation due to decline of traditional industries, with emphasis on North America and Western Europe. As to brownfield issues, the dominant place in the American context is occupied by the U.S. EPA (U.S. Environmental Protection Agency) [30] with a range of strategies, programs, actions, guidelines, pilot projects, and guides [8] for the treatment of degraded urban areas and for formulating directions for their regeneration.

The U.S. EPA is intended to provide technical support for solving environmental problems and for developing scientific bases for proper management of environmental resources, for examining sources and factors of pollution, and for reducing risks in the future. The research focus are the methods to prevent and control pollution of air, soil, water, contaminated sites, development and application of innovative and cost-effective environmental technologies and models for brownfield regeneration.

In most cities in America, the presence of brownfield sites has caused potential health risks, property value decline, increasing unemployment, and high contamination load. An intensive treatment of this problem has been topical over the past two decades, when a significant number of theoretical and practical studies and strategies have been developed in order to reduce potential contamination risks and to develop conditions for the sociological, cultural, and economic prosperity of the society and local communities.

A typical brownfield regeneration process begins with assessment of site in terms of contamination and, if it turns out that there are no negative environmental impacts and ecological risks, the restoration can start without delay. If this is not the case, the process starts with decontamination after which the situation is re-examined, hazardous substances are removed and, once the results are positive, the regeneration can finally start. The EPA has developed guidelines that are used to determine whether a brownfield site contains substances of very high or low risk for the environment and human health.

Figures 1 and 2 show a successful revitalization of an industrial district in Seattle, connection of the city to the coast through creation of a new art-prone landscape, and construction of the Museum of Arts and the Olympic Sculpture Park, where new forms of art, environment and urban construction have been developed.



Figure 1. Transforming an urban brownfield, reconnects Seattle to the waterfront, Seattle, U.S. 2009



Figure 2. Art Museum and Olympic Sculpture Park, Seattle, U. S., 2009

The EPA has identified some key elements in sustainable brownfield restoration, such as community profiling, community planning, organizational structure, risk management, legal issues, marketing, technological aspects, project financing, etc. [11].

The cornerstone of the EPA Brownfield Initiative is a brownfield pilot program ([www.epa.gov / brownfields](http://www.epa.gov/brownfields)) which is aimed at ensuring participation of community groups, developers, investors and other stakeholders in brownfield activities. Many states have established voluntary programs to encourage the assessment, cleaning and regeneration of brownfield areas. The EPA has developed a series of technical manuals and guidelines for the treatment of brownfield sites. Areas with high levels of contamination belong to areas with high risk, while those with significantly lower risk to human population and the environment are considered as low-

risk areas, and these latter areas are much more frequently encountered. The EPA strives to formulate and implement actions leading to a compatible balance between human activities and natural systems.

In the current state of the environment, with the present biodiversity crisis, global climate change, resource depletion, pollution of air and water, the brownfield regeneration is the first step in creating some kind of an apparent American culture. "Smart growth strategies" may be the solution for a sustainable future of cities. [6]

Figures 3 and 4 show a successful brownfield site decontamination in Austin, and its conversion into an environmentally friendly residential building, characterized by extensive use of renewable sources of energy.



Figure 3. Contaminated site

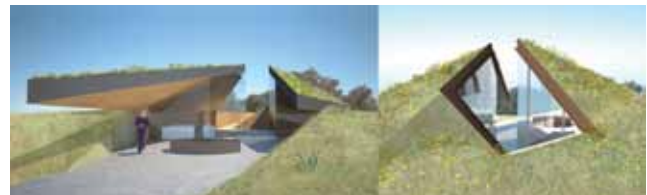


Figure 4. Red Bluff Residence : Austin, Texas, 2010 ,

In the European context, brownfield incentives started in the early 1980's in the UK, France, and Germany, where regional policies for remediation of degraded land are favoured, and specific programs for devastated land and recycling are created. These initiatives were activated due to increased awareness about negative environmental and economic effects, but also about the brownfield development potential. European cities, each faced with specific problems, have developed different urban regeneration strategies over the past two decades. Physical rehabilitation, social cohesion, reduced environmental risk, economic incentives, these are the key directions for sustainable brownfield regeneration in the European context. The number of activities related to brownfield policies and programs, with specific strategies and practical interventions, has increased over that time. In addition, various multi-partner research projects were implemented in order to trace directions of brownfield

regeneration and sustainable development of cities. Legal, political and other influences have largely determined the pace of brownfield regeneration and its transformation forms [31].

Engineering functions in the brownfield regeneration process include [15]:

- Tools for the use of brownfields including construction-related applications;
- Tools for soil management and contamination treatment;
- Criteria for the maintenance and/or dismantling of redundant buildings and installations;
- Tools for minimizing the costs of maintenance, modernization and replacement of infrastructure;
- Tools for reducing the use of primary raw materials, and increasing recycling rate of construction related waste, soil, and process residues.

