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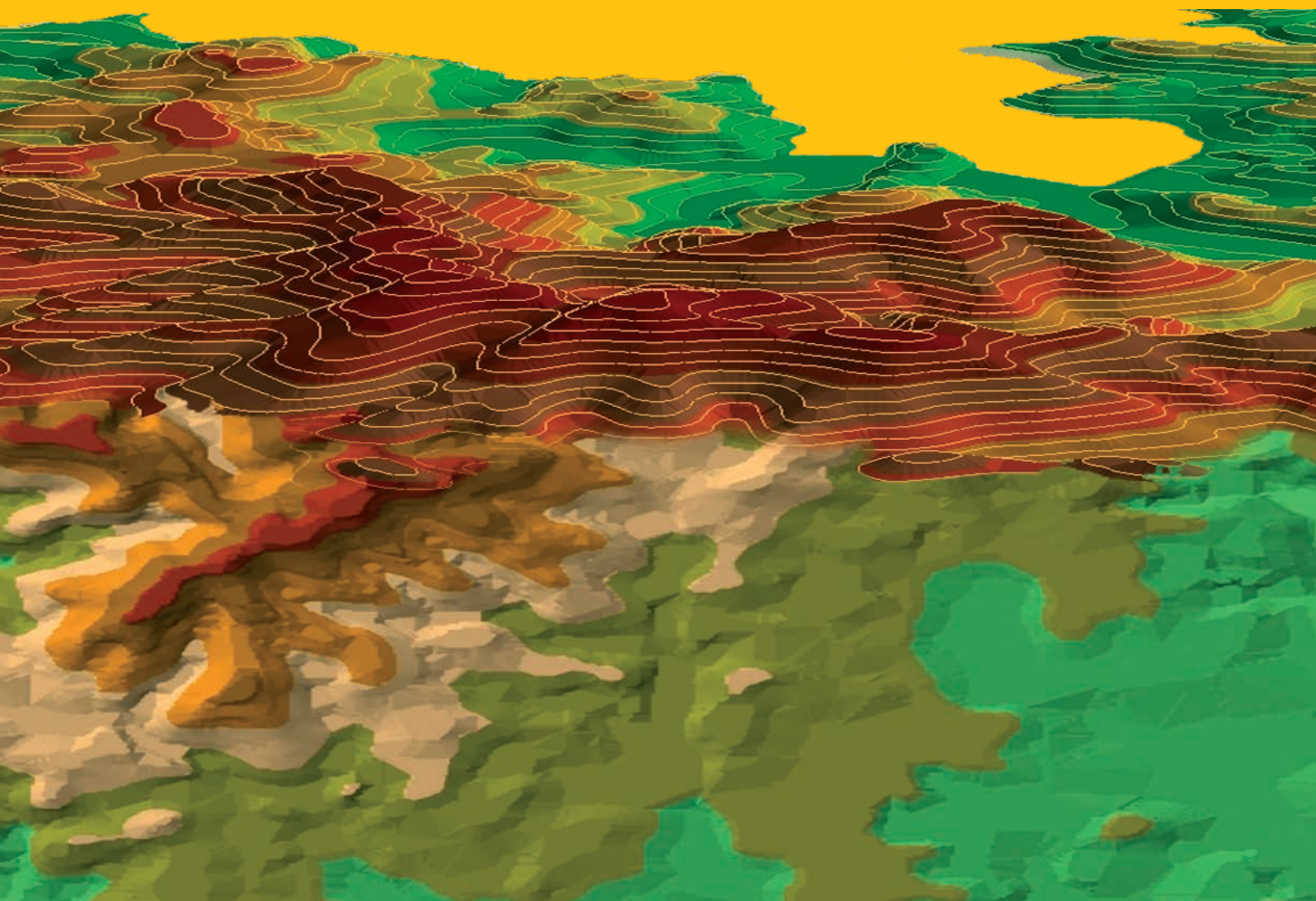

Fig. 4: Derelict site of previous coal-fired power plant in Oslavany municipality (Photo: J. Kunc)

Fig. 5: Derelict complex of previous textile factory Vlněna in Brno city centre (Photo: J. Kunc)

Fig. 6: Regenerarted buildings of the previous sugar factory in Židlochovice municipality (Penny Market, restaurant, and sport centrum) (Photo: J. Kunc)

Illustrations related to the paper by Bohumil Frantál, Josef Kunc, Eva Nováková, Petr Klusáček, Stanislav Martinát and Robert Osman

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Articles:

BROWNFIELDS: A GEOGRAPHICAL PERSPECTIVE

(Editorial for Special Issue)

Bohumil FRANTÁL, Stanislav MARTINÁT

The issues of remediation, regeneration and redevelopment of underused, abandoned, derelict and often contaminated lands and premises (so-called "brownfields") have recently become one of the greatest challenges for municipal planners and developers. Brownfields are results of economic restructuring processes in many countries; they are perceived as potential hazards to human health and the environment, burdens degrading the value of surrounding properties, barriers to local development and contributors to urban sprawl, grounds for neighbourhood crime and other illegal activities, etc. (see e.g. Greenberg et al., 2000; Susilawati, Kelsey, 2012).

The regeneration of brownfields has become more common during the last two decades since vacant developable land (or "greenfields") is less available, more expensive and more protected in densely populated areas and as a result of emerging policies, economic instruments, and management tools supporting the regeneration processes. The increasing number of projects and research platforms, which are supported by the European Commission or by national authorities, demonstrates the increasing interest of policy makers, too. On the other hand, as the global economic recession (or at least stagnation) proceeds, investments fall, many industries disappear or are moved to countries with lower labour costs – new brownfields emerge and redevelopment is still constrained by many barriers at economic, legal, political, social and technological levels.

The regeneration of brownfields is a complex and multidimensional problem that requires further interdisciplinary research. Such research should involve a variety of disciplines, such as technical sciences, environmental science, human and physical geography, economics, management and marketing, political science, sociology, law, etc. It should apply integrated approaches to create a vision of change across different stakeholder groups (politicians, developers, local communities, NGOs, researchers, experts, etc.) as well as across departmental and administrative boundaries, which constitute the scope of landscape planning and decision making to manage the required redevelopment processes as cost effective, profitable and economically, environmentally and socially sustainable.

The aim of this special issue of Moravian Geographical Reports is to extend the knowledge base about the nature, scale and dynamics of brownfields evolution and to provide theoretical and methodological tools for the identification of drivers of and barriers to the brownfield regeneration process. The emphasis is placed on analyzing and conceptualizing brownfields from the geographical (or spatial) perspective. Brownfields do not exist by themselves; they are located and rooted in a certain space, which exhibits hierarchical and functional structure. The geographical environment and driving forces acting within it have caused the formation of brownfields, and at the same time, the actual existence of brownfields affects the environment in many ways. With its integrative view of the world, geography can provide a framework for conceptualizing brownfields as products of the interrelationships between places and social and ecological processes (Bjelland, 2002).

Moreover, Geographic Information Systems (GIS), as an integral part of contemporary geography, can serve as a key tool for brownfields management (mapping, inventorying), control and decision support (site assessment, classification, and prioritization), and marketing (promoting revitalized sites to potential businesses – see e.g. Thomas, 2002 or Chrysochoou et al., 2012). Spatial analytical methods provided by GIS (e.g. hot spot analysis, neighbourhood-scale analysis, dispersion modelling, overlay analysis or advanced proximity analysis) have the potential to explore spatial effects of investments (how have the policies and regeneration processes affected their neighbourhoods in the sense of changing housing market conditions, local economic development, population growth, etc.) (Leigh and Coffin, 2005). They are useful for detecting evidence of environmental injustice (spatial relationship between the location of environmentally degraded brownfields and socio-demographic and health indicators of surrounding communities) (Maantay, 2002), assessing a realizable potential of brownfield sites for the development of renewable energies (Adelaja et al., 2010; Fyodorova, 2013) or to streamline the planning and decision-making process through wider public involvement (so-called public participation GIS) (Boot et al., 2001).

The reason why spatial analyses have not been applied in brownfield studies more frequently to date is the problem of availability and comparability of the objective data (official statistics, databases and registers of brownfields). Mapping and inventorying of brownfields is not centrally organized in many countries (Oliver et al., 2005). Detailed inventories (with specific location information, GIS layers, etc.) are unavailable or inconsistent (as different regional or local authorities use different criteria and methodologies); and registers owned by private companies (or consortia of owners) are often protected or provided only with limited descriptive information without the possibility of publication.

The papers presented in this special issue have benefited from utilizing detailed brownfields data, which might be used for spatial analyses.

In the first paper by Frantál et al., the authors present an introductory review of the academic literature, discussing the development of the brownfield concept, and putting the problem of brownfields regeneration into a spatial context. Then they attempt to verify empirically (analyzing data from the South Moravian Region, Czech Republic) which location and site-specific factors (e.g. peripherality of location, transport links, local economic potential, infrastructure, level of contamination, etc.) have a decisive influence on the successful regeneration of brownfields.

In the second paper by Krzysztofik et al., the authors (using data from the city of Sosnowiec, Poland) propose an individual typology for "functionally derelict areas", which dwells on a spatial and dynamic view of land use evolution (from the original, through transitional stages to the present state), reflecting the variability of land functions in time and space, as well as the specifics of local conditions.

The third paper by Novosák et al. focuses on the Ostrava metropolitan area, an area whose historical development was based typically on underground coal mining and the steel industry. The massive decline of these industries (ongoing from the 1990s) resulted in a large number of brownfields in the area. The paper attempts to explore and verify statistically significant differences in the spatial location and selected attributes of brownfields and redeveloped sites, and to identify basic types of brownfields in the model area.

The fourth paper by Skála et al. gives attention to post-agricultural brownfields, which are typical phenomena in post-socialist countries (as relicts of the transformation of the previous large-scale, centrally-planned agricultural sector). This type of properties that are specific in their spatial distribution, extent and character, surpasses the experiences of the EU15 countries or USA, which have longstanding practice in the redevelopment of primarily post-industrial and urban brownfields.

The final paper by Sun and Jones comes from the USA. Although the geographical scope of the MGR journal is intentionally limited to Europe, we decided to make an exception and to include this paper for the following reasons: the USA has already long-term research and practical experience with the regeneration of brownfields, and the paper (exploring spatial patterns and linkages between brownfield redevelopment projects and residential property values and neighbourhood demographic changes in Milwaukee County) presents a methodology (utilizing GIS), which could be applied in European conditions as well.

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LOCATION MATTERS! EXPLORING BROWNFIELDS REGENERATION IN A SPATIAL CONTEXT (A CASE STUDY OF THE SOUTH MORAVIAN REGION, CZECH REPUBLIC)

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Stanislav MARTINÁT, Robert OSMAN

Abstract

In this paper the authors attempt to answer the question of which location and site-specific factors have a decisive influence on the successful regeneration of brownfields. Using data from the South Moravian Region (Czech Republic), we analyze the spatial and functional distribution of brownfields, and test the correlation between the development potential of municipalities and the distribution of the brownfields that have already been regenerated. We then compare the structure and characteristics of existing and regenerated brownfields to identify significant drivers and barriers in the regeneration process. The findings indicate that regenerated brownfields are more likely located in municipalities with a higher local development potential (represented by the rate of local business activities, spatial peripherality –proximity to the regional centre and the main road network, and the quality of local infrastructure). It is also demonstrated that the large size of brownfields, their previous industrial use and the existence of contamination are not determinative barriers for regeneration if the brownfields are located in attractive areas and their ownership relations are not complicated.

Shrnutí

Na poloze záleží! Zkoumání regenerace brownfields v prostorovém kontextu (příklad Jihomoravského kraje, Česká republika)

Článek se snaží odpovědět na otázku, které lokalizační a specifické faktory mají rozhodující vliv na úspěšnou regeneraci brownfields. S využitím dat za Jihomoravský kraj, autoři analyzují prostorovou a funkční distribuci brownfields, testují souvislost mezi rozvojovým potenciálem obcí a rozmístěním již regenerovaných brownfields a porovnávají strukturu a charakteristiky existujících a regenerovaných brownfields, aby identifikovali signifikantní katalyzátory a bariéry procesu regenerace. Výsledky ukazují, že regenerované brownfields se mnohem častěji nachází v obcích s vyšším rozvojovým potenciálem, který je reprezentován zejména mírou lokální podnikatelské aktivity, periférností (blízkostí k regionálními centru a napojením na hlavní silniční síť) a kvalitou lokální infrastruktury. Také se potvrdilo, že velikost brownfileds, jejich předchozí industriální využití a existence kontaminace nepředstavují rozhodující bariéry, pokud se nachází v atraktivní lokalitě a nemají komplikované vlastnické vztahy.

Keywords: *brownfields, development potential, success factors, spatial analysis, South Moravian Region, Czech Republic*

1. Introduction

Brownfield has become a worldwide recognized term that refers to "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 … may be vacant, derelict or contaminated … therefore not necessarily available for immediate use without intervention" (Alker et al., 2000:49). The term originated in the early 1990s (e.g. Laws, 1994; Syms, 1994; Hanley, 1995) when practitioners and researchers saw how emerging regulatory frameworks designed to protect the environment were (as a side effect) inhibiting the re-use (clean-up and redevelopment) of former industrial and commercial sites (Bartsch and Collaton, 1997). Brownfields are results of changing patterns of

industry and development in many regions. They are largely regarded as liabilities degrading the value of the surrounding land (in the environmental, economic and social sense), it is often difficult to sell them, and municipalities are unable to revitalize them from their own resources (cf. Cabernet, 2005).

Some countries, for example USA, United Kingdom, France and West Germany, have long-term experience with the problems of brownfields, which had emerged already during the 1970s as a result of massively declining mining, heavy industries and textiles. In comparison, in countries such as the Czech Republic, Slovakia, East Germany, Poland or Romania, brownfields appeared in large quantities just after the collapse of socialism with the centrally planned economy and return of a market economy and the following globalization trends during the last decade of the 20th century.

Generally, the regeneration of brownfields has received increasing political credence in recent decades, since vacant agricultural or natural developable lands (or so-called "greenfields") become less available and more expensive in highly populated areas. The increasing number of various projects and research platforms being supported by the European Commission or national grant systems during the last decade is quite evident in the growing interest of policy makers in matters of brownfield regeneration (see the summary report on activities, products and tools developed by previous brownfield projects by Tölle et al., 2009).

