The Concept of Sustainability in the Context of Brownfields Regeneration

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ABSTRACT **Brownfield locations are abandoned and underused spaces whose regeneration is threatened by actual or potential environmental contamination. Contaminated brownfields are scars on landscapes that threaten the environment and human safety, but they also have the potential for renewal and reuse. In this chapter, the concept of sustainability will be explored in the context of the regeneration of brownfields. The basis of current and future sustainable development strategies for European cities is the efficient use of urban land, and brownfield locations are great land resources for many cities. Therefore, their regeneration is necessary in that they are sustainable in the long term and resilient to intensive changes in urban systems confronted with demographic growth, rapid urbanisation, climate and many other natural changes and disasters.**

This chapter explores the definition, classification, and critical analysis of brownfields' impact on the environment before and after their regeneration, in the context of development that accords with *sustainability science*, development that is based on economic, environmental and social sustainability in the field of urban planning and urban design. The characteristics of all three stated sustainability fields are synthesised in order to define economic instruments used to reduce environmental pollution, and strategies for the building of environmentally and socially resilient systems, instruments, and strategies, which are used as guidelines in the process of sustainable brownfield regeneration. In addition, the sustainability goals that will be achieved through the regeneration and redevelopment of brownfields are defined by, and based on, future development potentials, the improvement of economic, environmental and social values, and the qualities of these spaces and their surroundings.

KEYWORDS brownfields, land use, sustainability, resilience, brownfields regeneration

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1 Introduction

The subject of this chapter is brownfield locations. They are previously used locations that are now abandoned and underutilised spaces, mostly with a developed infrastructure that makes them easy to regenerate. Brownfields can be located in developed or partly developed urban areas and they represent great land resources, which need to be activated and connected with urban life. On the other hand, rapid urbanisation is indicated by the appearance and ongoing growth of mega-cities. These cities need to be smart and resilient because they have to survive shocks from global economic crisis, environmental catastrophes, and population growth (Desouza & Flanery, 2013 in Trkulja, Aleksić, 2016). Brownfield regeneration can contribute to the development of smart cities, particularly to the process of efficient land-use management.

The observation that cities are not environmentally sustainable is not a value judgement, simply a fact. Only two percent of the planet's surface is occupied by cities. Cities use up to 75 percent of the planet's resources and they generate the same proportion of waste. Intense economic processes and immense levels of resource consumption in cities increase and further stimulate their resource needs. Most cities today function on essentially linear based metabolisms. Resources move within urban systems without concern about those resources' origins or the impacts on waste destinations. Linear systems such as this are significantly different from natural dynamic circular system metabolisms where output is simultaneously input, self-renewing and thus sustaining life. In order to be sustainable, city systems must be based on a circular dynamic metabolism, which, by its essence, can improve itself, and efficiently use and re-use resources, thus, minimising material use and waste disposal into the natural environment (Girardet, 1996; Petrić, 2004).

Brownfield locations can sometimes be threatened with actual or potential environmental contamination. The existence of contaminated locations is an ecological problem that is becoming more and more pronounced. In the context of sustainable urban planning and urban design, in recent years a growing interest in the implementation of urban environmental management policies with mechanisms for effective land-use has been noted. It has influenced the development of *land-use planning* (Kaiser, Godschalk, & Chapin, 1995). *Land-use planning theory* mainly uses a model based on *rational planning*. This process implies that primary decision makers decide what is significant, viable, acceptable, and feasible from economic, political, ethical, and technical aspects (Essoka, 2003). In the period after World War II, the original scientific contribution was made by *urban land rent theory*, according to Alonso (1964) and Muth (1969), which was not clearly concentrated on environmental and spatial external effects. In recent years, politics and science have shown increasing interest in land-use change due to climate change, loss of biodiversity, and pollution. As a result of this, land use has been at the core of the sustainability debate (Nijkamp, Rodenburg, & Wagtendonk, 2002).

Land use is a multifaceted phenomenon that can be viewed from several aspects. It affects sustainability and ecological resilience, but also economic competitiveness and social equity. Therefore, it is important that the redevelopment of urban land be aligned with future development potentials and intergenerational issues. A very complex issue is the inclusion of urban rents as they can provide continuing sustainability in the urban area. However, with regard to governmental matters, this issue is usually dealt with in terms that emphasise the value of urban land (Nijkamp, Rodenburg, & Wagtendonk, 2002).

Nijkamp, Rodenburg, and Wagtendonk (2002) identified the unstable success factors for a useful clean-up policy for contaminated locations, and according to Kaiser et al. (1995 in Essoka, 2003) land-use planning is concerned with three sets of land-use values. The first set is of social use values regarding links between quality of life and the physical environment. The second set is of market values (commodity values of land), and the third is of ecological values.

Efficient use of urban land is the basis of current and future strategies for the sustainable development of European cities. Through trans-disciplinary planning and design, sustainability is promoted through the idea of urban resilience. This holistic planning method brings together all actors involved in the planning process, academic fields, professional areas, and all stakeholders. This approach allows different groups of actors to be involved in the urban planning and design process, creating a greater chance of meeting economic, environmental and social sustainability goals, and not just goals within one aspect (Ahern, 2010).

Desouza and Flanery (2013) acknowledge that the imperative for cities that can be considered smart is to be resilient. This means that resilience must be the most important aspect for the intelligent planning and design of the city. Surjan, Sharma, and Shaw (2011) consider that spatial or city planning procedures, based on the information available and static projections in current conditions of dynamic changes of urban patterns and climate, are gradually becoming redundant. Sudden extreme events have the potential to cause interruptions in urban environments, so city planning and design should pay attention to these issues in order to ensure a resilient future. Desouza and Flanery (2013) state that planning for resilience involves an estimation of cities' vulnerable network components and the understanding of their relations, as well as the ability to design different components in order to achieve resilience.