The goal of RESCUE research project was to solve the problems and effects of current procedures in the urban development across Europe such as: [15]

- Economic breakdown in former industrialised areas, enhanced by globalisation and accompanied by European structural policy;
- Long term presence of large derelict sites on good locations across Europe;
- High cost to develop such sites;
- Lack of technologies, tools and methodologies to attract new investors to invest in such sites;
- High unemployment rate in such areas;
- Lack of skilled workforce to assist in regeneration projects;
- Adverse effects on urban life;
- Social conflicts;
- Decline of income tax revenue at the level of local communities;
- Development of greenfield sites at the outskirts of the cities with adverse environmental effects.

The RESCUE project was aimed at developing criteria for brownfield restoration by encouraging policies of association or research institutions and local governments, by integration of project management policies, etc. [15]. There are different forms and strategies of brownfield reuse. According to the CABERNET network, conceptual models for converting unused property are [10]:

- Bath Model: represents the dynamics of creation and redevelopment of brownfield sites
- ABC Model: focuses on economic viability of brownfield developments (key financial aspects are the location, e.g. the site value after restoration, and financial efforts to prepare the site for development)
- Football Model: highlights interests of different stakeholders and identifies key drivers for development
- Land Use Puzzle Model: correlation of brownfield distribution, land development, and land use cycle

- Interaction Model: shows interactions between social, environmental, economic and administration factors in urban systems

An example of successful brownfield regeneration in Italy, involving transformation of an old industrial building into a modern museum characterized by strong emphasis on social and cultural values, is shown in Figure 5.



Figure. 5 Conversion of an old industrial building into a museum, Cormano, Milan Italy, 2005-2010

In most developed cities of America and Europe, there is a high concentration of brownfield land, which threatens to a lesser or greater extent the environment, and slows down urban renewal processes. On the other hand, there are numerous programs, strategies, research papers, and doctoral dissertations which deal with these issues and largely direct and encourage sustainable brownfield regeneration practices. However, more energy still needs to be invested to ensure more intense and productive treatment of brownfields in the context of sustainable development of cities.

5. Brownfield experience in Montenegro and its surroundings

In Montenegro, brownfield issues do not hold an important place in practical development of cities. Completed brownfield projects are scarce, although each city is faced with the presence of brownfield zones. Brownfield problems are mainly treated within certain broadly conceived programs and documents relating to the environment and sustainable development strategies [32, 33, 34, 35]. Although local governments and competent ministry deal with various environmental and sustainable development issues through various projects, strategies, plans, and laws, it should be noted that, unlike in Europe and the US, no organization that would specifically deal with brownfield issues has so far been set up. In addition, there are no databases that would provide information about the number of brownfields, and about related risk levels to people and environment. Montenegro is more oriented towards greenfield sites, which has resulted in excessive occupation of territory, especially in coastal cities as a result of intensive construction.

In the context of sustainable urban development of cities, an increasing interest has been expressed over the last decade in managing the quality of living environment. Two highly significant international architectural competitions for brownfield regeneration were held in Montenegro in 2008 and 2009. In Cetinje, the area of "Stari Obod" is to be converted into the University of Arts (Faculty of Fine Arts, Music and Drama, Figures 6, 7 and 8), while in Mojkovac the "Jalovište" site is to become a sports and recreation centre. The Jalovište site in Mojkovac was one of the most contaminated sites in Montenegro with the highest levels of environmental risk. In 2008 and 2009, it was remedied in several stages, and according to present day estimates, it has been successfully decontaminated. The term "brownfield" is very rarely used in Montenegro, and the relationship towards critical areas in cities has not reached a level that would require sustainable urban regeneration and sustainable local development.



Figure 6. Brownfield- industrial zone "Stari Obod"- existing situation

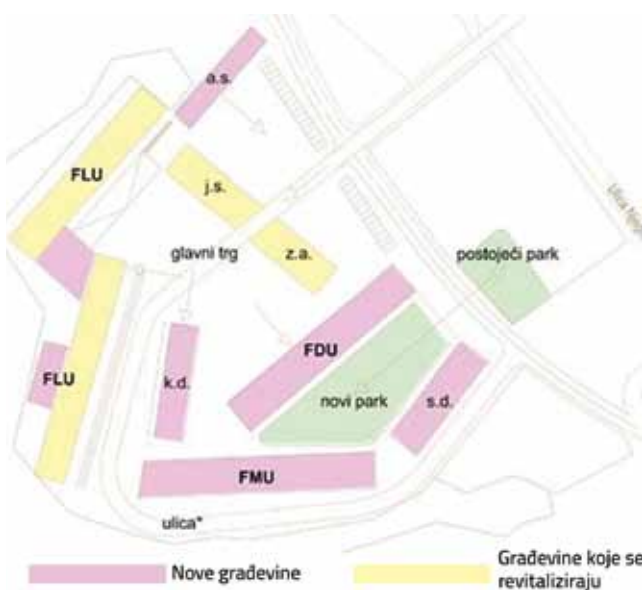


Figure 7. Changes in physical structure

In Montenegro and in surrounding countries, practical brownfield problems are mostly solved at the local community level. There is still no strong and clear strategy and management platform at the state level that would encourage significant investment in brownfields and promote urban regeneration and sustainable development. In other places, e.g. in Serbia [36, 37] and in Croatia, [38, 39, 40], some authors who have dealt with brownfield issues from scientific standpoint point out that more energy should be invested in the treatment of this problem and in strengthening public-private partnerships and brownfield investment strategies, which should be regarded as important links in the sustainable development of cities.