However, redevelopment has not been as effective as expected in many regions. Potential investors are often afraid of risk and uncertainties related to brownfields regeneration and they prefer to develop projects on greenfields. Especially in the post-socialist countries, a majority of investors who were engaged in brownfields regeneration were companies with foreign capital, for which economic profit and a fast return on investment were the key factors of investment. Thus, projects of a commercial use (e.g. supermarkets or shopping malls, offices and representative business headquarters or lucrative housing developments) realized mostly in large cities, are the most obvious regeneration projects. On the contrary, in developed countries such as USA, Sweden, Netherlands, or Germany, more frequently projects (especially in cases of the regeneration of larger post-industrial complexes) are based on investments provided by both private and public funds or by a so-called public-private partnership (Paull, 2008; Kalberer et al., 2005).

The objective of this paper is to answer the following questions: What factors have a decisive influence on the fact that just some brownfields have been successfully regenerated and are being newly used, while other ones stay derelict and vacant, or the process of their redevelopment has not been successfully completed? Why does the private sector invest in some regeneration areas and not in others, and what local and site-specific factors influence the decisions of investors and developers? These are the key issues for central and regional authorities, regional development agencies, urban planners and other decision makers who are responsible for wider territories (cities, districts, regions) and who need to effectively distribute and direct limited available resources, time, and energy to those locations and sites where publicly (co-)financed regeneration is required (i.e. locations where market forces are considered to be weak and display low levels of market efficiency) (cf. Ball et al., 1998).

2. Exploring brownfields as spatial phenomena: theoretical background

Besides the temporal or historical factors affecting the formation and evolution of brownfields in different countries (e.g. the specifics of evolution and structure of brownfields in post-socialist countries), it is argued that internal geographical factors also affect the actual situation and patterns of redevelopment. Oliver et al. (2005) identified significant regional trends amongst definitions or respectively concepts of brownfields, which reflected the national policy strategies regarding land regeneration and development in Western Europe, Eastern Europe and the Scandinavian countries. These authors documented how two indicators – population density and economic competitiveness – at a country level, determine the perception of what brownfields and derived regeneration priorities are (i.e. definitions and policies) – from pure contamination problem focus to development potential gaining understanding (cf. Oliver et al., 2005).

Even the conceptual delimitation and definition of brownfields is a dynamic element and has been changed and modified in the course of time and geographical contexts (see Box 1).

Besides the problem of finding a consensus on the conceptual definition of brownfields, the existing research[1] on brownfield regeneration has mostly focused on the following thematic areas:

[1] This paper focuses primarily on research work in the field of social sciences; however, brownfield regeneration (especially the problems of soil decontamination and remediation of sites) also has been dealt with in the sphere of environmental management, engineering geology, soil ecology, etc.

- Constructing a conceptual framework: structuring the regeneration process, identification of its particular phases, life cycles, components and actors (or stakeholders), and specification of their features and roles in the process – creation of regeneration "models" (e.g. Dixon and Doak, 2005; Pediaditi et al., 2005; Dixon, 2007; Williams and Dair, 2007);
- Exploring drivers and barriers: surveying and analyzing factors, which are significant for the success of the regeneration process; classification of these factors according to specific geographical or land-use contexts, exploring inter-group variability in perceptions and differences in the assessment of factors by specific stakeholder groups (e.g. Nijkamp et al., 2002; De Sousa, 2003; Lange and McNeil, 2004a; Alberini et al., 2005; Bacot and O'Dell, 2006; Dixon, 2007);
- Monitoring positive and negative effects and consequences: reporting about "good practices" or "bad practices", defining measures of success and sustainability of regeneration projects, assessing the economic, environmental and social impacts of projects (e.g. Lange and McNeill, 2004b; Franz et al., 2007; Wedding and Crawford-Brown, 2007; De Sousa et al., 2009; Doick et al., 2009; Hula, Bromley-Trujillo, 2010; Rall, Haase, 2011); and
- Developing classification and prioritization systems and assessment tools: establishing the quantitative criteria for valuation, classification and prioritization of brownfield sites as a part of the planning, decision-making and selection processes (e.g. Sayah, 2002; Thomas, 2002a, 2002b; Chen et al., 2009; Cheng et al., 2011; Bartke, 2011; Pizzol et al., 2011; Schädler et al., 2011; Agostini et al., 2012; Chrysochoou et al., 2012; Schädler et al., 2012).

The published works range from qualitative and more descriptive local case studies through to comparative case studies investigating more examples within specific areas (cities, regions) to a few complex meta-evaluations of existing methodologies, classification systems and tools (Dasgupta and Tam, 2009; Pediaditi et al., 2010).

In terms of practical policy (i.e. spatial and land-use planning, regeneration management, place marketing, etc.), representatives of public administration and other decision makers at different hierarchical levels (state governments, regional authorities and regional development agencies, local governments, etc.) pay (or should pay) special attention to the following strategic tasks concerning brownfields:

Box 1: Defining the indefinable?

Prevailing diversity and fluidity of definitions is maybe the most noticeable characteristic of "brownfields". At the beginning, the term was associated primarily with urban regeneration (Hanley, 1995; Lederman and Librizzi, 1995) and brownfields were defined by some authorities strictly as city areas and buildings (cf. Alker et al., 2000; Oliver et al., 2005). Later, the concept exceeded urban space and covered rural areas, too. Some national or departmental authorities have been using the term very universally and flexibly (including objects of all (post-) industrial, agricultural, business, military, transport, warehouse, housing, sport, and other land uses), while others regarded brownfields exclusively as industrialized sites or their conceptualizations excluded some types of objects or land uses such as agriculture (Syms, 1994), mining (Czechinvest, 2008), landfills or gas stations (see the international comparison of definitions summarized by Kirschner, 2005; Oliver et al., 2005). Contamination of sites has been another selection criterion. While in some countries (e.g. USA, Romania, Italy), brownfields are solely regarded as polluted or contaminated lands, some countries (e.g. Czech Republic, England) regard soil or groundwater contamination as an obvious yet not conditional characteristic of brownfield sites.

A similar definitional problem exists for "successful regeneration". According to some politicians, almost any project of regeneration - especially in locations with a large concentration of brownfields - is a success. However, the success can be assessed from different perspectives (according to region, academic discipline, stakeholder group, etc.) and measured by different indicators (Wedding, Crawford-Brown, 2007, Rall, Haase, 2011). According to Doick et al. (2009), success in brownfield regeneration has been generically described as economic benefit (De Sousa, 2003) or as civil infrastructure renewal, tax-based development, economic development and neighbourhood revitalization (Amekudzi, Fomunung, 2004). Doick et al. (2009) stress the importance of applying the concept of sustainability (including economic, social and environmental criteria) into the assessment of projects. The issue of success is even more complicated by the fact that successful regeneration could be replaced (especially in the conditions of a market economy) by unsuccessful development very quickly (see e.g. Dixon, 2007; Bacot, O'Dell, 2006).

Generally, the problem of defining "regeneration" also has spatial and temporal aspects. The first one is connected with the question whether a brownfield can be regarded as (successfully) regenerated when just a part (e.g. a few buildings) of a larger site is redeveloped, while the rest stays derelict. Another dilemma occurs when a site has been newly used and produces economic profit but without previous intervention (remediation, reconstruction: for example if vacant buildings are used as provisional storage spaces or when solar panels are constructed on contaminated land). The temporal aspect is connected with the question of what length of time should lapse between the previous use and the new use of a site to become a brownfield and not just a continual development. In the sense of these previous questions, brownfields can be divided at least into five categories: (i) newly used after complete (or almost complete) regeneration, (ii) newly used without significant regeneration changes, (iii) within the stage of regeneration, (iv) prepared for a new development (after demolition, decontamination), (v) derelict. (cf. more detailed categorization applied by the Liberec Region (2012)).

The prevailing diversity of concepts and definitions does not simply result from diverging national approaches, legislatures and policies (see e.g. Jackson, Garb, 2002; NICOLE, 2011), but it goes hand in hand with the problem of comparability of available data, including official statistics, inventories and registers of existing brownfields, documentation of successful regeneration case studies, etc.

- Inventorying – mapping, identification, analysis and registration of existing brownfields in specific territorial administrative units (regions, districts, cities). Inventories (registers, databases) could have the form of a table database (with basic descriptive data), info-sheets with more detailed information about sites and on-going regeneration stages and/or GIS layers (maps with coded sites and additional information);
- Prioritizing – evaluation and classification of brownfields according to their redevelopment potential, environmental risk or other criteria, which assists in the allocation of limited available resources (funding, time and energy) to those brownfield sites that are assessed as the most critical, urgent or profitable to redevelop; and
- Marketing – the application of information from databases for marketing of selected (prioritized) brownfields, fundraising, searching for potential private investors or public subsidies (e.g. EU structural funds), promoting examples of successful regenerations ("best practices") to stimulate the regeneration process.

It is important to emphasize that brownfields do not exist by themselves, independently, or in a vacuum. They are placed and rooted in a certain geographical space, which is hierarchically and functionally structured and also determined by individual sociological contexts: therefore, every brownfield site can be seen as quite unique. The geographical environment and driving forces acting within it have resulted in the formation of brownfields, but at the same time the actual existence of brownfields affects the environment on the rebound. Therefore, brownfields have to be perceived in their spatial context and we should take into account (when assessing them) not just site-specific attributes but also contextual factors acting at a higher hierarchical level (cf. Dasgupta, Tam, 2009; Chrysochoou et al., 2012). The factors affecting the evolution and potential regeneration of brownfields are summarized in Tab. 1.

It is not possible to say *a priori* which of the general factors, location factors or site-specific factors are the most important determinants and drivers of the regeneration process. The table represents an open system (with other macro factors – geographical, historical, political, and economic – acting on higher hierarchical levels, e.g. global economic trends, political processes and regulatory acts at the European Union level, etc.) where partial factors are related and affect each other. To identify and analyse the relative importance of each of these is a task for comprehensive and interdisciplinary research, which is limited by the availability of data and by the fact that it is impossible to objectively quantify and measure the effect of many factors (especially those "soft" factors acting on macro and meso levels).

With respect to brownfield regeneration, the location factors can be regarded as local development potential or area competitiveness, which is a result of and a complex expression of environmental conditions, economic potential and social capital (see e.g. Coombes, Raybould, 1989; Coombes et al., 1992; Wong, 1996). The factor of development potential of a locality is very relevant for the brownfields regeneration issue,

Spatial level	Factors	Characterization
Macro level	General factors	General factors are associated with political, economic, and social climate of countries or broader regions. They include: the legislative instruments concerning national and regional development policies, spatial planning strategies; economic instruments including grant titles, bank loan availability, subsidies, tax benefits, foreign direct investments; regeneration management instruments including availability of information, databases, tools, education, and political-institutional practices, etc.
Meso level	Location factors	Location factors are characteristics and attributes of the location (area) where a specific brownfield is located. For different spatial levels it could be a municipality, district or region. Every particular factor (or measurable indicator) is relevant at a different spatial level according to data availability. They may include geographical location within a region, transport links, socio-demographic structure of local population, economic potential, rates of unemployment and business activities, social capital, and also "soft factors" such as local political leadership, community involvement, etc.
Micro level	Site-specific factors	These factors are related to particular brownfield sites. They are typically represented by the property size, previous use, number of buildings and structures, soil quality and extent of contamination, available infrastructure, ownership/property relations, actual property price, expected demolition and remediation costs, etc.

Tab. 1: Spatial scale of success factors. Source: Authors' conceptualization

from several points of view which are all interrelated. They can be described in the form of the following assumptions or hypotheses that drive this research study:

- Brownfields have originated in areas with socioeconomic structures and a concentration of industries that were in some way affected by economic, demographic or social changes and transformations;
- Regenerated brownfields are more likely located in areas characterized by higher development potential (i.e. a low development potential of localities is one reason why investors are not interested in brownfields which are located there); and
- A long-term presence or a larger concentration of brownfields in certain localities or regions affect negatively their image and decrease even more their actual development potential.

In this study, we will try to verify the above-stated hypotheses by using brownfields data from the South Moravian Region in the Czech Republic.

3. Case study: analysis of brownfields in the South Moravian Region

3.1 Study area

The Czech Republic belongs to the group of countries with a very large recent appearance of brownfields which are especially associated with the long-term industrial traditions of the country. The fall of socialism in 1989 and the return of the free market economy caused the collapse of many economic activities, decline and restructuring of many sectors including agriculture (Svobodová and Věžník, 2009), coal mining (Vojvodíková, 2005), heavy industry (Klusáček, 2005), the textile industry, military spending (Hercik et al., 2011), etc. Later on, global economic trends further affected the restructuring of traditional industries. The current occurrence of many abandoned, neglected, unused areas and buildings of different types and scales (from small-sized areas of up to one hectare to "megasites" covering tens of square kilometres) is one of the results of these processes.

The Czechinvest Company (2008) implemented, within the scope of the Czech National Strategy of Brownfields Regeneration, a monitoring study (Search Study of the Localization of Brownfields, 2005–2007) which identified in total 2,355 brownfields in the country's territory. However, this number is approximately just one fourth of the real estimated state of all existing brownfields. Database representativeness is limited by the fact that different regions have used different methods and criteria for the mapping and inventorying of brownfields. Recently some regional authorities started to prepare their own up-dated databases of existing brownfields, with more complex information to assess and prioritize the sites according to their potential, promote them to attract investors and to stimulate the regeneration process.

For the purposes of our analysis we used the brownfields data of the South Moravian Region, which can be regarded as one of the most systematic and complex brownfield inventories in the Czech Republic. The South Moravian Region is located in the South East of the Czech Republic and shares a border with Austria and Slovakia (see Fig. 1). It is the fourth largest in area and third largest in the number of inhabitants among the regions in the Czech Republic. The region consists of 673 local administrative units (municipalities). The city of Brno is the geographical and administrative centre of the region and it is the second largest city in the Czech Republic (with

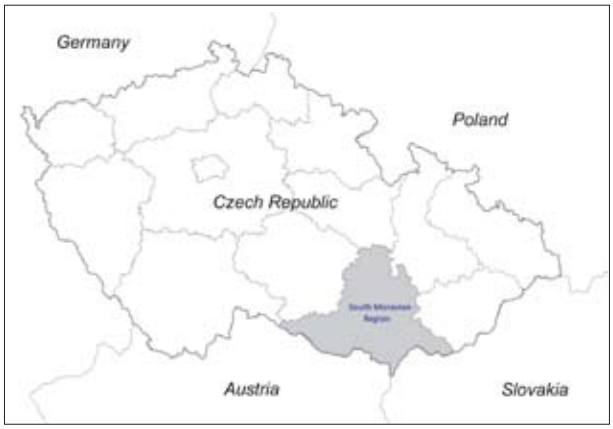

Fig. 1: Area under study

Total area	719,555 ha
Population	1,166,313 (in 2011)
Population density	ca. 162 inhabitants/km^2
Statutory city	Brno (population approximately 379,000 inhabitants)
Number of Districts (NUTS4)	7 (Blansko, Brno, Brno-venkov, Břeclav, Hodonín, Vyškov, Znojmo)
Number of municipalities (NUTS5)	673 (incl. 49 cities and 41 townships)
Municipalities with extended jurisdiction	21

Tab. 2: Basic characteristics of the South Moravian Region. Source: Czech Statistical Office, 2011

ca. 379,000 residents and a greater metropolitan area with ca. 800,000 residents). Basic characteristics of the region are summarized in Table 2.