The economic, ecological, and social structure of a city is seen as the network of components of that city that are in interaction with each other. Inefficient land-use negatively affects all three components. The goal of urban space transformations is to satisfy the changing needs of their users in a characteristic XXI-century dynamic life. Therefore, the connection between society and space is a key cause and effect relationship that requires not only flexibility and transformability of space, but also that space's sustainability. So the question that is asked is how do brownfield locations regenerate in order to be

sustainable through efficient land-use? In order for the process of brownfield regeneration to be better managed, the strategies for the building of resilient economic, environmental and social components of cities must be defined. These strategies will emerge from research on brownfields, sustainability, and resiliency, and thus they will link all the key elements of this research. Brownfield regeneration plays an important role in the management and planning of cities that seek to become sustainable. Therefore, it is a necessary and inevitable element of sustainable urban design.

2 The Theoretical Basis of the Brownfield Concept

2.1 Definition of Brownfield Locations

The issue of brownfields appeared among the political issues of developed countries in the 1970s as a result of structural changes in society and innovations in transport, construction, and production (Trkulja, 2016). Brownfield locations are abandoned and underutilised spaces that are places of actual or potential environmental contamination. The reason for the discontinuation of use of those spaces may be: functional - brownfields without prior activity but with the owner or user; legal - brownfields without the right to use or at the stage of bankruptcy or liquidation; property - brownfields with disputed or unprotected property relations; and physically - when the former owner or user left the location and left it under the jurisdiction of the municipal or city administration (Stojkov, 2008). The decline in traditional industry and the carelessness of former industrial land users have left what are, due to real or potential pollution, scars upon the urban landscape, most in North America and Western Europe (BenDor, Metcalf, & Paich, 2011; Perović & Kurtović-Folić, 2012), and brownfield issues have become an integral part of the concept of sustainability. Therefore, it is necessary to give an insight into the American and European experience of defining the term *brownfield* because there is no internationally agreed definition for this term. However, the most widespread are three definitions: the definitions from the United States (USEPA, 2002), the European Union (CABERNET, 2006) and the United Kingdom (EP, 2003). Also, Yount (2003) claims that two forms of brownfield definition are needed. The first is a wide, generally agreed upon conceptual definition, and the second implies a standardised definition. Conceptual definition should include terms that are unequivocal, and should permit practitioners and policymakers a wide latitude of solutions to the environmental, economic and social problems of brownfield sites. A definition satisfying these criteria was developed in 2001 in US federal law by the "Brownfields Revitalization and Environmental Restoration Act" (BRERA), and Yount believes it is better than other definitions that are in use and should be implemented by local and state governments. According to the Act, the "term 'brownfield site' means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential

presence of a hazardous substance, pollutant, or contaminant" (US Congress, 2001, in Yount, 2003, p. 26). The same author believes that BRERA's conceptual definition is better than other definitions because it can encompass the issues of current and previous property use, site scope, perception of contamination, type of contamination, being subject to other programmes and laws, the effects of pollution on redevelopment, and redevelopment potential. Other definitions mostly deal with these issues only in part.

Six years before the BRERA definition (1995), the US Environmental Protection Agency (USEPA) officially launched its "Brownfields Action Agenda" under which brownfields were defined as "abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination" (USEPA, 1995 in Yount, 2003, p. 27). However, in 2002, USEPA changed the definition of brownfield, aligning it with the BRERA definition, so the term brownfield represents "a site, or portion thereof, that has actual or perceived contamination and an active potential for redevelopment or reuse" (USEPA, 2002 in Yount, 2003, p. 28).

At the European level, there is no general definition of brownfield. The *Concerned Action on Brownfield and Economic Regeneration Network* (CABERNET, 2006, p. 23), revising the definition by CLARINET (the *Contaminated Land Rehabilitation Network for Environmental Technologies*), has defined brownfields as sites that: "have been affected by the former uses of the site and surrounding land, are derelict or underused, may have real or perceived contamination problems, are mainly in developed urban areas and require intervention to bring them back to beneficial use". The CABERNET definition puts emphasis on the need for intervention as a common characteristic of all brownfields.

A survey by CABERNET revealed that there is an obvious contrast in the presentation of the term *brownfield* between the nations of Western Europe and Scandinavia and a difference is seen in relation to the population density and competitiveness. The rest of Europe revealed a wide range of brownfield definitions with dominant issues being contamination (for more details see Table 3.1: *Definitions of 'brownfield' land in European nations based on the responses of members of the CLARINET and CABERNET networks* in CABERNET, 2006, p. 29-30).

Based on the CABERNET survey, it is obvious that the lack of a general European brownfield definition and the scarcity of brownfield data in some European countries are the most important barriers to the successful monitoring of brownfield flows. Therefore, improving the complementarity of data for all European countries is crucial to solving the problem of brownfield locations. Presenting a successful brownfield regeneration and urban land management plan can increase brownfields' competitiveness and accelerate their renewal (Oliver et al., 2005).

The CABERNET definition is analogous to the commonly used definition of brownfield in the United Kingdom according to which the term denotes "previously developed land – PDL" (EP, 2003, p. 3), and therefore

encompasses a wider area and range of sites. However, the United Kingdom is well known for the redevelopment of former industrial locations and two beautified meanings of the term *brownfield* (of which one has been mentioned earlier). The second meaning interprets brownfield as a "chemically challenged" land (Nathanail, 2011). Alker, Joy, Roberts and Smith (2000) discussed, examining the brownfields problem and its significance for UK government policy, the need to define the term 'brownfield' examining it from a multidisciplinary perspective. They revised the use of the term 'brownfield' at that time and suggested that a brownfield location "is any land or premises which has previously been used or developed and is not currently fully in use, although it may be partially occupied or utilized. It may also be vacant, derelict or contaminated. Therefore a brownfield site is not necessarily available for immediate use without intervention" (Alker et al., 2000, p. 49).

These different definitions are due to the fact that certain locations are considered brownfield locations in one but not in other definitions. These different definitions are due to the fact that certain locations according to certain definition but not according to all brownfield definition. However, the common view is that there are obstacles to such sites' redevelopment. Unfortunately, less widely appreciated are developed infrastructure, good access and the position of brownfields (Nathanail, 2011).