Figure 8. Brownfield regeneration: First Award architectural competition entry for urban complex in Cetinje, 2009

6. Optimum patterns and strategies for sustainable regeneration of brownfield sites

Based on the study of referent practical and theoretical experiences in a predominantly European and American context, it can be concluded that a variety of activities are currently considered and implemented in the context of sustainable brownfield regeneration. According to authoritative research, it can be concluded that future sustainable brownfield regeneration incentives should be focused around the following issues: socio-economic, environmental and cultural rehabilitation of cities. This can be done through an interdisciplinary action that would bring together all interested stakeholders and all forms of knowledge, in order to enable regeneration of brownfield sites in accordance with modern needs and demands of the society. The process of brownfield treatment can be undertaken in several stages:

- Phase I: Identification of brownfield and character assessment

- Phase II: contamination assessment
- Phase III: improvement of brownfield area
- Phase IV: reconstruction, revitalization, and change of use

The sustainable brownfield regeneration is a complex process that involves a strategic approach through all phases of implementation. Key principles are: sustainable town-planning and architectural solutions and brownfield management. The main objectives of brownfield regeneration are:

- Beneficial land use,
- Ecological safety (protection of the environment, conservation of natural resources, biodiversity)
- Economic viability (new jobs and other benefits)
- Promotion of cultural identity (authenticity, recognisability, attractiveness, compactness)
- Improvement of sociological dimensions (demographic factors, neighbourhoods ...)

To ensure sustainable urban development, a general strategy for the treatment of brownfield locations includes:

- Clearly defined legal framework
- Local and state authorities and institutions, and all other stakeholders, should be made aware about the potential value of these areas
- Developed knowledge capacities for solving these problems
- "brownfield" lobbying in the scope of programs, strategies and plans that are being developed in the field of spatial and urban planning and design
- Adaptation of urban development policies
- Cooperation between public and private sectors and all stakeholders
- Precisely defined stages of intervention

In the scope of a general strategy, a range of other strategies should be developed to define in more detail:

- The policy for regulation of risk factors
- The criteria for assessment of contamination
- Support mechanisms and incentives
- Social, environmental and economic benefits
- The forms of partnerships

Potentials and limitations of brownfield sites are quite complex, which is why appropriate action must be taken, sometimes involving a certain amount of risk, so that these sites can be improved in a productive and beneficial way.

Essential components of successful brownfield development include [41]:

- Finding financing
- Accurate estimation of cleanup/decontamination requirements
- Effective community involvement
- Successful negotiation with regulators
- Cost-effective and efficient cleanup

A key issue regarding brownfield regeneration is whether the rehabilitation process will ensure the protection of public health and provide adequate control of environmental risks in the current and repaired state, and what benefit will be obtained by changing the existing situation? Additional important issues include limiting factors such as the right to property, public interest, historical context, size, access, authenticity, price, and responsibility.

7. Conclusion

Global processes (urbanization, global economy, etc.) are increasingly affecting the shape of our cities. This results in the uniformity and degradation of city structures. For that reason, recognisability of urban environments is crucial for the sustainability of the local settings, regarded in the global context. Spatial resources, especially natural ones, and their appropriate treatment, are the main factors of urban sustainability.

Social divisions and global processes have disrupted the continuity of city images, and brownfields, as dominant products of such processes, are interpretations of visual, psychological, sociological, and ecological types of disruption, while also revealing economic, cultural, and identity-related restrictions. On the other hand, it is precisely these areas that are potential stimulators of sustainable development and their appropriate treatment allows creation of new sustainable values of urban space. New values, new impulses and new places of identity, as important elements of a sustainable city of the 21st century, point to the importance of urban brownfield regeneration, particularly in the context of reduction and expansion of suburban areas, disburdening of greenfield areas, and orientation to brownfield regeneration projects. The distribution and increasing dominance of brownfields in cities around the world points to the need for strategic actions directed toward sustainable regeneration and sustainable development. According to the U.S. and European experiences, brownfield activities have been more pronounced over the past two decades, when many programs, projects, strategies and measures for their treatment have been developed. However, there is still no universal and strategically determined relationship to brownfield, which is one of the key aspects of sustainable development. The reasons for this are mainly: lack of awareness about importance of brownfield regeneration, high costs of brownfield restoration, lack of experts for this kind of work, and weakening economies. To enable proper brownfield regeneration, strategic criteria and appropriate control mechanisms must be set up, public-private partnerships must be strengthened, and a holistic approach to this problem must be developed.

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