3.2 Data sources and methods

The objective of this paper is to analyze factors affecting successful brownfield regeneration. The analysis attempts to answer questions such as: why some brownfields have become objects of concern for developers, politicians, experts or other actors, having been selected as the most profitable or urgent to invest money, time and energy, regenerated and newly-used, while other sites have been out of attention, remaining neglected or derelict, or the process of their regeneration has not been successfully completed.

In order to answer the above questions, we apply a spatial and statistical analysis of objective data (inventories of existing and regenerated brownfields), unlike most previous studies which explored and assessed the significance of factors affecting brownfields regeneration, according to various stakeholder surveys, interviews with experts (De Sousa, 2003; Alberini et al., 2005) or case studies (reconstruction of regeneration processes) of a few specific projects (Franz et al., 2007). Moreover, while most of the previous studies focused on "soft" factors and procedural processes facilitating redevelopment (governmental support, type of funding, political leadership and collaboration, community involvement, etc.), we focus deliberately on the relevance of "hard" or more concrete spatial factors as determinants of the regeneration process.

Our analyses are based on the following data sources:

a) Regional database of existing brownfields – provided by the Regional Development Agency of the South Moravian Region. This database consists of 362 brownfields located in 135 municipalities in the region (including 127 sites in Brno city). The database includes basic site characteristics such as identification code, location, site name and description, area size, original use, current use, type of ownership, contamination, available infrastructure, etc.). As concerns the size criterion, the database covers brownfield sites larger than one hectare or built-up areas larger than 500 m^2 in the case of single objects;
b) Database of successfully regenerated brownfields –collected by the authors from a literature retrieval of various reports about successful regenerations of brownfields (e.g. RRAJM 2010, 2011), and a survey with representatives of municipalities with extended jurisdiction (asking for examples of successful regeneration in the municipalities of their administrative district). This database includes 75 cases of regenerated brownfields located in 37 municipalities (with 35 cases in Brno city). Newly-used brownfields after complete (or almost complete) regeneration were recorded in the database (i.e. partially used sites without significant regeneration changes were excluded); and
c) Statistical data on municipalities – indicators were selected that were thought to be representative of phenomena and processes that are characteristic for the development of municipalities (including geographical, demographic and socioeconomic indicators). In this selection process, we were inspired by the previous studies of local development potential or local competitiveness (Coombes et al., 1992; Wong, 1996, 1998; Bernard, 2011). The final selection, however, was driven by the specifics of brownfields regeneration problems but also limited by the availability of statistical data at the level of municipalities in the Czech Republic.

First, we analyze the spatial distribution of existing brownfields according to their previous use, area size, current use, and property relations. Second, we assess the development potential of municipalities by applying a principal component analysis (PCA) to municipal data in order to explore the structure of relations among selected variables and to find out if they can be divided into groups with similar meanings. These groups (components) then represent new factors, which we test in relation to the spatial distribution of regenerated brownfields. Third, we apply correlation analysis to test the relations between the values of overall potential of municipalities or its components (as independent variables) and the number of regenerated brownfields in municipalities (as dependent variable) to validate our set of indicators and the assessment model. Fourth, we analyze the structure and characteristics of regenerated brownfields and compare them with the structure of existing brownfields to identify which site-specific factors are significant drivers for the regeneration process.

3.3 Spatial distribution and structure of existing brownfields

The spatial distribution of brownfields is uneven, i.e. there are more brownfields located in some municipal cadastres while other municipalities have no evidence of brownfields. The distribution of brownfields (see Tab. 3) reflects general national trends: the larger concentration of sites (mostly post-industrial ones) is in the larger cities (see Figures 4 and 5 on cover p. 2); the other brownfields (predominantly post-agricultural) are located mostly in traditional rural micro-regions. The third most frequent types of brownfields are those previously-used objects of civic

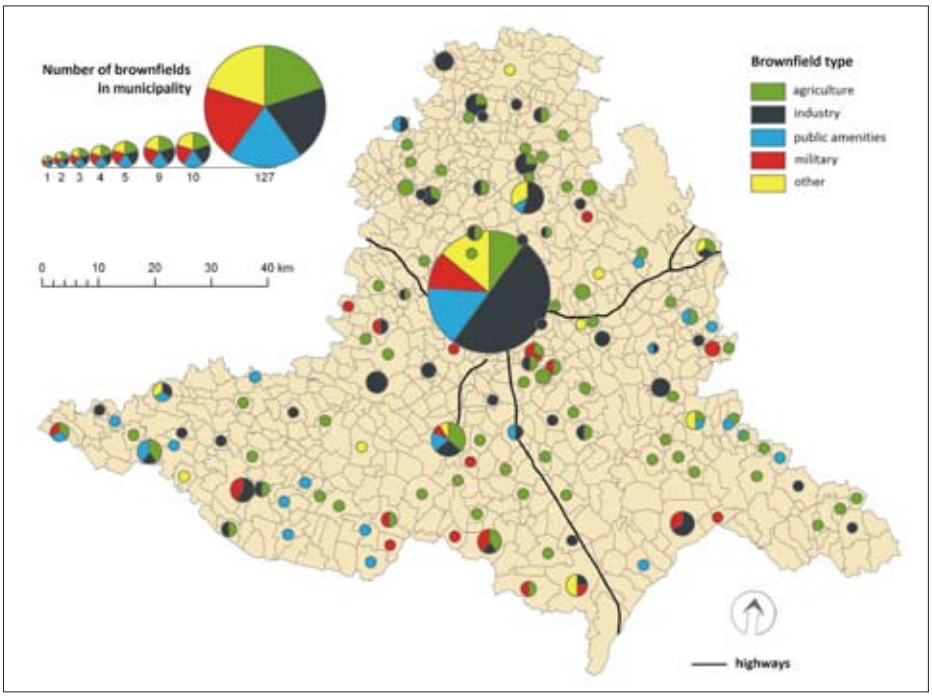

Fig. 2: Spatial distribution of existing brownfields in the South Moravian Region
Source: RRAJM, Authors' elaboration

	Total number in region	% of total in region	% of total in Brno	Total area (ha) in region	% of total area	Average area (ha)
Industrial	134	37.0	49.0	557	38.0	4.2
Agricultural	108	30.0	11.0	381	26.0	3.6
Military	34	9.5	9.0	315	22.0	9.3
Civic amenity	52	14.0	16.0	57	4.0	1.1
Other	34	9.5	14.0	144	10.0	4.2
Total	362	100.0	100.0	1453	100.0	4.05

Tab. 3: The structure of brownfields in the South Moravian Region according to their previous use and area size
Source: RRAJM, Authors' calculations

amenities (closed schools, cultural houses and hotels), which are concentrated mostly in peripheral rural areas near the southern and eastern borders of the region. A significant proportion of brownfields in the region is represented also by post-military sites and objects (barracks, hangars, etc.), which are located mostly on the southern border (previously known as the "iron curtain") with Austria and in the city of Brno and close surroundings.

As the largest city in the region, Brno has the highest concentration of brownfields. Previous industrial sites and vacant factory complexes represent nearly one half of them. There is also a higher concentration (in comparison with the rest of the region) of derelict sites of previous civic amenities, sports facilities and objects that were previously used for transport services (the most obvious type in the category of "others"). Generally (as concerns the whole region), post-military sites occupy on average the largest areas while the smallest ones are sites of abandoned civic infrastructure (schools, local cultural centres, tourist hotels). The category "other" is represented mostly by sites and buildings connected with the rail transport infrastructure, church buildings and castles.

More than one half of all brownfields (in Brno more than two thirds of brownfields) are currently partially used for some provisional productive activities (most usually some buildings are utilized as warehouses, storage spaces or premises for small-scale production and businesses). Most often, the temporarily-used spaces are parts of larger post-industrial brownfields (previous factory complexes) in cities, and buildings of former agricultural cooperatives in rural municipalities. As might be expected, brownfields without complicated property relations are more likely to be utilized.

3.4 Assessment of the development potential of municipalities

A final data set comprising the 25 variables considered as indicators of local development potential was examined, from which 16 variables were used in the factor analysis (see Tab. 4). We excluded non-relational variables (i.e. variables that represent absolute values and do not account the size of spatial units/ population), subsequently variables inappropriate for the factor analysis (dichotomous variables and those with high frequencies of zero values) were excluded or transformed into new variables. We used the method of principal components analysis, with the Oblimin rotation method. The measures of the Kaiser-Meyer-Olkin test of sampling adequacy (KMO = 0.731) and Barlett's test of sphericity ($p < 0.001$) confirmed the appropriateness of the selected variables for the factor analysis. The total variance explained by four extracted factors is 62%. The factors were named as follows: (i) Peripherality; (ii) Demographic growth; (iii) Business activity; and (iv) Infrastructure.

At the first stage of calculating the overall development potential we recalculated the values for each of 16 ariables that were of different scales (in the ranges from <0–3> to <2–265>) and transformed them into variables of similar scales. We applied a formula that allowed us to assign a dimensionless index between 0–1 to any concrete value.

There are two possible methods of calculation, which are as follows:

a) $$I_{xi} = (X_i – X_{min}) / (X_{max} – X_{min})$$

(with the growing value of X_i indicator quality / the potential of partial indicator is increased);

b) $$I_{xi} = (X_{max} – X_i) / (X_{max} – X_{min})$$

(with the growing value of X_i indicator quality / the potential of partial indicator is decreased)

At the second stage we computed partial scores for all four extracted components of the development potential (accounting for the weights of respective variables resulted from the PCA), and then the overall score as a total sum of the four components. For simplicity, clarity and representation for graphic visualisation, the values for all partial components as well as the total sum index for all municipalities were converted into five categories (quintiles) according to

	Component			
	1 Peripherality	2 Demographic growth	3 Business activity	4 Infrastructure
Distance from Brno city	– 0.894			
Unemployment rate	– 0.755			
Distance from expressway	– 0.737			
Distance from MOJ	– 0.559			
Housing development		– 0.858		
Population growth		– 0.815		
Age index		0.599		– 0.473
Tax revenues per capita			0.712	
Business activities			0.704	
Education index	0.348		0.641	
Employment in tertiary sector			0.530	0.341
State subsidies per capita			0.518	
Population density	0.320		0.517	
Available communal amenities				0.795
Infrastructure				0.785
Rail connection				0.715

Tab. 4: The extracted components (factors) of local development potential and factor loadings
Notes: Principal Component Analysis, rotation method Oblimin with Kaiser Normalization. Factor loadings lower than +/– 0.3 were excluded from the Table
Note: MOJ = municipality of extended jurisdiction
Source: Authors' calculations

the percentage within the data definition file (0 – 20 – 40 – 60 – 80 – 100%, where 1 = deeply below average potential; 2 = below average potential; 3 = average potential; 4 = above average potential; 5 = highly above average potential). The results are presented in the following map (see Fig. 3).

It is evident from the map that municipalities with the highest development potential are represented by district towns and smaller municipalities located in the surroundings of the regional centre and close to motorways or first class roads.

3.5 Relation between local development potential and regeneration of brownfields

The key question is whether the selection of our indicators and the values of overall development potential of municipalities are relevant for the process of brownfields regeneration. The statistical analysis (see Tab. 6 for the results) proved a significant correlation between the spatial distribution of regenerated brownfields and the development potential of municipalities where these brownfields are located. It is evident from the spatial distribution of regenerated brownfields (see Table 5 and Fig. 3) that more than 2/3 of regenerated brownfields are located in municipalities of the highest development potential (categories 4 and 5) while these municipalities represent less than one fifth (17%) of the region.

The most significant factors related to regenerated brownfields are factors of business or economic activities of the local population (which proved to be closely related to the population density) and geographical location within a region or peripherality (represented especially by proximity to regional centre and distance from main road transport axes). The factor of a municipality's infrastructure is more significant in the dataset

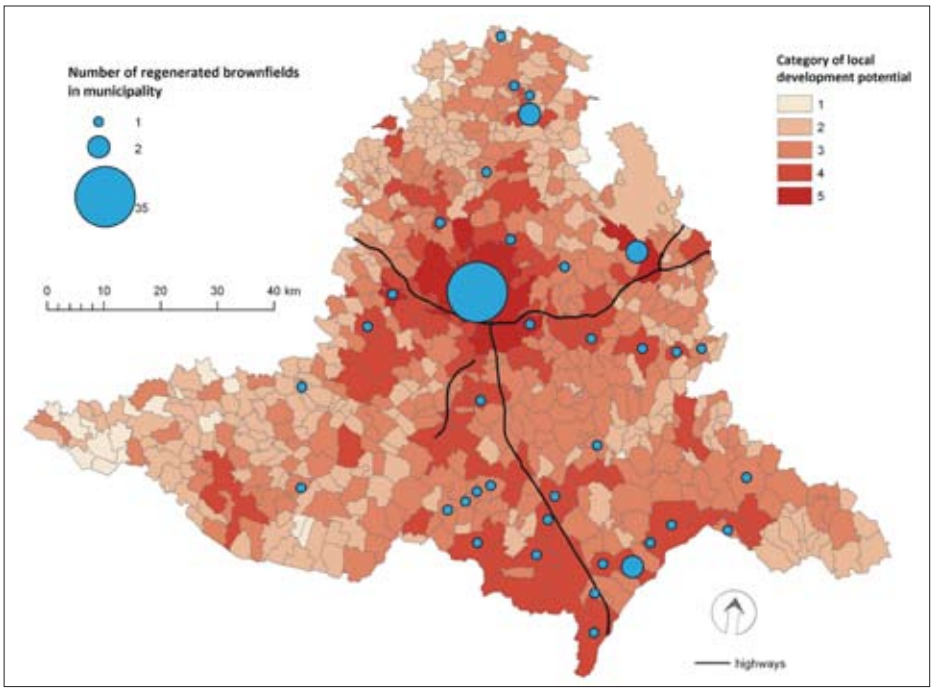

Fig. 3: Categorization of municipalities according to development potential and spatial distribution of regenerated brownfields. Source: Authors' elaboration

Municipality category	Share of all municipalities [%]	Share of all regenerated BF [%] (including Brno cases)	Share of all regenerated BF [%] (excluding Brno cases)
1	5	0	0
2	41	5	7
3	37	20	35
4	15	25	48
5	2	50	10

Tab. 5: The distribution of municipalities according to the category of development potential and the share of regenerated brownfields within each category
Source: Authors' calculations

excluding Brno city. Somewhat surprisingly, the factor of demographic growth appeared not to be significant for the regeneration of brownfields in our dataset.