USEPA estimated that there are more than 450,000 brownfield locations across America (Howland, 2007) and that their renewal will require from 100 billion to over 650 billion dollars (Schädler, Morio, Bartka, Rohr-Zänker, & Finkel, 2011). According to a CABERNET survey of 22 European countries, there are more than 950,000 brownfield sites, with an area of more than 2 million hectares, requiring 100 billion euros for their renewal (Schädler et al., 2011). These data indicate a large spatial resource of brownfield locations that can accept new functions and contents that would significantly affect both the quality of life and the safety of people (Trkulja, 2015a, 2016).

In the Western Balkan countries, the phenomenon of brownfield locations has not been substantially explored. The problems and potentials of these areas are not recognised. There is no official definition or categorisation, nor a clear vision for their renewal at the local or national levels. The practical problems of brownfields are solved only partially (at the level of local communities) in the main, because there are still not firm and clear official strategic and management platforms at national levels. Partial consideration of the importance of brownfield locations, the non-inclusion of all potential stakeholders in the process of their regeneration, ignorance of the degree of sites' pollution, and the possibility of ecological problems occurring are just some indicators of the non-strategic regeneration of brownfield locations in the process of sustainable urban planning and design. On the other hand, efficient land management and adequate presentation of brownfield locations would encourage investment in brownfield regeneration and promote their sustainable development (Trkulja, 2015a).

2.2 Classification of Brownfields

In the literature, there is no wide range of data on the classification of brownfield locations. However, the classification of brownfields is most often considered in relation to their position within an urban community, the sites previous purpose, the market relations of a brownfield's location, the profitability of regeneration, and according to potential environmental pollutants. According to the position within the urban tissue, there are three characteristic brownfield types: in the central area, on the city's periphery, and in historic areas (Perović & Kurtović-Folić, 2012).

According to their previous purposes, brownfields are usually considered abandoned or underutilised. Previous purposes were those such as: industrial zones, railway complexes, military complexes, coastal areas, municipal public service facilities (hospitals, prisons, schools, cultural centres, agricultural cooperatives, agricultural combines etc.), mining installations, closed gas stations, devastated residential buildings, neglected monuments, and crowded garbage dumps (Danilović, Stojkov, Zeković, Gligorijević, & Damjanović, 2008; Nathanail, 2011; Perović & Kurtović-Folić, 2012).

Regarding market relations to brownfield locations, there are four different types of these spaces: spaces left exclusively to the market; spaces that the market comes to after the identifying and removing of environmental damage at the location; spaces that emphasise social and ecological values above real market value; and spaces that have an active health and ecological hazard without economic justification (Jackson, 2006 in Stojkov, 2008).

Depending on the profitability of regeneration, CLARINET (Ferber & Grimski, 2002 in Nathanail, 2011) suggested a threefold classification of brownfield locations that represents economic components of brownfield locations: profitable locations (category 'A'), locations on the 'Break Even' Value Line (category 'B') and unprofitable locations (category 'C'). This model is particularly useful because it examines the extent to which it is possible to achieve productivity by use of brownfield locations. This classification of brownfields can help institutions responsible for local and regional development and investment to define a strategic framework for the brownfields' development (Djukić et al., 2014).

USEPA (2001 in Perović & Kurtović-Folić, 2012) classified brownfields based on their previous function but from the aspect of pollution: oil and petroleum facilities, manufacturing (for example, cement plants, pesticide facilities, plastics facilities, etc.), recycling, treatment and repair facilities, and miscellaneous (for example, agri-business, landfills and dumps, quarries, print shops).

Unlike the above classification, which relates to what brownfields *are*, Nathanail (2011) has offered a few examples of what brownfields are *not*: in-use military ranges and factories, houses where people live,

construction areas, farmland, overgrown gardens, scorched forest areas, and recolonised mines.

Finally, it is important to note that classifications based on economic, environmental, or social factors are still developing. They can be of great importance for any level of government management in defining the objectives of brownfield regeneration. The classification of brownfields determines their basic characteristics (position, previous purpose, profitability, level of pollution), which can be crucial not only for the flow of the regeneration process and for the urban design, but also for the urban management and planning process.

2.3 Influence of Brownfields to the Environment Before and After Their Regeneration

Brownfields have a negative influence on their wider environment in economic, environmental, social, psychological, and aesthetic terms. Some of the negative influences of brownfields are that: there is a loss in the economic value of land in the brownfield environment; they are sources of infection, contamination of the land and ecosystem disturbance; they can contribute to the development of social pathology, having a negative psychological effect on the citizens in the neighbourhood; they threaten the identity of the city; and they frequently display bad aesthetics of space (Stojkov, 2008). In addition, Ferber and Grimski (2002) believed that brownfields are characterised by unattractiveness for new investors, the collapse of economics, high unemployment, and social conflicts that adversely affect urban life and reduce tax income for the communities. All of this initiates a greater use of greenfields. Because of these characteristics, it can be concluded that brownfields also negatively influence human security by emphasising the relationship between environmental quality and human security. These relationships are close because human security is connected to environmental changes, and environmental changes are directly and indirectly affected by human actions and conflicts. The human security agenda focuses on protecting and improving human security by emphasising, inter alia, prevention of ecological crises in ways that cure their causes, not just the consequences. Therefore, brownfields need to be renewed, thus preventing degradation of the environment, and thereby preventing the disturbance of human security (Trkulja, 2015b; 2016).

USEPA and BMBF (*German Federal Ministry of Education and Research*) created a bilateral working group to share information on the regeneration of contaminated locations. Steffens and Vieten (2000 in Weber, 2008) wrote the final report. Both countries (USA and Germany) had the same opinion: it is necessary to solve five problems that obstruct brownfield regeneration. These problems related to assessment procedures for previously used sites, analyses of markets for the reuse locations, cost-financing calculations, financial risk management reports, and cost benefit analyses.

Among the risks we should include are site pollution, counterproductive structural support for the further development of greenfield locations, marketing problems that are created by the earlier bad image of brownfield locations, possible problems related to the building organisation and harmonisation of actors, etc. (Stojkov, 2008).

For investors, brownfields pose a particular challenge because investing in them in urban spaces has both risks and many advantages. They can be viewed with regard to economic, environmental, and social sustainability goals (Trkulja, 2016). Positive economic effects are enabling the development of a wider brownfield environment, benefitting from the additional value of the land, reduction of economic losses due to the excessive spread of cities, reduction of traffic, urban infrastructure improvements, and increased investment power. Renewal of brownfields can also lead to positive environmental effects such as elimination of health risks (contamination), removal of 'wild' solid waste, elimination of the risk of underground and surface water pollution, elimination of soil contamination, reduced risk of hazard and increased quantity of high-quality greenery (Stojkov, 2008). Smart reuse of brownfield sites is a necessary prerequisite for egalitarianism and astute environmental management (Nathanail, 2011). In this regard, the renewal of brownfield locations can lead to the following positive social effects: elimination of poverty, more active employment in traditional industrial zones, the possibility of achieving more vital cultural projects, preservation of cultural heritage, promotion of social equity in brownfields, increasing the level of citizen security by providing a healthier living and working environment and absolutely improving the image and identity of the city (Stojkov, 2008).

Based on all of the above, it is concluded that brownfields have negative effects on their environments and create different economic, environmental, and social problems. They endanger the economic development of their surroundings, the quality of the environment and urban life, social well-being, and human security. Additionally, they aesthetically endanger the image of the city and contribute to its bad image. On the other hand, brownfields represent significant reserves of infrastructure, buildings, land, and greenery. Thus, the occupied brownfield space can accept different functions and activities, primarily recreational, entertainment, cultural, and service. The economic, ecological, and social potentials of these locations indicate their importance for the urban community, and point to the necessity of their renewal (Trkulja, 2015a).

3 Concept of Sustainability

The sustainability concept was created in the early 1970s as a reaction to a huge growth of urban systems and modern development practices leading to a worldwide environmental and social crisis (Wheeler, 2004 in Trkulja, 2015c). The term 'sustainability' means "the ability to sustain, or a state that can be maintained at a certain level" (Kajikawa,

2008: 218). In the early 1980s, the term 'sustainable development' was first used for the global strategy for preservation of nature adopted by the *International Union for the Conservation of Nature* (IUCN) and the *World Wide Fund for Nature* (WWF). The concept of sustainable development was promoted in 1982 at the *United Nations Conference for Environment and Development* (UNCED), held in Nairobi in Kenya, and in 1983, the *United Nations General Assembly* brought a resolution to take the initiative to establish the *World Commission on Environment and Development* (WCED), known as the *Brundtland Commission*. The paradigm of sustainable development rose to fame in 1987 when the Brundtland Commission, in their report "Our Common Future", created the generally accepted definition of sustainable development, which says "Sustainable development is a development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 8). This definition attracted broad attention and became widely used (Dovers, 1993 in Kajikawa, Ohno, Takeda, Matsushima, & Komiyama, 2007), so many authors took it as relevant (Bătăgan, 2011; Bell & Morse, 2005; Dovers & Handmer, 1993; Franz, Pahlen, Nathanail, Okuniek, & Koj, 2006; Janić, 1997; Kajikawa, 2008; Williams & Dair, 2007; Wu, 2010).

In 1999, the *Board on Sustainable Development* compiled the report "Our Common Journey", fronted by the *US National Research Council* (USNRC), which described a transition toward sustainability as a process between the following two generations that "should be able to meet the needs of a much larger but stabilizing human population, to sustain the life support systems of the planet, and to substantially reduce hunger and poverty" (Kates, NRC, BSD, 1999, p. 4). The USNRC report suggested the development of a *sustainability science* that gained significance in academic circles after the publication of the article "Sustainability Science" in *Science* magazine in 2001. In this article, Kates et al. (2001, p. 641) described 'sustainability science' as a new field that requires us "to understand the fundamental character of interactions between nature and society and to encourage those interactions along more sustainable trajectories". Many authors have taken this definition of 'sustainability science' that emphasises the interaction between society and nature (Carpenter et al., 2009; Clark, 2010; Potschin & Haines-Young, 2013). In the field of urban planning, *Sustainability science* is based on intertwined relations between economic, ecological, and social sustainability.

3.1 Economic Sustainability

Although sustainability directly relates to biology and ecology, the concept of sustainable development also includes elements of economic activity, i.e., sustainable economic development (Portney, 2003). The effects of climate change and global environmental change, which are related to the loss of drinking water and the loss of biodiversity, are increasingly present. Therefore, economists and society as a whole consider that the economics should also deal with issues of sustainability (Baumgärtner & Quaas, 2010). In 1920, the English economist and theoretician Arthur

Cecil Pigou, in his work "The Economics of Welfare" (1920), made the most significant shift in the understanding of ecological problems and the elaboration of their possible solutions in the sphere of economic sciences. The significance of Pigou's elaboration is not only in the fact that he brought some basic problems of environmental protection to the forefront, but also that he indicated the question that later got its serious foundation in "economic instruments in the field of environmental protection" (Slijepčević, Marković, Ilić, & Ristić, 2013).

For decades, economists have contributed to discussion about different aspects of sustainability, but only recently has the term *sustainability economics* been explicitly used in environmental protection. Baumgärtner and Quaas (2010) systematically defined *sustainability economics*. They explained its evolution, its subject focus, and the aims of its study. The evolution is based on the idea of justice, which relates to the equal rights between present and future generations of humans. Its subject focus is the humans–nature relationship. Sustainability economics is moving towards the long-term and uncertain future; economic efficiency is seen as a saving in the distribution of natural goods and services. According to the same authors, *sustainability economics* lies at the crossroads of *ecological economics* and *environmental economics* (see more in Field & Field, 2008; Kolstad, 2000; Wiesmeth, 2012) and uses their concepts and methods. However, it has a specific evolution and subject focus.

The subject focus of these sciences/areas, which study the relationship between people and nature in order to create a sustainable environment, has led to the definition of 'economic instruments in the field of environmental protection'. These are emission tax, product tax, tax differentiation, subsidies by country, and marketable permits.

– *Emission tax* is the classical *Pigou Tax* where the amount of tax burden is determined by the polluted emissions unit – measuring harmful emissions (discharged emissions). It is a complicated and expensive technique (Baumol, 1972; Slijepčević et al., 2013). It is used to return environmental changes to effective distribution (Wiesmeth, 2012).