3.6 The structure of regenerated brownfields

Table 7 presents the most frequent types of the actual use of regenerated brownfields in Brno city and the rest of the region. While in the urban areas a predominant type of new use is represented by construction of new supermarkets, shopping centres and commercial or multifunctional projects, the new use of brownfields in rural areas is represented most often by small-scale manufacturing or investment in facilities for tourism, recreation or culture (horse farms, hotels, tourist centres, museums, etc.).

More than one half of the regenerated projects (55%) have been realized on previous industrial brownfields (mostly located in urban areas), almost a third (29%) on agricultural brownfields (in rural areas), and a tenth (9%) is represented by regenerated objects of previous public amenities. There are only three cases (4%) of regenerated post-military brownfields. However, this percentage structure is very similar to the structure

Independent variables (factors of local development potential)	Pearson's correlation (r)	
	Dataset including Brno	Dataset excluding Brno
Factor "Overall development potential"	0.292**	0.298**
Factor "Business activities"	0.445**	0.241**
Factor "Peripherality"	– 0.203**	– 0.222**
Factor "Infrastructure"	0.172*	0.232**
Factor "Demographic growth"	0.009	– 0.060

Tab. 6: Correlations between regeneration of brownfields and factors of local development potential
*Notes: Correlation is significant at the ** 0.01 level (2-tailed) or * 0.05 level (2-tailed)*
Source: Authors' calculations

Brno (number of cases)	Rest of the Region (number of cases)
Shopping centres, supermarkets (10)	Manufacturing, storage, logistics (16)
Research and education (7)	Tourism (agro-tourism), recreation (11)
Manufacturing, storage, logistics (6)	Multifunctional (commercial / residential) (6)
Multifunctional (residential / commercial) (5)	Culture, public amenities (4)
Business premises, office spaces (5)	Residential (housing development) (4)
Sport and recreation (2)	Renewable energy (3)

Tab. 7: The most frequent current uses of regenerated brownfields
Source: Authors' calculations

of existing brownfields (see Tab. 3). We can say that the post-industrial sites are more frequent among the regenerated brownfields (see Fig. 6 on the cover p. 2), while the military and transport brownfields are less well represented.

The average size of the regenerated brownfield is 8.5 ha (the size ranges from small objects of 0.1 ha to large 30 hectare regeneration projects). The amount of regeneration costs ranges from some ten millions of Czech crowns to hundreds of millions for the largest regeneration project (the shopping and social centre Gallery Vaňkovka in Brno).

As to contamination, somewhat less than half (44%) of the regenerated brownfields were previously contaminated (in comparison, contamination is confirmed or expected in 54% of the existing brownfields). Thus, we can say that the factor of contamination is not a crucial barrier for regeneration. Almost two thirds of regenerated brownfields were privately owned (at the time when regeneration started), while one third were in public ownership. An absolute majority of regenerated brownfields have had a simple ownership structure. This is a confirmation of previous studies that have emphasized that the key barrier for investment and development is a complicated (multiple) landownership related to the brownfields (see. e.g. Adams et al., 2001).

4. Discussion and conclusions

Our analyses have demonstrated that regenerated brownfields are more likely located in municipalities with a higher local development potential – which is represented and can be measured by the following

specific factors and indicators: local business activities (tax revenues per capita, number of entrepreneurs, level of education of the local population and the share of people working in tertiary sector), peripherality (proximity to regional centre and district cities, proximity to main road network), and quality of the local infrastructure. According to the comparative analysis of the structure of existing and regenerated brownfields we can argue that a large size of the brownfield, its previous industrial use and the existence of contamination may not to be determinative barriers of regeneration – if the brownfield is located in an attractive area (e.g. city centre) and does not have complicated ownership relations. However, the factor of real and/or perceived contamination is more complicated and depends on an actual level of contamination (most of the existing brownfields have not gone through a complex investigation and the databases report only the status of site – with approved, expected, and/or unexpected contamination – and not the level of contamination).

Similar findings about the role of location factors have been reported from the USA by Lange and McNeil (2004a), who found that sites located near airports, close to the central city, or close to rail access are developed more quickly. Longo and Campbell (2007) analyzed revitalized brownfields in England and confirmed that sites located in more prosperous regions (London, South West, and South East) are more likely to be regenerated compared to sites located in other regions. However, they did not reveal a significant influence of population density on brownfields regeneration, nor a significant difference in the redevelopment of sites in rural versus urban areas. As concerns site-specific characteristics, a site owned by the private sector, of smaller size and suitable for housing, made it more likely to be re-used.

Studies based on surveys or interviews with stakeholders (Adair et al., 2002) showed that the primary reason why the private sector invests in some regeneration areas is the perception of achieving the target rates of return. Conversely, the principal reasons for non-investment include the negative image of a locality or neighbouring environments, the perception of bureaucratic grant regimes and the lack of capital (funding). Similarly, Coffin and Shepherd (1998) identified four key barriers to regeneration: legal liability, limited information, limited financial resources, and limited demand for the properties.

In many cases, however, even good conditions for the effectiveness and prosperity of a locality (and for brownfields regeneration) may not be utilized if there are subjective problems and barriers (weak local political involvement, a deficit of information, poor communication and cooperation (see e.g. De Sousa, 2003), i.e., if the key actors are not able or do not want to exploit the potential. On the contrary, "soft factors" such as political leadership and good cooperation of stakeholders can turn even insufficient conditions and low potential into positive results. There are many examples (so-called "best practices") reporting how human factors as an initiator of brownfields regeneration (e.g. making a good project proposal, gaining a local community support, acquiring of grant titles, etc.) have overcome locational handicaps or modified the characteristics of suitability of an area or a concrete brownfield site according to specific project purposes (see e.g. RRAJM, 2010, 2011).

Together with Adair et al. (2002), we can recapitulate that investment decisions on brownfields regeneration are a function of the availability and perceived quality of a property, occupier demand, characteristics of the local labour markets, transport links, social factors, and regulatory and planning considerations. The private sector is opportunity driven, invests in areas where it is comfortable and where returns are achievable commensurate with the risk taken - in this respect, grant regimes should be used as tools to lever investment.

Another practical problem is to differentiate between different stakeholders' (investors') concerns. Yount and Meyer (1999) emphasized (according to interviews with developers and lenders) that effective policies and programmes need to be framed within an understanding of the different needs of smaller and larger redevelopments. While market forces were equally significant inducements for both types of projects, important needs of small developers were not met: they were less likely to receive government subsidies, had greater difficulty accessing private capital, and lacked information about processes associated with remediation, while developers of large projects were more likely to benefit from public financing and were able to mobilize a network of supportive organizations to help them manage barriers to project completion.

In this respect, it is very important to study the specific local political, cultural and social structures and contexts of regeneration processes, the roles of specific actors, etc. That is a broad area for future interdisciplinary research. At the same time, it is very important to analyze (deconstruct) and present "best practices" as examples of the successful regeneration of brownfields in various geographical and land-use contexts . Finally, it is important to analyze general factors at the macro level (national legislative frameworks, policies, economies, etc.), which significantly affect factors at lower levels.

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A DYNAMIC APPROACH TO THE TYPOLOGY OF FUNCTIONAL DERELICT AREAS (SOSNOWIEC, POLAND)

Robert KRZYSZTOFIK, Iwona KANTOR-PIETRAGA, Tomasz SPÓRNA

Abstract

The increasing number of wastelands in East-central European countries is primarily a consequence of functional transformations and movements in the structure of employment. Taking into account such a challenge in this article, the authors propose an approach in which the basic category is a typological proposal with reference to areas with derelict functions, which in turn refers to research within the scope of human geography. In their methodological proposal, the authors consider such variables as: (i) the diversification of management and use of space; (ii) time; (iii) economic functions; and (iv) the scope of geographic research. The effect of including these variables is an attempt to dynamically depict the evolution of land use, with particular attention paid to wasteland: original state – transitional state (derelict areas) – present state. The typological depiction of the emergence and transformation of areas with derelict functions is presented for the case of Sosnowiec.

Shrnutí

Dynamický pohled na typologii funkčně opuštěných oblastí (Sosnovec, Polsko)

Rostoucí počet opuštěných území v zemích střední Evropy je většinou důsledkem funkčních transformací a změn ve struktuře zaměstnanosti. Autoři v článku navrhují specifický přístup, kde je základní kategorií pokus o vytvoření typologie funkčně opuštěných území, která je vztažena k výzkumu a předmětovému rámci humánní geografie. V návrhu své metodologie berou autoři v potaz následující proměnné: (i) diverzifikace managementu a využití prostoru, (ii) čas, (iii) ekonomické funkce a (iv) rámec geografického výzkumu. Smyslem zohlednění těchto proměnných je pokus o popis dynamiky vývoje land use se zvláštním zaměřením na funkčně nevyužívaná území: původní stav – přechodný stav (opuštěné plochy) – současný stav. Typologický popis vzniku a transformace funkčně opuštěných území je prezentován na příkladu města Sosnovec (Polsko).

Keywords: *brownfields, typology of functional derelict areas, Sosnowiec, Katowice Conurbation, Poland*

1. Introduction

The issue of brownfields is one of the most crucial elements discussed in geographical studies and research on urban space (Alker, Joy, Smith, 2000; Ferber, Grimski, Millar, Nathanail, 2006; Grimski and Ferber, 2001; Thornton, Franz, Edwards, Pahlen, Nathanail, 2007; Thornton, Nathanail, Franz, Pahlen, 2007; Tolle, Muszyńska-Jeleszyńska, Tadych, Jasińska, 2009). This assertion is a direct result of worldwide dynamic functional changes related to the transformation from production-based economies to economies based on services (Hudson, 2005; Müller, Finka, Lintz, 2005; Steiner, 2003).

In the context of the emergence of brownfield areas, this issue should be understood in two depictions. Firstly, the functional changes take place within the interaction of the 2nd and 3rd sectors of economy. New service institutions are developing at the cost of disappearing or shrinking manufacturing operations. It should be highlighted, though, that this transformation is accompanied by changes within the services themselves. The more creative and modern activities, based on knowledge, are replacing those, which despite their service character, refer to a sub-group of "simple" services or primary in some other way.

The functional transformations taking place in highly-developed countries in Europe and in the world are, in their general dimensions defined by the evolution of the employment structure. Hence, one of the key issues is also the answer to the question as to what happens to areas and places where these changes are happening. Derelict areas in cities, including

brownfields, constitute a final stage of complicated socio-economic processes at the meeting point of global or national factors with local ones.

In the countries of Central and Eastern Europe, the post-industrial, post-mining and other wastelands are not only typical for the last 20–25 years (Müller, Finka, Lintz, 2005). However, compared to the post-socialist and western countries, this issue is differently ranked in the hierarchy of urban politics and management. As far as derelict areas are concerned, compared to western European countries, a gradual convergence of strategic and operational activities is noticeable in the most recent period. A crucial problem is definitely posed by a lesser scale of financing enterprises aimed at reclamation or, generally, new forms of development, particularly for those enterprises that are not of a commercial character.

A problem that unifies the countries of different economic pasts is the scale of the phenomena, reflected in the fact that in many cases, brownfield areas are equal to the areas of operating plants and areas with economic functions. Frequently, the derelict areas exceed the total area of the established investment property in a given town (housing, industry, services, and municipal services).

Among the cities extremely exposed to such a situation, there are post-mining and post-industrial centres, which, in their development, relied on a very explicit functional dependency: industry (mining) – urban space: employment in industry (mining) – level of socio-economic development of the city (Tkocz and Riley, 1999; Wirth, Černič-Mali, Fischer, 2012). A strong functional specialization is an indispensable element in the process of the dynamic development of a city. But the lack of balance in the city development, and a specialized economic base, always pose a threat in a moment of crisis or a system transformation.

One of the European regions where these phenomena have been taking place at a high intensity level is the Katowice conurbation in the Silesian Voivodeship in Poland. The scale of de-industrialization and restructuring of industry, even at the beginning of the 1990s, has become a key issue here requiring an urgent solution (Tkocz and Riley, 1999). The problem had several aspects: political, social, economic or spatial. The shrinking number of mines, steelworks and other industrial plants resulted in the accumulation of problematic areas, unprecedented in other Polish regions. In each case, they required urgent planning intervention, whose aim would be the re-definition of spatial, social and economic functions.

One of the first cities where the process of de-industrialization was intensified with extreme rapidity was Sosnowiec. The economic and functional slump that took place there already at the beginning of the 1990s lead to quite a strong reaction. Paradoxically, the impact of negative phenomena present there 20 years ago led to the realization that coherent anti-crisis policies could be worked out (Krzysztofik, Runge, Kantor-Pietraga, 2012a; 2012c). One of its aims was undoubtedly the issue of the dynamically increasing number and area of brownfields and other derelict areas.

Therefore, from today's perspective, Sosnowiec constitutes the most relevant proving ground connected with the issue of brownfields. As far as the brownfields are concerned, the city has a peculiar milieu, constituting a model template for: problems, structures, paths, urban policies, and brownfield mechanisms on the scale of Poland. Thus, it is a resourceful research area for many disciplines, geography being one of the key ones.

The aim of this article is an attempt to define such a research model for functionally derelict areas, which would include elements of both the variability of functions in time and space, and the specifics of locational conditions. On the other hand, the authors would like to see its significance in the general division of geographic and economic sciences, which constitute their scope of research interests. This model also attempts to grasp various depictions of the brownfield phenomenon and their role in urban space. It was assumed that this aim may only be achieved in relation to a dynamic or multi-level presentation. However, its basic assumption was the reference to the issue mentioned at the beginning of the introduction, pointing out that brownfields and other types of derelict areas are truly only transitional effects of changes in the functional structures of particular cities.