– *Product taxes* tax products, which almost invariably generate pollution, either by their production or consumption (input taxes and taxes on final products). They take the form of existing value-added taxes or excises, and they are often used (Slijepčević et al., 2013).

– *Tax differentiation* implies a different tax burden for similar products that are different in their ecological characteristics. The use of these taxes was particularly present in the 1990s, especially in the Scandinavian countries that had implemented a comprehensive ecological tax reform. Namely, these taxes are often called *Ecotaxes* or *Ecological taxation* and are related to taxes that promote environmentally sustainable activities through economic incentives (Slijepčević et al., 2013; Wiesmeth, 2012). *Ecotaxes* include *green taxes* and *pollution taxes*. Green taxes help to ensure efficient regulation of the physical environment. Ideally, green taxes should account for all social costs that are not included in the

normal/internal costs charged by private actors and that arise from the polluter. Green taxes relate the tax burden from taxation of income and capital to fossil fuel consumption, resource extraction and pollution creation, and would discourage economic activities based on intensive use of materials and energy, favouring the provision of services and activities through intensive work (Slijepčević et al., 2013). Pollution tax is used to achieve an environmental standard. Ecological efficiency has replaced economic efficiency (Wiesmeth, 2012).

– Direct and indirect *subsidies by country* include exemptions from paying taxes if these funds are invested in ecological equipment (Janić, 1997) in order to reduce pollution in the production process. It is a *Pigouvian subsidy* (Turvey, 1963).

– *Marketable permits* include trading emission permits. The environmental authority can directly issue the requisite number of permits in order to achieve the prescribed ecological standard. Once the initial distribution of permits is done, polluters can freely trade these pollution permits. The basis of this system is the fact that a company that determines that it is easy for it to reduce its pollution level will buy a pollution permit from a polluter whose pollution reduction is expensive. The total environmental standard has been preserved because nothing has happened that would change the total number of permits, and this is exactly what determines the level of pollution. The efficiency of marketable permit systems is directly related to the competitiveness of the markets in which polluting companies compete (Taschinia, 2010).

Subsidies and taxes have completely opposite effects on the production profitability in a polluting industry: subsidies enhance profits, and taxes reduce them (Taschinia, 2010).

3.2 Ecological Sustainability and the Concept of Resilience

The focus of ecological sustainability is the reducing of harmful effects on the environment, resources preservation for future generations, and maintenance of ecological standards: clean air, soil and water, and the presence of various plant and animal species whose habitats are regularly maintained to ensure sustainable development. It implies the protection, preservation and improvement of the environment (Slijepčević et al., 2013).

Aspects of ecological sustainability are explored within *urban resilience theory*, which aims to understand the dynamics of well-defined coupled social–ecological systems (Jerneck et al., 2011). In this chapter, research on *ecological resilience* is emphasised, while in the next section, *social resilience* will be explored.

Nowadays, after sustainability, resilience seems to be the new in-word in urban and regional issues. Resilience is for the period after 2010 what sustainability was from the 1980s to 2010 (Foster, n.d.).

Etymologically, the term *resilience* is formed from the Latin *resiliēns*, the present participle of *resilīre,* which means to rebound or to recoil (Barnhart, 1995 in USAID, 2006). However, what exactly does it mean for urban planners, designers, and ecologists? The leading global network committed to building a sustainable future, *ICLEI – Local Governments for Sustainability*, added the theme of adaptation to its strategic plan in 2006, and in 2010 the *City of Bonn* (Germany), the *World Mayors Council on Climate Change* and *ICLEI* started work on *Resilient Cities*, as the first *World Congress on Cities and Adaptation to Climate Change*. In 2012, it was renamed as the *Global Forum on Urban Resilience and Adaptation* (*Resilient Cities series*).

The concept of resilience in ecological systems was first presented in 1973 by the Canadian ecologist Crawford Stanley (Buzz) Holling in his article "Resilience and stability of ecological systems" (1973) to describe the observed dynamics of the ecosystem, exploring the relationship between resilience and stability. Independently or with groups of authors, Holling published several articles defining the term *resilience* at the end of the 20th century and the beginning of the 21st century, and some of these definitions are listed in Table 3.1).

Holling, 1973, p. 14	resilience is "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables"
Holling, 1986, p. 297 in Reggiani, Graaff & Nijkamp, 2002, p. 215-216	resilience "emphasises the boundary of a stability domain and events far from equilibrium, high variability, and adaptation to change"
Peterson, Allen, & Holling, 1998, p. 10	ecological resilience is "a measure of the amount of change or disruption that is required to transform a system from being maintained by one set of mutually reinforcing processes and structures to a different set of processes and structures"
Holling, 2001, p. 394	the adaptive capacity; that is, the resilience of the system: "a measure of its vulnerability to unexpected or unpredictable shocks; this property can be thought of as the opposite of the vulnerability of the system"
Walker, Holling, Carpenter, & Kinzig, 2004	resilience is "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks – in other words, stay in the same basin of attraction"

TABLE 3.1 Definitions of resilience according to Crawford Stanley (Buzz) Holling

After Holling's definitions, the beginning of the 21st century brought many articles and many discussions about the definition of resilience. Many other authors have defined the term (Ahern, 2010; Elmqvist et al., 2003; Folke, 2006; Henstra, Kovacs, McBean, & Sweeting, 2004; Klein, Nicholls, & Thomalla, 2003), and summarising these definitions, it is concluded that resilience is the reaction of the ecosystem to disasters created as a result of economic activities and other natural phenomena (detailed classification of Natural and Technological Disaster Classification, see in Jha, Miner, & Stanton-Geddes, 2013, p. 168). However, according to Gil-Romera et al. (2010, p. 45) "resilience not only refers to the ability of an ecosystem to recover after an impact, but also to the ability to learn from the disturbance, i.e., to reorganize in a way that buffers future disturbances".

According to Folke et al. (2002), for social-ecological systems (SES) resilience is related to three parameters. The first is "resilience as persistence", the ability of SES to absorb shocks and remain within a

certain state. The second is related to SES' adaptation to the shocks, and the third to the transformability – the ability of SES to start new developmental processes and to remain stable.

Several authors (Ahern, 2011; Godschalk, 2003; Jha et al., 2013; Wilkinson, 2011) have defined strategies for the building of ecological resilient systems.

– One of them is *multifunctionality,* which implies interweaving and combining different plant species in order to create a multifunctional ecological system. In addition, it includes the creation of a green infrastructure that is a feature of the resilient systems (for example: the Portland Green Street Program; Banff National Park in Alberta, Canada; Buffalo Bayou Park in Houston).

– Then, there are *redundancy* and *modularization*. Redundancy is the inclusion of more functionally similar components that act as support to each other, to guarantee that the breakdown of one component does not lead to the breakdown of the complete system (for example: Illinois Green Alleys program). Modularization is dispersion of ecological systems (separation into basic parts) and spreads risks across more different systems, rather than relying on a centralised system (for example, the Augustenborg Housing Project, Mälmo, Sweden).

– Another strategy is the protection of *biodiversity*. It can be grouped into two categories: *functional diversity* that includes different ecological functions in order to protect the system against various hazards; and *response diversity,* which, in ecological systems, implies the different species within functional groups that have certain responses to hazards (for example, Natur-Park Schöneberger Südgelände in Berlin, Germany).

– Ecological resilience also implies the existence of *multi-scale networks and connectivity*, i.e., ecosystem functions that affect the distribution of resources, species, energy, information, and transport. The interdependence of these elements influences the sustainability of the city (for example, the Staten Island Bluebelt in New York). It can also be defined as *interdependence* or integrated systems of components for mutual support (for example, High Line in New York, USA, and Promenade plantée in Paris, France).

– An ecological resilience system should be *effective* to create a positive relationship between received and spent energy. There should be *autonomy*, the capability of the system to operate independently of outside control. The ability of a system to anticipate a change or disaster is defined as *strategic forecasting*. The natural environment should be *inexhaustible* and *invulnerable*, and it has a *strength* and *power* to resist danger or other outside forces. The system needs to be *adaptable* and to have the ability to organise itself, adapting to changes or disasters (*self-organisation*).

– *Adaptive planning and design* is a strategy that puts urban design in the context of resiliency. It affects how well the plan will adapt to changes

in the environment. Urban plans and designs should assume possible effects on specific landscape functions or processes. In addition, implemented plans are 'research polygons' for experts and decision makers to learn from, through monitoring and analysis. With adaptive planning, urban plans adapt to disasters, and they are variable (for example, the SEA Street project in Seattle, Washington; the Emscher Landscape Park in Duisburg, Germany).

Landscapes are heterogeneous spatial entities and their sensitivity to disturbances varies by the sort, frequency, and power of those disturbances. Therefore, it is essential for landscapes or cities that planners and designers identify potential disasters, their frequency and power, as well as the possibilities for these landscapes or cities to adapt to such disasters and remain resilient. Thus, urban resilience precedes the protection of urban ecosystems with the planning for possible environmental disasters (Ahern, 2010).

3.3 Social Sustainability and the Concept of Resilience

At the centre of social sustainability is a person or a group of people, or a specific society. The sustainable society is "the one that lasts for several generations, which is far-sighted and flexible and wise enough to prevent destruction or undermining of the physical and social systems on which it stands" (Janić, 1997 in Trkulja, 2015c, p. 48). Therefore, social sustainability implies "avoiding possible tensions or serious social conflicts" (Slijepčević et al., 2013 in Trkulja, 2015c, p. 48). It also implies a "fair distribution of products and narrowing the gaps in levels of development between different social and territorial groups" (Vujošević & Spasić, 1996 in Trkulja, 2015c, p. 48).

Aspects of social sustainability are examined within the purview of *social resilience* that complement the understanding of the dynamics of well-defined, coupled social-ecological systems, within urban resilience theory. Sociologists use the term *resilience* to describe the possibilities and ways that human abilities, after absorbing stress, return to normal states (Surjan et al., 2011). Adverse effects need to be transformed into personal, relational and collective growth, by strengthening existing and by developing new relationships (Cacioppo, Reis, & Zautra, 2011). Murray and Zautra (2012) have used this wider conceptualisation of resilience in order to describe the term as an adaptive reaction to disasters expressed through three processes: recovery, sustainability, and growth.

Many authors have given their definitions of the term *social resilience* (Cacioppo et al., 2011; Lang, 2010; Longstaff, 2005; Murray & Zautra, 2012; Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008), and in summarising these definitions, it is concluded that *social resilience* represents the ability of individuals or groups to be flexible when responding to danger, to compensate for the damage incurred, to recover from stressors, and to continue their existence.

Social resilience is "a multilevel construct because it represents a feature of groups as well as a feature of the individuals in the group" (Cacioppo et al., 2011, p. 46). Therefore, it is studied as an *individual resilience* and as a *community resilience*. Individual resilience represents "the processes of, capacity for, or patterns of positive adaptation during or following exposure to adverse experiences that have the potential to disrupt or destroy the successful functioning or development of the person" (Castleden, McKee, Murray, & Leonardi, 2011, p. 372). On the other hand, *community resilience* is "a complex process as it involves the interaction of individuals, families, groups and the environment" (McAsian, 2010 in Withanaarachchi, 2013: 6). The latter is more popular and has been explored more than *individual resilience*, and thus many authors have defined the concept (Adger, 2000; Ahmed, Seedat, vanNiekerk, & Bulbulia, 2004; Brown & Kulig, 1996/97; Bruneau et al., 2003; Coles & Buckle, 2004; Ganor & Ben-Lavy, 2003; Jha et al., 2013; Kimhi & Shamai, 2004; Maguire & Cartwright, 2008; Norris et al., 2008; Paton, Millar, & Johnston, 2001; Pfefferbaum, Reissman, Pfefferbaum, Klomp, & Gurwitch, 2005). Summarising these definitions, it is concluded that *community resilience* represents the ability of a community to respond positively to changes or stress, to deal with them, and maintain the core community functions. Discussions about community resilience often point out that the whole is beyond the sum of its parts, which means that "a collection of resilient individuals does not guarantee a resilient community" (Norris et al., 2008, p. 128). Also, Brown and Kulig (1996/97, p. 43) noted that "people in communities are resilient together, not merely in a similar way" which means that the community resilience does not guarantee the same individual resilience.