2. Definitions: wastelands and functionally derelict areas

2.1 Terms of functional derelict areas

Having a positive reference to the proposed definitions of wasteland, brownfields and other areas where the previous prevailing functions have disappeared (Adamski and Oprych, 2012; Gasidło, 2010; Gasidło, Gorgoń, 1999; Jarczewski, 2009; Kirkwood, 2001; Morancho, 2003; Nathanail, Thornton, Millar, 2003; Popescu and Pătrăscoiu, 2012; Sellers, Mofat and Hutchings, 2006; Vojvodíková, Potužník, and Büregermeisterová, 2011; www.umwelt.sachsen.de/umwelt), the authors propose to describe them with a common superior term of areas functionally derelict.

In this phrase, the focus is shifted to the issues of:
- the decline of former functions;
- the lack of new functions being shaped; and
- the functional genesis of their existence.

In connection with the above, the term of functionally derelict areas shall be understood as such areas, together with their existing development and infrastructure, which have lost their previous functions through the disruption of typical processes, structures and phenomena that were present there.

The term functionally derelict area refers to the existing term of derelict area in a way that highlights the genesis of the phenomenon in the name. Functionally derelict areas constitute a majority of derelict areas in general, especially within city borders. Direct causes of the emergence of derelict areas might also be different: natural, political, behavioural (Stangel, 2011; Sustainable brownfields – Cabernet, 2005; Tomerius, 2000; www.environ.ie/en). The denomination functional (derelict areas), at the highest level refers to their economic or socio-economic background.

It is important to emphasize that the strictly geographical-functional viewpoint of brownfields and derelict areas changes the defined general (multi-criteria) hierarchical order of them. In geographical-functional explanations, brownfield areas consist on wider terms of derelict areas. In the Cabernet definition (the EC funded expert network on brownfield regeneration), the situation is opposite – derelict areas are one among five key groups of space (Franz, Pahlen, Nathanail, Okuniek, Koj, 2006, p. 136).

However, from the financial and legal point of view, the two above-mentioned approaches and the three-element (A-B-C) model use the same division of the concerned sites:
- viable sites (private-driven projects),
- marginally non-viable sites (public-private partnership),
- non-viable sites (public-driven projects) (Sustainable Brownfield Regeneration. CABERNET Network Report, 2005, p. 43);

as well as the four-element (A-B-C-D model) of the D. Butzin team, where derelict sites are additional element:
- viable sites (private-driven projects);
- marginally non-viable sites (public-private partnership);
- non-viable sites (public-driven projects); and
- permanently derelict sites (Franz, Güles, Prey, 2006).

As mentioned, the key scope of interest in the term of functional derelict areas, is the interaction of the previous socio-economic function of a given space to its present state expressed by land use, inter alia. In the designation of "derelict sites", on the other hand, the scope of interest lies in aesthetic, marketing or socio-psychological issues. As far as spatial issues are concerned, a crucial element is the aspect of derelict sites surroundings, as well as the derelict site–neighbourhood relationship (Sustainable brownfields – Cabernet, 2005; Tomerius, 2000; www.environ.ie/en).

Within the functionally derelict areas, areas and facilities of various natures may be distinguished: derelict greenfields, greyfields (grayfields), brownfields and blackfields (Tab. 1). In this case, their division comes as a result of three premises treated jointly: economic or socio-economic functions, land use, and interference in the human environment. Therefore, their definition range is not always going to be identical with some adopted typologies. In reference to them, it is proposed to broaden the term of greyfields and slightly narrow the term of blackfields. Detailed definitions of various types of the functionally derelict areas are presented in the following list.

Derelict greenfields – areas which require planning and functional intervention connected with the need to develop the former agricultural areas, including arable land, meadows, gardens, plantations and also facilities and infrastructure previously used for agricultural purposes[1]. Derelict greenfields constitute, relatively, the least burdensome space, which requires a functional transformation and a new form of spatial development. We are assuming that derelict greenfields emerge during the decomposition of hitherto prevailing functions for the period of 3–5 years or longer. The so-called urban fallows or areas with noticeable plant succession are typical forms of derelict greenfields. In some cases, after a period of several to several dozen years, the form of greenfields may be acquired by areas, which previously served different functions (industrial, services, housing and others), depending on the degree of decline of the previous functions as well as the possibilities for plant succession.

Greyfields (grayfields) – areas and facilities which have lost their former service or housing functions. Most depictions of greyfields point their definition range

[1] Greenfields from a morphological point of view comprise both natural as well as agricultural areas (without agricultural infrastructure).

Former functional type of the concerned area			Type of functional derelict area			
			Greenfields	Greyfields	Brownfields	Blackfields
Economic functions	1st sector	Agriculture	X	X	-	x
	2nd sector	Mining	x	X	X	x
		Industry (& construction)	x	X	X	x
	3rd sector	Logistics and comunication	x	X	x	x
		Commercial	x	X	-	-
		Recreation	x	X	-	-
		Other services	x	X	-	x
Non-economic functions		Residential	x	X	-	-
		Military	x	X	x	x
		Other	x	X	x	x

Tab. 1: Geographical typology of functionally derelict areas: previous functions versus dominant type
Note: X – a key type of functionally derelict area for the function in question; x – other types of functionally derelict areas. [-] – relation not existing. Source: Authors

only towards prior large-size facilities with commercial functions. Our research, however, from a functional point of view, indicates that similar conditions (crises in the given branch of services or commerce) have lead to abandoned office buildings, service facilities and compact housing areas. A functional key to understanding greyfields should be the fact that they were not previously connected functionally with agriculture or industry.

We are assuming that greyfields emerge during the decomposition of previous prevailing functions for a period of two or more years. Greyfield areas are not formally inhabited (former housing function) nor are there any business activities conducted there (service functions). Typical forms of greyfields are vacant buildings and abandoned buildings, including unfinished buildings.

Brownfields – areas and facilities which have lost their former industrial or mining functions and have not obtained new ones yet. On brownfield areas there is no formal production or exploitation activity. This period lasts for at least a year or longer. Brownfields, due to their previous functions, require urgent planning intervention and a quick process of redevelopment. Typical brownfield forms are abandoned lands, buildings and industrial (or mining) infrastructure, as well as fundamentally transformed arrangements of geographical environment components in a larger area.

Blackfields – areas (or facilities) which have lost their prior economic function, mostly industrial or mining, and whose existence constitutes a real threat to the natural environment and especially to human life and well-being. Blackfields require not only immediate intervention at the planning level, but also urgent actions in situ, which would eliminate or limit the harmful influence on the environment. Blackfields are qualified as such, soon after they have ceased to serve their economic function, frequently remaining beyond institutional or social supervision. Blackfields include all types of landfills and dumping grounds of harmful materials, substances, etc., post-floatation basins, areas chemically or radiologically contaminated, and other areas with a significantly negative influence on human well-being and life.

The inclusion of the functional factor in the emergence of derelict areas is important insofar as that, in every case, it makes it easier to dynamically analyse transformations taking place in a given area. Such a depiction was recently applied in studies referring to Ostrava (Vojvodíková, Potužník and Büregermeisterová, 2011), Łódź (Piech, 2004; Kotlicka, 2008), and Craiova (Popescu and Pătrăscoiu, 2012).

The range of problems connected with understanding the term of brownfields, also in its genetic and functional context, is reflected in Fig. 1, for example. In reference to the scope of human geography and its academic sub-disciplines, the authors indicate a need to refer to them in an attempt to create a dynamic and functional model of derelict areas. Therefore, this model includes:

- the research subject for various academic sub-disciplines of anthropogeography (human and social geography, settlement geography, agriculture geography, geography of industry, geography of services, geography of transport, geography of tourism, commercial geography, spatial aspects of all branches of geography);
- the time factor, creating the picture of development stages for a given fragment of space; and
- the specific locational conditioning factors, conditioned by functions in an urban system.

Considering the above issues, derelict areas in this study include semantically more elements than those highlighted in the model developed by the CABERNET project. Of those that are in that model, we have integrated in our study the types: *Derelict*, *"Historical" Urban Green Space* and *Vacant*.

2.2 Toward the functional background of explanations

The final research proposal referring to the above assumptions is presented in Table 1. There, a division into economic and non-economic functions is pointed out. Within economic functions, three primary sectors are highlighted: agriculture (including forestry and fisheries), production (including the building industry) and services. Due to the role of particular activities in the structure of local urban economies, it was decided to additionally differentiate mining and industry within the 2nd sector. In comparison, within the sector of services, the categories are pointed out which have particular meaning in the local economy and therefore constitute a crucial element that differentiates the urban landscape. In many cases, meaningful perception differences of given services are noticeable. Recreation and tourism have an areal character and simultaneously a limited scale of development. Transport has a linear and point located character, with dominating infrastructure that does not consist of buildings. Commerce is the opposite; being one of the most basic services in the city and of point-location character, but in the case of the largest malls and shopping centres – it has areal character. All the above issues are particularly crucial in the situation when a given type of service has become a derelict function or a vanished function from a different perspective in a given area.

The other group pointed out consists of non-economic functions. This category includes social functions and functions socially useful. Housing functions are listed first, being primary for each city and not having, ultimately, an economic character (Fig. 2 – see cover p. 3). Other crucial functions are military functions and those related to the defence and safety of a country or a region. The last category is composed of the remaining socially useful functions, mostly connected with municipal services (functional landfills, sewage treatment plants, cemeteries and others).

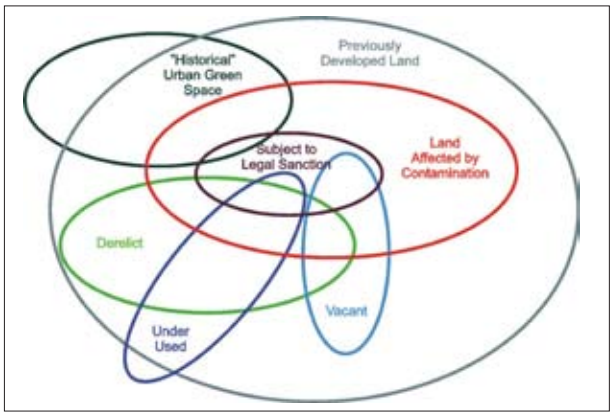

Fig. 1: Relationship between brownfield-related definitions Source: Sustainable Brownfield Regeneration. CABERNET Network Report, 2005, p. 26

The functional types of area development methods are, in the following part, juxtaposed with the four types of functionally derelict areas. The main aim of the juxtaposition of both elements is to indicate the potential and dominating possibilities of transformation of a given area or facility into a concrete type of the functionally derelict area.

Greenfield areas may emerge on areas previously used for any purposes. In most cases, it happens after a longer period of time (Fig. 3 – see cover p. 3). Such an area, as a rule, previously underwent a stage of partial reclamation. Buildings and infrastructure were demolished. To conclude, conditions for unconstrained plant succession were created. Areas previously used in agriculture constitute a typical functional structure, which is a base for greenfield development. Abandoned fields or meadows relatively quickly become areas of expansion for wild plants. Characteristic urban fallows come into existence dominated by grass, bushes, tall weeds and arborescent communities. The observed proportions of plant types are varied.

Analogous to greenfields, facilities (including their surroundings) of greyfield type also may be of various functional genotypes. In the case of agriculture, these are abandoned buildings used for agricultural production (pigsties, stables, garages, administration buildings). In the case of mining, these are service facilities located in the proximity to industrial areas that are not directly used for production or exploitation. Greyfields, though, constitute a type of functionally derelict areas mostly related to former services.

Another type of derelict areas is represented by brownfields. Brownfields emerge in post-mining and post-industrial areas, hence they are a typical form in urban structure. Due to the fact that brownfields cover vast areas, there appears to be a problem in their definition, resulting from the future specific character of these places. Within many brownfields, there are, for example, water basins, which are legally or illegally used for recreation. Another problem is posed by forests (frequently of vast area), which by way of succession, have covered former areas of mines or other industrial plants (Krzysztofik, Runge, Kantor-Pietraga, 2012b). Some production facilities,

formally operating within services connected with transportation, logistics and communication, and acting for the benefit of railway or road engineering, were also included in brownfield areas.

The last category includes blackfields, which, in majority, represent a consequence of industrial or mining activities. Contamination, which endangers human lives or well-being strongly influences components of the natural environment (atmosphere, surface and ground water, soil). It may also result from other business and non-business activities; e.g. from abandoned pesticide tanks or other chemicals in agriculture, insufficient safeguarding of abandoned municipal units dealing with utilization and sewage or waste storage, and also service buildings where laboratory work was conducted with the use of toxic and poisonous substances.

The creation stage for functionally derelict areas is only a part of the longer process of urban space management. Equally important is the method of their reuse. Therefore, in the research on abandoned or degraded areas, a crucial element is the issue of methods and paths leading to redefinition of these functions. In a dynamic method, this process is presented by Figures 4 and 5.

In the first case (illustrated by Fig. 4) a re-use of functionally derelict areas is assumed, with the inclusion of the range of functions discussed above. In an obvious manner, the inflow of certain functions and also internal determinants of development to a specific city may be and frequently are an assumption for redevelopment of functionally derelict areas. In each case, competition is present in the line of functionally derelict areas – areas continuing their development within the framework of defined functions. Another area for competition is the question of which of the functionally derelict area types is going to "win" the attention of municipal authorities, various developers, public opinion and other institutions. Experience from the area of the Silesian Voivodeship indicates that chances are relatively equal, but it should be stressed that a different group of stakeholders supports redevelopment of each type of space. Regardless of the inflow of new functions as external impulses, the transformation of brownfields may come as an effect of actions taken within an internal potential. In this case, key actors are mainly municipal authorities or municipal authorities with the participation of a public or private entity.

Figure 5 presents a situation where no visible transformations were recorded in the functionally derelict areas in the examined period of time, due to

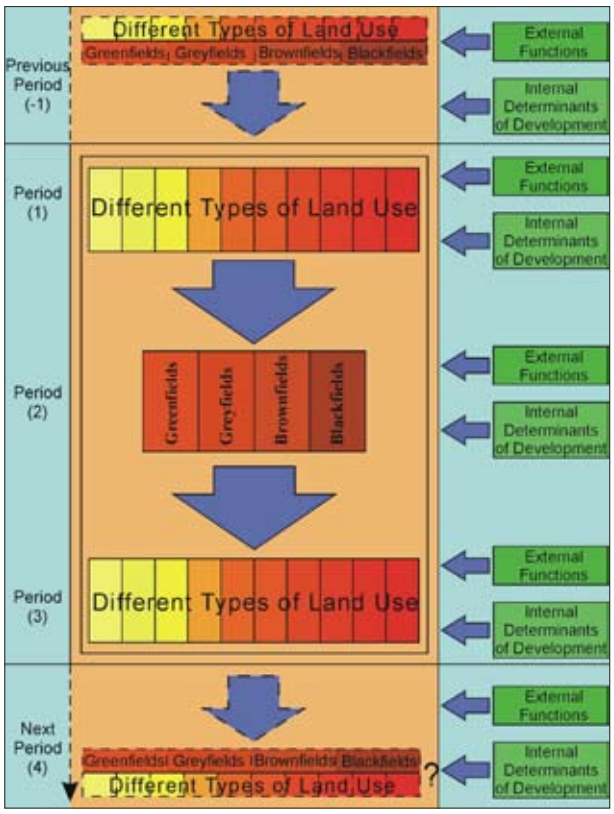

Fig. 4: Model of land use transformation with the stage of functional derelict areas. A positive path
Source: Authors

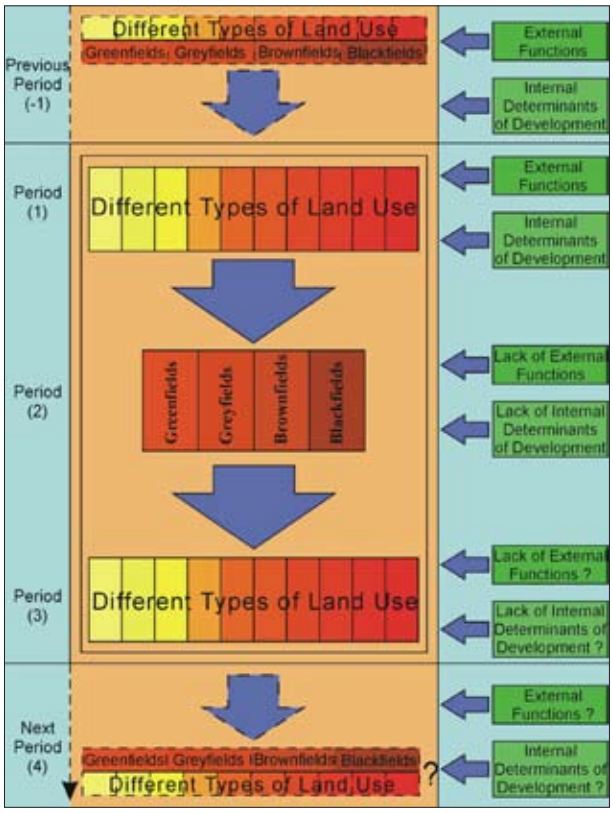

Fig. 5: Model of land use transformation with the stage of functionally derelict areas. A negative path
Source: Authors

the lack of inflow of functions within urban borders and the lack of initiatives from urban authorities or other actors.

The presented examples are of a model character. In the first case, we assume that transformations are going to reach any level of the new form of development. In the second case, that it is not going to happen at all. The reality shows that some changes occurred in almost all medium-size towns and cities in Poland researched by the authors (44 cases). In all of them the changes were not sufficient, but for the majority, not always desired or expected.

The model pointed out above is of a two-stage character, i.e. it defines the stage of emergence of a functionally derelict area [Period (1) to Period (2)] and its possible development or lack of it [Period (2) to (Period (3)]. Comprehensive explanation of these transformations will make it possible to have a broader analysis of the given area. That is, on the one hand, it allows one to refer to the stage of primary land use [Previous Period], before the function analysed presently as derelict was shaped there. It is particularly interesting if this function had not been shaped in a previous derelict area with, e.g. the 19th century genesis. Other former functional changes are also interesting.

On the other hand, the model reveals the necessity for academic research regarding further spatial and functional transformations in the future [Next Period]. This is particularly the case if the instability of a new way of development is observed or there are barriers which might have some influence on it in the nearest future, e.g. profitability of some industrial or service branches, free interpretation of the local spatial development plan, etc.

3. Derelict areas in Sosnowiec and the form of their development in the period 1990–2012

3.1 Downsizing of the economic base of Sosnowiec and its consequences

Sosnowiec is one of the largest cities in the Katowice conurbation and in the Upper-Silesian Industrial Region. It experienced an almost historic cycle of redefining its functions in the last two decades, which, for the first time since the establishment of the city in 1902, transformed from industrial to service and industrial. In the background of the transformation of the city's functional image, there were serious economic, social, spatial or infrastructural problems. Sosnowiec is a large central-European city, which is ranked as a leading city as most affected by the political and economic transformation at the turn of the 1980s and 1990s. On the other hand, it constitutes a model example of multi-aspect shrinkage (Krzysztofik, Runge, Kantor-Pietraga, 2012a).

In the period 1990–2012, as many as three out of four coalmines were closed down in the city and in one coalmine the number of employees was cut by half. Significant restructuring also took place in the two local ironworks. The huge centre of textile and clothing almost totally collapsed, including three of the largest facilities which had employed several thousand people before 1990. A large number of metal and machinery facilities were reduced. The functional crisis affected services as well, even local agriculture. In the period of 1990–2012, the city lost over 40 thousand inhabitants and this depopulation process continues. The demographic decline trend is going to prevail into the future. By 2035, the population of the city will have decreased to 160.8 thousand (from 215.3 thousand in 2010 and 259.4 thousand in 1990).

Another crucial consequence of the economic and social crisis of the city is the dynamic increase of brownfields, and to a lesser extent greyfields and derelict greenfields (Fig. 6).

Nevertheless, it should be highlighted here that since the early 2000s, a process of economic reorganization of the city is taking place, which has significantly slowed down the crisis, if not stopped it. A considerable success in redefining the function of the city was a concept, which stressed the need for developing local wastelands. Urban policy was

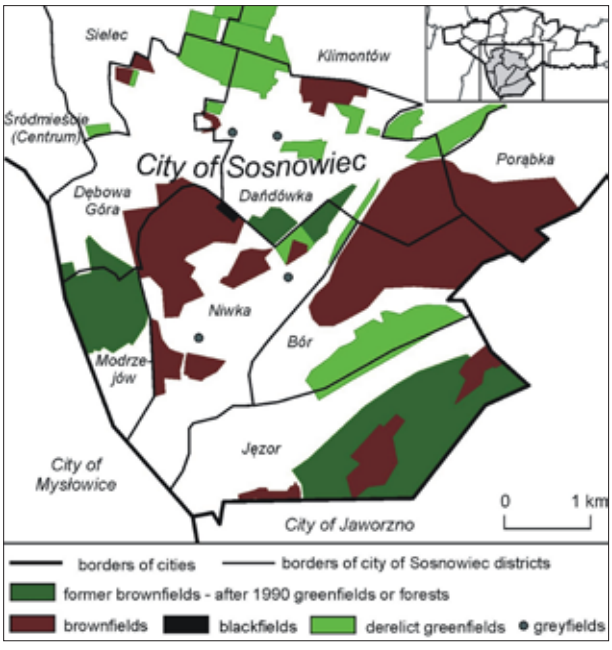

Fig. 6: Functionally derelict areas in the south districts of Sosnowiec, 1990–2012
Source: Authors

focused on regaining post-mining and post-industrial areas for economic purposes. Coming to terms with a not always "reasonable" pace of closing coalmines, decisions were taken to transform post-mining areas into new and diversified developments. Their character was described, depending on the specific location, as a new industry zone or a new industry and services zone. A significant role in the policy of eradicating brownfields in the city was played by the Katowice Special Economic Zone (KSEZ) and special programmes and tools endorsed by municipal authorities, such as The Economic Gateway of Silesia. Within the Katowice Special Economic Zone only, there emerged 13 new industrial facilities (Fig. 7). The sound investment policy with the simultaneous institutional and financial support, as well as individual actions of many entities, have enabled success to be reached within a dozen years, and this has not been experienced by any other city of similar size in Poland (Krzysztofik, Runge, Kantor-Pietraga, 2012a). Sosnowiec has become a leading town in the category of number and size of new investments per 10 thousand inhabitants, and even a leader in the whole conurbation considering the corporate tax receipts from companies located in former brownfields. A positive aspect is also the number of employed persons. Companies of diverse branches located in the brownfields employ over four thousand persons.

The described phenomenon of the "economic" governance (municipal authorities, KSEZ, individual entrepreneurs, central government, EU) of the problem of brownfields is of permanent character. However, the effects of this policy are variables over time. The investment activities peaked in 2006–2010 and the number of developments has been decreasing currently. This is a result of the general world economic crisis as well as of the lack of municipal financial resources, which would be the city's own contribution to build a new technical and transport infrastructure on the extensively developed brownfields so far (see Fig. 6 – large area marked in brown on the border of Bór, Dańdówka and Porąbka districts). An opportunity for the development of these areas is likely to be

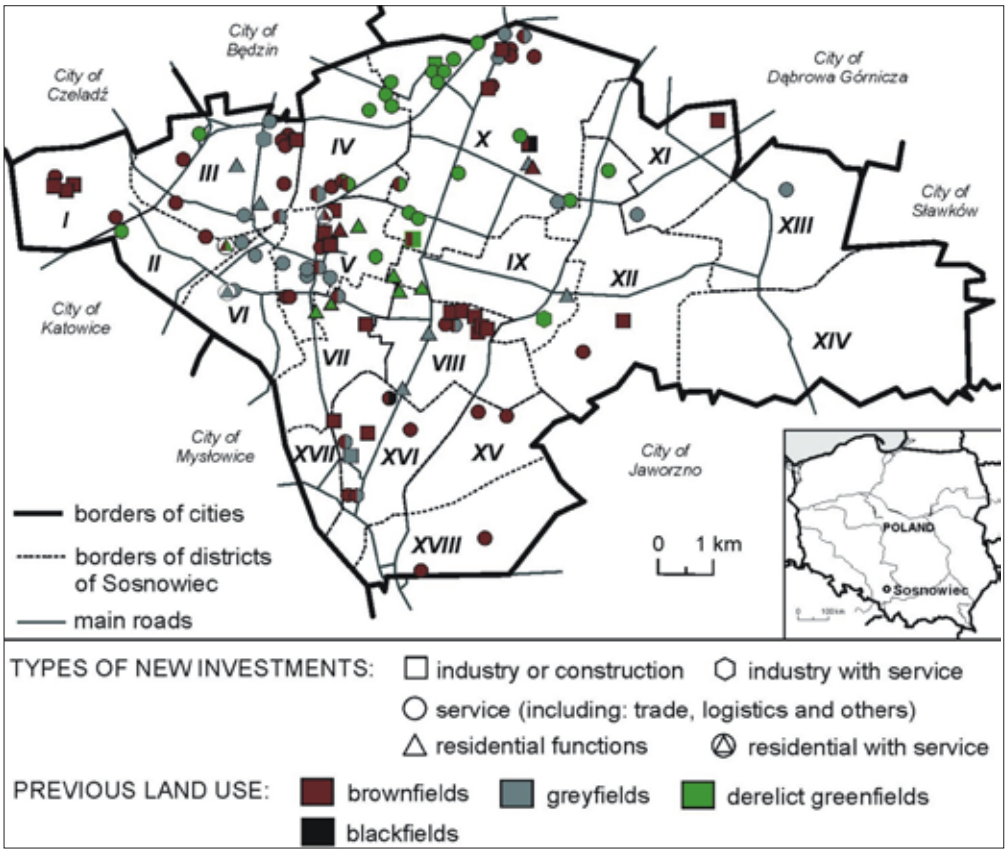

Fig. 7: New investments in the derelict areas in the city of Sosnowiec, 1990-2012; a geographic-functional approach Explanations: 1 – borders of cities; 2 – borders of districts of Sosnowiec; 3 – main roads; TYPES OF NEW INVESTMENTS: 4 – industry or construction; 5 – industry with services; 6 – services (including: trade, logistics and others); 7 – residential functions; 8 – residential with services; PREVIOUS LAND USE: 9 – brownfields; 10 – greyfields; 11 – derelict greenfields; 12 – blackfields. City districts: I – Milowice; II – Stary Sosnowiec; III – Pogoń; IV – Środula; V – Sielec; VI – Śródmieście (Centrum); VII – Dębowa Góra; VIII – Dańdówka; IX – Klimontów; X – Zagórze; XI – Kazimierz Górniczy; XII – Porąbka; XIII – Ostrowy Górnicze; XIV – Maczki; XV – Bór; XVI – Niwka; XVII – Modrzejów; XVIII – Jęzor. Source: Authors

a new instrument of regional policy, the so-called OSI (Strategic Intervention Areas). The OSI will be financed from EU funds.

3.2 The "post-brownfield" landscape in Sosnowiec

The process of restructuring and closing industrial facilities in Sosnowiec resulted in a clear increase in the number and size of functionally derelict areas. From estimates, it is concluded that in the period from 1990 to 2010, their area increased by approximately 450 ha. This was additionally increased by wasteland areas that emerged in previous historical periods, even dating back to the second half of the 19th century. They were mostly areas connected with the former open-cast coal mining.

At the same time, in almost all city districts, single abandoned buildings appeared, or their fragments connected with services or trade. A majority of them were redeveloped relatively quickly. Some buildings though, especially the ones of large cubic volume, remained unoccupied. Some of them, such as the multi-storeyed Silesian University of Medicine in the Ostra Górka district, have not yet been completed. Former farmlands, where production has ceased, have constituted a peculiar category of derelict area. They were both privately-owned (Józefów, Porąbka, Kazimierz Górniczy), as well as state-owned (Sielec-Klimontów). In the Dańdówka district, abandoned gardens and orchards are noticeable.

Together with the emergence of successive wastelands, some of the formerly shaped ones were developed gradually. An increase in the dynamics of redeveloped areas took place in the 2nd half of the 1990s. Developers were mostly attracted to derelict greenfields or greyfields. New enterprises were mostly connected with large format commerce, services and housing development. A crucial element deciding on the location was the availability of convenient transport.

An investment breakthrough did not happen until after 2000, though. At that time, a transformation of economic structure in new investments took place. Industrial facilities began to dominate. Commerce and services became of secondary importance. Another crucial issue connected with that stage was the concentration of new investments in brownfields. This direction constituted a primary trend in the investment policy of the city as well as in the Katowice Special Economic Zone. Starting in 2000, the number of new industries grew rapidly. By 2009, 17 facilities were opened altogether, built from scratch (see Tabs. 2 and 3). Moreover, several smaller production companies (frequently established from the collapsed old ones) used the buildings and infrastructure of closed-down facilities that operated in the socialist era. Since 2007, in the process of brownfields development, the dominating enterprises have been services. Some, such as the editorial office of a large regional newspaper and the most modern printing house in Central and Eastern Europe, Dziennik Zachodni (Polskapresse company) or the Exhibition Center Expo-Silesia, were particularly important investment points, also at the metropolitan scale.