Several authors (Bruneau et al., 2003; Jha et al., 2013; Wilkinson, 2011) have defined strategies for building social resilient systems. One of them is *robustness,* or the ability of the community to hold out against a stress without distress. Then, there is *redundancy*, a measure of the interchangeability of damaged or destroyed elements. It refers to the resource of diversity: communities that depend on limited resources are less capable of coping with changes involving consumption of resources (dependence on resources as opposed to redundancy). The power of a community to deal with a change (*strength*) and the capacity of a community to achieve goals in a timely manner with minimal losses (*speed*) are also characteristics of the resilient community. Also recognised are *adroitness* or *resourcefulness*, i.e., the capacity of the community to, if compromised, identify problems and mobilise resources.

Social integration helps in improving the quality of life and the elimination of bad images of communities. *Cultivation of systems and education* involves the use of moveable knowledge, skills and resources that have an effect on social systems, as well as the combination of experimental and experiential knowledge. Information on a disaster or change gives community members a basis for determining the priority measures for its alleviation, but also the involvement of community

members and stakeholders in urban projects, including public-private partnerships (*participation*).

The ability of the community to strategically anticipate future changes (*ability to predict*), as well as the ability of the community to organise itself (*possibility of self-organisation*), are significant features of a resilient society. Urban poverty is especially sensitive to the effects of changes and disasters due to the location of homes of poor community members, lack of income and lack of reliable basic services. *Reduction of urban poverty* is definitely one of the goals of a resilient community.

All these strategies help urban designers to create the spaces needed for the development and social integration of resilient communities.

4 Towards the Sustainable Regeneration of Brownfields

Because, in this chapter, the concept of sustainability is explored in the context of the renewal of brownfields, it is necessary to place brownfield locations in the context of sustainability. Williams and Dair (2007) defined their approach to this topic. They believe that it is primarily necessary to establish a definition of sustainability in line with brownfield development. Based on it, precise sustainability objectives should be developed. They are achieved through brownfield regeneration and learning from existing examples of brownfield regeneration.

The definition of sustainability in line with brownfield development is similar to the definition of sustainable brownfield regeneration that many authors have described (Franz et al., 2006; Nathanail, 2011; Schädler et al., 2011; Perović & Kurtović-Folić, 2012; Thornton, Franz, Edwards, Pahlen, & Nathanail, 2007). Sustainable brownfield regeneration includes "making abandoned, underused, derelict and, only occasionally contaminated, land fit for a new long-term use in order to bring long-lasting life back to the land and the community it lies within" (Nathanail, 2011, p. 1079). It is not a destination but a journey, and it may include several cycles of land reclamation, redevelopment, or refurbishment (Nathanail, 2011). If the concept of sustainability is a reference to practical problem solving, it is necessary to develop a specific framework that defines what sustainability is and what it is not. Thus, RESCUE (*Regeneration of European Sites in Cities and Urban Environments*) built up an approach to sustainability that is operational in the brownfield regeneration context. This approach is based on four dimensions of sustainability: economic, environmental, social, and institutional (UN Commission on Sustainable Development, 2001 in Franz et al., 2006). Based on these dimensions, a definition of sustainable brownfield regeneration was established:

"Sustainable brownfield regeneration is the management, rehabilitation and return to beneficial use of brownfields in such a manner as to ensure the attainment and continued satisfaction of human needs for present

and future generations in environmentally sensitive, economically viable, institutionally robust and socially acceptable ways within the particular regional context" (RESCUE, 2003 in Franz et al., 2006, p. 139).

This definition of sustainable brownfield regeneration suggests that sustainable development should be viewed as a journey that balances four dimensions of sustainability, and not a destination that needs to be reached in the future. The focus is on the flexibility of sustainable development instruments and the flexibility of the process (journey) in order to adapt to changes made during the brownfield regeneration. This is very important in defining objectives and indicators of sustainable brownfield regeneration (Franz et al., 2006).

In the framework of the broad sustainability components (economic, environmental, and social), it is necessary to determine objectives suitable for brownfield redevelopment projects (Williams & Dair, 2007). Objectives should be broadly defined in order to include possible changes at locations. In this regard, the general objectives of sustainable brownfield regeneration are separated. One of these is the promotion of brownfield projects in order to increase the stakeholders' participation in projects' emergence and implementation. By involving more stakeholders, projects will be more socially acceptable and better.

Additionally, fair discussions, achieving better quality information, and adequate information exchange are needed, not only during the project's development, but also during site operations. Transparency in decision-making will improve communication structures. During site operations, it is necessary to manage the risk from contamination, prevent adverse impacts on the environment and protect human health and safety as well as the environment. Re-use and reconstruction of existing buildings and infrastructures on brownfield sites are primary. In order to ensure cost effectiveness in the location, production of renewable energy is one possible avenue. A significant objective of sustainable brownfield regeneration is to promote employment and economic development, as well as harmony between the regeneration of brownfield locations and regional land management. It is certainly necessary to advocate an approach that integrates economic, environmental, and social aspects (Franz et al., 2006).

Brownfield regeneration can contribute a lot to sustainable economic growth. Namely, in the process of brownfield regeneration many companies are involved, which thus provide jobs and salaries for their workers. Property investors can increase their rental incomes. The regeneration will contribute to an increased value of property in the environs, which is a benefit for all residents of the surrounding settlements of the former brownfields. These benefits become possible if three economic sustainability objectives are met: providing opportunities for more efficient and competitive business, providing employment and supporting local economic diversity. Clearly, there is the potential for these to be fulfilled through the development of brownfields.

Literature that links environmental sustainability with brownfield locations is more developed than literature about economic and social sustainability. The objectives of environmental sustainability that can be achieved with the renewal and redevelopment of brownfield locations are to minimise the use of resources and to minimise pollution. Resource use can be reduced in the construction and end-use of objects, but without disturbing their functionality. Reducing the use of resources also means waste reduction and energy-use reduction. Reduction of pollution refers to site remediation and the cleaning up of contaminated land, construction techniques that don't pollute the air and don't make noise, the choice of less polluting materials, etc. Furthermore, space users should not pollute the air, ground, or water.