The trend of dominating investments connected with services located in brownfields is confirmed by those realized in 2012, (Raben, the Silesian University of Medicine, the Sosnowiec Park of Science and Technology, the Climbing Centre – Poziom 450) as well as those under construction (see Tab. 4).

The awareness of the problem of development and location of functionally derelict areas in a given city and the scale of further investments in them allows for an empirical reference to the dynamic model previously proposed (Fig. 7). Table 5 presents a simplified version for the city of Sosnowiec. The simplification in this case lies in the fact that the "X" symbol indicates the existence of the functional transformation of the given arrangement and the "-" symbol indicates the lack of change. Instead of using symbols, one may enter for example a number of interactions of each type or the total area subjected to a functional transformation within the framework of particular functional types.

A complement to the model that makes the whole process legible comes in the form of a specification, indicating the dominating types of functionally derelict areas subject to disappearance in the space of a given city and the types of spatial development that are in their developmental stage (see Tab. 6). These specifications point out not only the method of making use of various types of functionally derelict areas, but they also may give evidence of the potential demand for them. From the academic point of view, they indicate the direction of general functional transformations in cities.

In the case of Sosnowiec, it is clearly noticeable that the regressive character in the structure of land use applies to former mining, agricultural and industrial areas. Their transformations went in the direction of several different functional types, but diverse from the previous ones. Only in some of the former post-industrial areas was this function recreated. Functionally derelict areas where the method of former use was different had an incidentally regressive character. An expansive character was typical for the following types: other services, commercial, and residential as well as logistics, transportation and industry. The scale of quality transformations

No.	Name of enterprise	Function of enterprise	Former land use type	City part
1	Auchan	Retail	Der.gr.	Środula
2	AUMA Polska	Manufacture of metal products	Der.gr.	Zagórze
3	Banasik Wholesaling	Wholesale	Der.gr.	Zagórze
4	Bodzio Meble	Retail	Der.gr.	Zagórze
5	Brzozowy Stok (Osiedle) (The Birch Slope – H. Estate)	Housing estate	Der.gr.	Sielec
6	Castorama	Retail	Der.gr.	Zagórze
7	Decathlon	Retail	Der.gr.	Środula
8	District motor vehicle inspection station	Car service	Der.gr.	Zagórze
9	E. Leclerc	Retail	Der.gr.	Zagórze
10	Ewmar-Ness	Wholesale	Der.gr.	Zagórze
11	Ford – Szumilas	Retail	Der.gr.	Zagórze
12	Leroy Merlin	Retail	Der.gr.	Środula
13	Macro Cash&Carry	Wholesale	Der.gr.	Zagórze
14	Mercedes	Retail, wholesale & services	Der.gr.	Stary Sosnowiec
15	Mikołajczyka (Osiedle) (The Mikołajczyk – H. Estate)	Housing estate	Der.gr.	Dębowa Góra
16	Municipal Rescue and Fire Department (Division Porąbka)	Services	Der.gr.	Porąbka
17	Neuca	Wholesale	Der.gr.	Zagórze
18	Norauto	Retail & services	Der.gr.	Środula
19	ProLogis Sosnowiec	Logistics	Der.gr.	Zagórze/Środula
20	Puczpol	Manufacture, wholesale and service of metal products	Der.gr.	Klimontów
21	Słoneczne (Osiedle) (A Sunny – H. Estate)	Housing estate	Der.gr.	Dębowa Góra/Sielec
22	Trade and Service Centre	Retail, wholesale & services	Der.gr.	Sielec/Klimontów
23	Wzgórze (Osiedle) The Hill (H. Estate)	Housing estate	Der.gr.	Sielec/Dębowa Góra
24	Toyota – Konsek	Retail & services	Der.gr.	Zagórze
25	Volkswagen – Magro	Retail & services	Der.gr.	Pogoń
26	Zielona Dolina (Osiedle) (The Green Valley – H. Estate)	Housing estate	Der.gr.	Dańdówka

Tab. 2: New larger enterprises located in the derelict greenfields in Sosnowiec after 1990. Functions and localization
Source: Authors

No.	Name of enterprise	Type of functional derelict areas	Former land use type or institution	Function of enterprise	City part
1	Aldi (Pogoń)	Br	Meat industry	Retail	Pogoń
2	Aldi (Sielec)	Br & Gy	Post-mining railway sites	Retail	Sielec
3	Alicja	Gy	Abandoned community and entertainment center	Services	Ostrowy Górn.
4	Amtra	Br	Politex – cotton-industry plant	Wholesale	Pogoń

Tab. 3: Economic activities in Sosnowiec – the most important investments in brownfields and also in larger greyfields (as of 31.12.2012)
Notes: Br – brownfields; Bl – blackfields; Der. gr – derelict greenfields; Gy – greyfields; KPP (Kopalnia Piasku Podsadzkowego) – Sand Pit; KWK (Kopalnia Węgla Kamiennego) – Hard Coal Mine; the authors considered both investments in new construction and new investments "in old walls" (refurbished buildings or objects)
Source: Authors

Tab. 3 – continuing

No.	Name of enterprise	Type of functional derelict areas	Former land use type or institution	Function of enterprise	City part
5	Autodrom Sosnowiec	Br	Former construction industry	Entertainment	Pogoń
6	Automax	Br and Der. gr	Former mine slag heap and derelict greenfields	Retail and services	Środula
7	Bart	Gy	Abandoned house	Services and contr.	Pogoń
8	Biedronka (Sielec)	Br	Cotton-industry (before 1945)	Retail	Sielec
9	Biedronka (Zagórze)	Br	KWK "Porąbka-Klimontów"	Retail	Zagórze
10	Bitron	Br	Coal mining (before 1945)	White goods industry	Dańdówka
11	Black Red White	Gy	Secondary school – the mining specialization	Retail	Zagórze
12	Budecon	Br	"Silma" – socialist electronics industry	Construction	Zagórze
13	Budirem	Br and Bl	KWK "Porąbka-Klimontów"	Construction	Zagórze
14	Caterpillar	Br	Coal mining (before 1945)	Automotive	Dańdówka
15	CEBI Poland	Gy	Coal mining (before 1945)	Electronics industry	Niwka
16	Caritas	Gy	Former secondary school	Centre of care (NGO)	Sielec
17	Coopra	Br	Politex – cotton-industry plant	Wholesale and retail	Pogoń
18	District motor vehicle inspection station	Br	Former mine slag heap and derelict greenfields	Car service	Środula
19	Duda-Silesia	Br	KWK "Saturn"	Meat-industry	Milowice
20	Elgum Automotive	Br	Politex – cotton-industry plant	Automotive	Pogoń
21	Energy – community center	Gy	Secondary school – the energy specialization	Community centre; NGO offices	Pogoń
22	Expo Silesia	Br and Gy	"Silma" – socialist electronics industry	Exhibition	Zagórze
23	Europa Shopping Center	Gy	Not finished and abandoned building	Retail and service	Centrum
24	EZT	Br	"Silma" – socialist electronics industry	Security and cleaning services	Zagórze
25	Fashion House Outlet Cent.	Br	Industrial railway sites	Shopping centre	Jęzor
26	Ferroli	Br	KWK "Sosnowiec"	Manufacture of metal products	Sielec
27	Geiger Technik Polska	Br	Coal mining (before 1945)	Manufacture of metal products	Dańdówka
28	Geocarbon	Br	KWK "Niwka-Modrzejów"	Investigation and research services	Niwka
29	Gimplast	Br	KWK "Saturn"	Manufacture of plastic products	Milowice
30	Grzybex & Klich-Pol	Gy	PSS "Spolem" - unfinished wholesale buildings	Wholesale	Kazimierz Górniczy
31	Heraeus Electro-Nite Polska	Br	KWK "Sosnowiec"	Electronics industry	Sielec
32	High School of Medicine	Br & Gy	KWK "Niwka-Modrzejów"	High school	Niwka
33	Hoermann Polska	Br	KWK "Saturn"	Manufacture of metal products	Milowice
34	Housing estate at Kilińskiego St.	Br & Der. Gr	Post-railway sites	Housing estate & retail	St. Sosnowiec
35	Housing estate at Kosynierów St.	Br	KWK "Porąbka-Klimontów"	Housing estate	Zagórze

Tab. 3 – continuing

No.	Name of enterprise	Type of functional derelict areas	Former land use type or institution	Function of enterprise	City part
36	Humanitas – High School	Gy	Former office building	High school	St. Sosnowiec
37	Iglotex	Gy	Former wholesale	Wholesale	Zagórze
38	Janus	Br	"KBO" – former construction company	Manufacture of metal products	Dębowa Góra
39	Indoor Karting – Adrenalina	Br	Politex – cotton-industry plant	Entertainment	Pogoń
40	Instac	Br	KWK "Kazimierz-Juliusz"	Construction	Porąbka/Juliusz
41	Kana – Education Center	Gy	Former natural therapy centre	Services	Sielec
42	Magneti Marelli Exhaust System	Br	Coal mining (before 1945)	Automotive	Zagórze
43	Municipal Department of Real Estate Management	Gy	Former local clinic	Services	Sielec
44	Municipal Cemetery	Br and Bl	Post mining sites	Cemetery	Niwka
45	Municipal Landfill Department	Br	KPP "Maczki-Bór" (sand pit)	Modern landfill site	Porąbka/Juliusz
46	Municipal Office (building at 3 Maja St.)	Gy	Former Municipal Hospital No. 2	Municipal Office	Centrum
47	Nadwozia-Partner	Br	Coal mining (before 1945)	Automotive	Dańdówka
48	Netto	Br	Former metal industry	Shopping centre	St. Sosnowiec
49	Nowa Wanda (New Wanda)	Br and Der. gr	Stone-waste and derelict greenfields	Housing estate	Dębowa Góra
50	Office and service building at Nowopogońska St.	Br	Former office-building of "Buczek" steelworks	Service and offices	Pogoń
51	Office and service building at Andersa St.	Br and Gy	Office-building of former "Wanda" industrial plant	Service and offices	Dębowa Góra
52	Office and service building at Jedności St.	Br and Gy	Office-building of former industrial plant – elements for construction	Service & offices	Dańdówka
53	O.K. Sosnowiec	Br	KWK "Porąbka-Klimontów"	Manufacture of plastic products	Zagórze
54	Okrąglak	Br and Gy	Local clinic at KWK "Sosnowiec"	Hotel (3-stars) and restaurant	Sielec
55	Plastic Components and Modules Poland	Br and Der. gr	Derelict greenfields and brownfields	Automotive	Zagórze
56	Plastic Components Fuel System Poland (former Ergom Poland)	Br	Coal mining (before 1945)	Automotive	Dańdówka
57	Plejada	Br	Former mine slag heap	Shopping centre	Środula
58	Police station	Br & Gy	"Intertex" – cotton industry plant (office building)	Public services	Pogoń
59	Polskapresse	Br	KWK "Saturn"	Printing, editorial off.	Milowice
60	PRC Group (former SEGU Polska)	Br	KWK "Sosnowiec"	Automotive	Sielec
61	Process Electronics	Br	Coal mining (before 1945)	Electronics industry	Dańdówka
62	Poviat Employment Agency	Gy	Former student hotel	Services	Sielec
63	Pronos	Br	Former construction company	Manufacture of metal products	Kazimierz Górniczy
64	Raben Group	Br	KPP "Maczki-Bór" (sand pit)	Logistics	Bór
65	Real	Br	Old sand pit area	Shopping centre	Milowice
66	Recreation-Sport Centre (Środula)	Br and Der. gr	Old quarry & stone-waste hill	Recreation	Środula

Tab. 3 – continuing

No.	Name of enterprise	Type of functional derelict areas	Former land use type or institution	Function of enterprise	City part
67	Residential block at 11 Listopada St.	Gy	Abandoned hotel for workers	Residential function	Dańdówka
68	Residential block at Czeladzka St.	Gy	Unfinished and abandoned building	Residential function	Pogoń
69	Residential blocks at W. Polskiego St.	Gy	Unfinished and abandoned buildings	Residential function	Dańdówka
70	Residental block at Mjr Hubala-Dobrzańskiego st.	Gy	Abandoned hotel for workers	Residential function	Klimontów
71	Residential block at Kosynierów St.	Gy	Abandoned hotel for workers	Residential function	Zagórze
72	Residential block at Mariacka St.	Gy	"Metalowiec" – former community centre and cinema	Residential function	Pogoń
73	Residential block at Sienkiewicza St.	Gy	Unfinished & abandoned building	Residential function and retail and services	Centrum
74	Saltzgitter Mannesmann	Br	KPP "Maczki-Bór" (sand pit)	Wholesale	Bór
75	Selw-2	Br and Gy	Steelwork "Buczek"	Service and manufacture	Środula
76	Silesian Logistics Centre	Br	Coal mining (before 1970)	Logistics	Jęzor
77	Silesian Revenue Office	Gy	Abandoned hotel for workers	High school	Dańdówka
78	Silesian University of Medicine	Br	Wasteland	Administration	Zagórze
79	Sistema Poland	Br	"Silma" – socialist electronics industry	Wholesale	Zagórze
80	Sosnowiec Park of Science and Technology	Br	KWK "Niwka-Modrzejów"	Research &Technology	Niwka
81	Stelonex	Br	"Silma" – socialist electronics industry	Logistics	Zagórze
82	System	Br	"SPBP" – former contruction company	Furniture manufacture	Dańdówka
83	Tesco (Sielec)	Br	Cotton-industry (before 1945)	Retail	Sielec
84	The Climbing Centre –Poziom 450	Br	KWK "Sosnowiec"	Recreation	Sielec
85	The Jehovah's Witnesses Convention Centre	Br and Gy	"Transgór" – former logistics company	Religious functions	Niwka
86	TM Steel	Br	"SPBP" – former contruction company	Wholesale	Dańdówka
87	University of Silesia – Faculty of Philology	Gy	Abandoned old hospital	High Education	Pogoń
88	Watt	Br	Coal mining (before 1945)	Engineering industry	Niwka
89	Wrzosowe Ogrody (Heather Gardens)	Br	KWK "Sosnowiec"	Housing estate	Sielec
90	Zap	Br and Der. gr	Former mine slag heap and derelict greenfields	Wholesale	Środula