The objective central to the sustainability debate is to look after the natural environment and its biodiversity. If a location is undeveloped for some time, it is necessary to make an environmental study and assess the development of flora and fauna. On-site habitats should be linked to neighbouring habitats. It is also necessary to provide open spaces and gardens in residential areas. Water areas and flows must be protected from pollution and flooding, and water recycling systems should be used (Williams & Dair, 2007).

On the other hand, brownfield development projects offer an opportunity to achieve social sustainability. The primary objective of social sustainability in the renewal and redevelopment of brownfield locations is to observe ethical standards during the process of brownfield development. It is necessary to provide a safe and healthy work environment, reasonable working hours for workers, and so on. This contributes to the improvement of the quality of life of each individual, but also helps communities to increase social capital by providing space for social interaction (Williams & Dair, 2007).

Adequate local services and facilities to serve the development are needed, such as community buildings, open spaces and playgrounds, shops, and schools. Provision of services enables people to satisfy their individual needs for education, healthcare, leisure and so on, but also helps communities to develop social capital by providing space for formal and informal social interaction.

If a brownfield is suitable for housing it is possible to regenerate it for housing to meet local needs. It is desirable that the project is in accordance with the principles of sustainability. Housing provision in brownfield renewal locations may affect the demographic trends of the population and the broader development of the city.

It is necessary to integrate local development into the development of the city and the region. This is especially important in industrial brownfield locations that were once isolated and lacked good connections to the rest of the city. If it is planned to organise housing areas in these locations, it is important to connect them adequately to the rest of the city and thus avoid social exclusion. Physical integration is particularly important for vulnerable societies that are often physically isolated.

Integration can be achieved by creating better connections with other neighbourhoods and by creating better traffic infrastructure. It is essential that the project design will involve various users: the elderly, teenagers, children, and people with disabilities.

In brownfield regeneration, it is necessary to integrate sites into the environment and make them attractive to live in. It is also necessary to provide economic cost-effectiveness for the companies that would operate there. This enables high quality and liveable development.

Brownfield development projects should conserve local culture and heritage. Brownfield locations often have strong cultural or social meanings for people. There are many studies on the preservation of culture and the social importance of space. They show different techniques used to revive past cultures. These include the retention of existing buildings, the use of local knowledge in new development, and the introduction of public art into space. However, the historical context may sometimes have negative connotations for local people. In such cases, it is necessary to create a new image for these areas (Williams & Dair, 2007).

Kilper and Thurmann (2011) elaborated upon the link between space and society in the context of resilience. They understand the space as a social construction. Space is created by people. It is a result of their actions. Resilience includes social interaction and integration. Thus, people easily overcome negative images in their own eyes, as well as negative images in the eyes of other people. Therefore, social interaction and integration contribute to the improvement of the quality of life and the image of the city.

All of the above-mentioned strategies for the building of environmental and social systems, as well as economic instruments in the field of environmental protection, as listed in the previous section, are applicable as principles or guidelines in the process of the renewal of brownfield locations.

In order to achieve sustainability objectives through the reuse of brownfields, it is necessary to search for practical examples. Namely, it is necessary, beyond merely defining the terms and objectives of sustainability, for local governments to move quickly towards the implementation of urban adaptive planning. The *ICLEI - Global Forum on Urban Resilience and Adaptation*, which has been continuously hosted in Bonn (Germany) since 2010, helps local governments and other organisations to achieve sustainability objectives in brownfield locations by offering practical examples from around the world, case studies, innovations, ideas, suggestions, lessons, and advice on how to create resilient cities (Resilient Cities series).

The process of brownfield regeneration also requires an interdisciplinary approach and staff with specific skills, as well as specific databases. Sustainable renewal of brownfield locations is only possible if there is

competence and the ability to communicate with different experts in order to solve problems in better ways.

5 Conclusions

This research into brownfield and economic, environmental, and social sustainability has allowed a broad elaboration of these topics highlighting the need for sustainable land-use.

Brownfields constitute large land resources for many cities, and efficient use of urban land is a significant basis of current and future sustainable development strategies. Therefore, the question is raised as to how to renew brownfield locations to be sustainable.

The answer to the research question has been synthesised through the consideration of sustainable brownfield regeneration definitions and the definition of both economic instruments in the field of environmental protection and strategies for the building of environmentally and socially resilient systems. Additionally, the sustainability objectives that should be achieved through the renewal and redevelopment of brownfield locations are listed. It is emphasised that the sustainable development process requires continuous revision in order to adapt to changes, priorities and the development of knowledge and technology that take place during the process of brownfield renewal. It can be seen that much greater flexibility in managing this process is needed. To this end, it is necessary to observe cities as complex adaptive systems with interconnected structural components (economic, ecological, and social), each of which can be planned and designed individually. This view of cities enables higher quality and more resilient improvements.

Resilience is "a complex, multi-dimensional challenge for urban sustainability planning and design" (Ahern, 2011, p. 343) which requires an adaptive capacity in urban plans with regard to environmental changes, such that planning may be more flexible in the future. Therefore, urban planning does not have to be rigidly defined, and environmental changes should be understood as opportunities for analysis and learning. Resilience requires the monitoring, assessment, and innovative renewal of urban plans in relation to current and future situations. Resilience is the key for local development, as urban systems and communities need to be able to anticipate, ameliorate, and survive stressful situations, and adapt and recover after them. The capacity and ability for this are possessed only by the resilient city, so in planning long-term sustainability cities have to improve their resilience and manifest a synergy between sustainable planning and the reduction of stress risks.

To these ends, it is necessary firstly to note that brownfield locations typically represent economic, environmental, and social problems for cities, and to define the strategic concepts and priorities for the development of these areas. It is essential to adopt a policy of attracting and directing investors to brownfield locations, eliminating existing legal

barriers to their renewal and giving stimulation for investment in their renewal. It is also necessary to educate the public about the benefits of reusing brownfields, and to disseminate information and knowledge about successful examples of sustainable brownfield regeneration. These actions will contribute to a more comprehensive consideration of both the problems and the potentials of brownfield locations, thus initiating the development of better design for brownfield renewal.

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