Name of enterprise	Function of enterprise	Former land use type	Former land use or economic institution	City part	Will be open
Hotel Mercure	Hotel	Brownfields and Greyfields	Mining power station	Sielec	2013
Hotel ibis Style	Hotel	Brownfields	Mining power station	Sielec	2013
Kaufland	Retail	Brownfields	Metal industry	Stary Sosnowiec	2013

Tab. 4: Sosnowiec. Enterprises under construction (01.01.2013)
Source: Authors

		Functional type of derelict area									
		I Sector	II Sector			III Sector			Non-economic		
New type of functional land use	**FUNCT.**	AGRIC	MININ	INDUST	LOG&C	COMM	RECR	O. SER	RESID	MILIT	O. FUN
	AGRIC	-	-	-	-	-	-	-	-	-	-
	MININ	-	-	-	-	-	-	-	-	-	-
	INDUST	-	X	X	-	-	-	-	-	-	-
	LOG&C	X	X	-	X	-	-	-	-	-	-
	COMM	X	X	X	-	X	-	-	-	-	-
	RECR	-	X	X	-	-	X	-	-	-	-
	O. SER	X	X	X	X	-	-	X	X	-	-
	RESID	X	X	-	-	-	-	X	X	-	-
	MILIT	-	-	-	-	-	-	-	-	-	-
	O. FUN	-	X	-	-	-	-	-	-	-	-

Tab. 5: Dynamic model of the functional land use transformation
Explanations: AGRIC – agriculture; MININ – mining; INDUST – industry; LOG&C – logistics and communication; COMM – commerce (retail and wholesale); RECR – recreation and tourism; O.SER – other services; RESID – residential functions; MILIT – military; O.FUN – other functions
Source: Authors

Previous functions	Number	Emerged functions	Number
Mining	7	Other services	5
Agriculture	4	Commercial	3
Industry	3	Residential	3
Logistics and communication	1	Logistics and communication	2
Residential	1	Recreation	2
Other services	1	Industry	1
		Other functions	1

Tab. 6: The number of previous and newly emerged functions of functionally derelict areas in the city of Sosnowiec (1990–2012). Note: Without change within the same type
Source: Authors

expressed in numbers had its reference in the count of enterprises, too. Generally, the newest investments were observed in the post-mining and post-industrial brownfields and derelict greenfields.

Both the quality, as well as the quantity depictions showing the transformations in functionally derelict areas, may constitute a significant supplement (e.g. the employment structure) in defining general changes in the functions of the city.

4. Conclusions

Functionally derelict areas currently constitute a crucial problem in the spatial development of cities. On the one hand, they offer incentives for investment through their accessibility, price, location, and functional diversification. On the other hand, due to their disadvantageous image, there may represent some barriers, too. Not every developer is able to undertake the challenge of locating an enterprise in the "wasteland". The problem frequently arises from the fact that the investment site is an enclave, still surrounded by derelict areas, where the urban landscape is usually decomposed. Perceptually, it is the antithesis of development.

From this case study of Sosnowiec, however, where investment zones have developed in dispersed form and where the need to be a "pioneer" has always existed, this barrier can be broken. In this case, the diffusion model has become apparent – hierarchical and infectious. In the case of hierarchical diffusion – new investments were located in almost exclusively derelict areas, where the factor of low price, good transport accessibility and allotments of proper size were the most influential.

Following pioneer investments, new developments agglomerated around them in the process of a so-called infectious diffusion. From the perspective of over 20 years, it can be stated that this development model of functionally derelict areas, and particularly brownfields, is most welcome. It is recommended also from the viewpoint of economic, tax, social and spatial benefits.

The examined case of Sosnowiec also reveals that consistent and open urban policies focused on wasteland development may even create a model example of facing the problem for other post-mining and post-industrial cities. In Sosnowiec itself, a form of milieu has been shaped, which redefines the current development of the city.

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THE SPATIAL PATTERN OF BROWNFIELDS AND CHARACTERISTICS OF REDEVELOPED SITES IN THE OSTRAVA METROPOLITAN AREA (CZECH REPUBLIC)

Jiří NOVOSÁK, Oldřich HÁJEK, Jana NEKOLOVÁ, Pavel BEDNÁŘ

Abstract

Differences between brownfields and redeveloped sites in the Ostrava metropolitan area are subject to analysis in this paper. Environmental burden and former functional use were identified as statistically significant characteristics of such differences. In addition, relations between selected attributes of brownfields and redeveloped sites were analyzed using the "if–then" decision rules of the rough set method. In this way, the research demonstrated the significance of spatial aspects and identified two fundamental types of brownfields in the model area. The first type is represented by agricultural brownfields in the hinterland zone, that are characterized by a complicated ownership structure. Brownfields of the second type are located particularly in the inner city morphogenetic zone, and are characterized by potential problems with environmental burden. In this context, brownfields and redeveloped sites differ respectively in the combination of these characteristics.

Shrnutí

Prostorový vzorec a charakteristiky brownfields a nově využitých lokalit v Ostravské metropolitní oblasti (Česká republika)

Cílem článku je analyzovat rozdíly mezi brownfields a nově využitými lokalitami v ostravské metropolitní oblasti. Ekologická zátěž a bývalé funkční využití byly v tomto ohledu identifikovány jako statisticky významné charakteristiky. Současně jsou na bázi využití „když – pak" rozhodovacích pravidel metody rough množin hodnoceny relace mezi vybranými atributy brownfields a nově využitými lokalitami. V tomto ohledu výzkum potvrdil významnost prostorových aspektů a identifikoval dva základní typy brownfields v modelové oblasti. První typ je reprezentován zemědělskými brownfields v zázemí modelové oblasti, které jsou charakteristické komplikovanou vlastnickou strukturou. Brownfields druhého typu jsou lokalizovány převážně v morfogenetické zóně vnitřního města a jsou charakteristické potenciálními problémy s ekologickými zátěžemi. Kombinace uvedených charakteristik nám umožňuje odlišit brownfields a nově využité lokality.

Keywords: *brownfields, redeveloped sites, rough-set method, Ostrava metropolitan area, Czech Republic*

1. Introduction

Sustainable development is regarded as a prominent concept in modern society, posing the challenge of balancing economic, social and environmental goals. A number of conflict issues exist (see e.g. Conroy and Berke, 2004), however, including soil consumption. From the sustainability viewpoint, it is highly desirable to reduce soil consumption as much as possible. Thus, it is not surprising that the redevelopment of brownfields is fully in accord with the sustainable development concept (Hemphill, Berry, McGreal, 2004). Nevertheless, there are several barriers to brownfield redevelopment, including the fundamental characteristics of brownfields. Spatially, the issue of brownfields is discussed in various contexts. First, brownfields are firmly embedded in research focused on the decline and regeneration of old industrial regions in Europe and North America (e.g. Florida, 1995). Second, brownfields in metropolitan areas are subject to research, considering specifics of morphogenetic zones on the one hand, and development problems of compact and dispersed cities on the other (e.g. Sýkorová, 2007; Kunc, Klusáček, Martinát, 2011). Third, the developmental potential of brownfields

in rural and peripheral regions has been evaluated (see e.g. Svobodová, Věžník, 2009; Vaishar, Jakešová, Náplavová, 2011; Klusáček, Krejčí, Kunc, Martinát, Nováková, 2011). Altogether, the spatial dimension is an important element in brownfield research.

These issues create the cornerstones of this article. Our focus is on the spatial analysis of the fundamental characteristics of brownfields, a common theme in the scholarly literature (see e.g. Kunc and Tonev, 2008). However, the characteristics of brownfields are traditionally evaluated in isolation, not considering the relations between brownfields on the one hand and redeveloped sites on the other. Thus, the goal of this research is to analyze the differences between brownfields and redeveloped sites, emphasising their spatial location in morphogenetic zones of the Ostrava metropolitan area. The article is structured as follows: the next section provides theoretical underpinnings of our research; the third section sketches out our methodology; the fourth section presents the main empirical findings and these are further discussed in the fifth section, followed by our conclusions.

2. Literature review

Brownfield redevelopment has been a subject of research from several viewpoints. The first area of interest, relevant for our article, concerns barriers of brownfield redevelopment, which include the characteristics of brownfields. There are several attributes analyzed in the scholarly literature.

The potential for brownfield redevelopment is in many cases reduced by the location of brownfields in inner cities (Doetsch, Rüpke, 1998). Such a location tends to be connected with a limited space for firm expansion and with complicated transport accessibility (e.g. Koll-Schretzenmayr, 2000 for case studies on this issue). This situation reduces the redevelopment potential of brownfields because transport infrastructure is an important location factor in the decision-making process of developers (see e.g. Holl, 2004). Moreover, it is noteworthy that city centres and suburban areas are regarded as morphogenetic zones with the most evident changes in the functional-spatial structure of post-socialist cities (Sýkora, 2003). Thus, the potential of brownfield redevelopment in inner cities is further affected.

Potential brownfield redevelopment may be further lowered by an intricate ownership structure. In this regard, Adams, Disberry, Hutchison, Munjoma (2001) underline the owners' undue notion of brownfield value on the one hand and at their unwillingness to sell or rent brownfield sites for various reasons on the other. Similarly, Koll-Schretzenmayr (2000) identified intricate ownership structure as one of the main barriers to brownfield redevelopment. The brownfield legacy is reflected not only in an intricate ownership structure but also in the uncertainty of environmental burden. Consequently, financial and time costs of brownfield redevelopment projects increase (Nijkamp, van den Burch, Vindingi, 2002).

There are two areas of research where characteristics of brownfields play an important role. The first area is focused on the spatial analysis of brownfields; for example, Kunc, Tonev (2008) chose the city of Brno for their analysis. The spatial dimension of their analysis was based on morphogenetic zones of the city and they showed the importance of the inner city for the location of brownfields. Sýkorová (2007) who focused her analysis on the City of Prague, employed the same analysis, identifying the inner city and suburban zones as the most problematic ones when considering the location of brownfields. In other studies, Vojvodíková, Potužník, Bürgermeisterová (2011) dealt with brownfields at a municipal level, while Svobodová, Věžník (2008) carried out research at a regional level. These research projects have two aspects in common: first, various attributes of brownfields were quantified (including former functional uses, environmental burden, transport accessibility, or ownership structure); subsequently, the authors suggested a form of brownfield classification.

The second area of research concerns the evaluation of brownfield redevelopment potential. Traditionally, simple multi-criteria methods are applied and attributes of brownfields play the role of criteria. Their different importance is estimated by weights and some form of aggregation of the criteria provides the value of brownfield redevelopment potential. Such a model was suggested for example by Doetsch, Rüpke (1998), and in a slightly adapted version replicated by Rydvalová and Žižka (2006). Similarly, Vojvodíková (2004) developed an evaluation model based on multi-criteria methods.

The above-mentioned areas are very important for brownfield redevelopment research but spatial analyses of brownfields are traditionally realized in isolation, not considering their broader relations to redeveloped sites. In this respect, the brownfield-greenfield debate is more common (see e.g. De Sousa, 2006).

3. Methodology

To meet the goal of this article, a complex methodological approach was applied: for further details, see Novosák (2009). In this section, we sketch out the most important aspects of the methodology.

3.1 Determination of brownfields and redeveloped sites

The first aspect of the methodology is related to the question of how to define the key terms of brownfield (see Alker, Joy, Roberts, Smith, 2000 for a detailed review of definitions) and of a redeveloped site. Various attributes of brownfields play a role when defining the term, but the requirement of unused or underused site is the most controversial because of its subjective nature (see e.g. Yount, 2003).

In this article, brownfields and redeveloped sites are defined using four characteristics. Two of them are common for both types of sites – the requirement of area size larger than one hectare on the one hand, and of a limited set of functional uses on the other. This set includes agricultural, mining, industrial, transportation, military and other non-residential functional uses except dumps and selected public service facilities. It is noteworthy that our methodology is focused on rather large non-residential brownfields – a quite common approach in brownfield assessment (see e.g. Kunc and Tonev, 2008 or Sýkorová, 2007).

The third characteristic employed for the identification of brownfields is the degree of their functional use in the period 2008–2009. In this regard, we first compiled a database of sites larger than one hectare, which were used for any of the above-mentioned functional uses in the early 1990s. For this purpose, we used cartographic and other archival sources of information. Subsequently, we identified brownfields based on their ownership structure and physical deterioration. There was a requirement that a total ownership share of entities active on the site was below 50% of its area. Ownership structure data was compiled from cadastre.

The fourth characteristic employed for the identification of redeveloped sites is the change in economic activities between the early 1990s and the period 2008–2009. In this regard, we first compiled a database of sites larger than one hectare, which were used for any of the above-mentioned functional uses in 2008–2009. Subsequently, we identified entities active on the site in the early 1990s using cartographic and other archival sources of information. Subsequently, the position of these entities in 2008–2009 was evaluated. A site was understood as redeveloped if the entities active thereon in the early 1990s were not dominant employers on the site in 2008–2009.

Finally, two methodological notes have to be added. First, the sample of brownfields and redeveloped sites was compiled using the authors' own methodology that included analyses of cartographic and archival sources and field mapping. In this regard, our sample was different from the official databases such as the brownfield database of Ostrava City (e.g. Vojvodíková et al., 2011). Second, in the definition of redeveloped sites we emphasized the change of dominant employers. There could have been various periods when the redeveloped sites were not used, so that redeveloped sites in our definition are not necessarily redeveloped brownfields in the traditional way of thinking – long-term abandoned sites.

3.2 Model area delimitation

The second aspect of the methodology concerns the question how to define the Ostrava metropolitan area, the model area of our analysis. This task was resolved on the basis of close functional links between the Ostrava City and surrounding municipalities. Thus, requirements on daily employment commuting to Ostrava City, on administrative links with Ostrava City, and on urban mass public transport connection with Ostrava City were imposed (see Novosák, 2009 for details). On this basis, the administrative area of Ostrava City (including five specific zones: compact inner city, dispersed inner city, zone of housing estates, zone of transition, and suburban zone) and thirty one municipalities in its hinterland (constituting the zone of surrounding municipalities) formed our model area (see Fig. 1).

3.3 Additional data sources

The third aspect of the methodology is the selection of attributes for the further analysis of differences between brownfields and redeveloped sites. In this regard, we respected the most important attributes identified in our literature review: Tab. 1 summarizes these attributes and their possible values. Note that the analysis is based on categorical values of the attributes.

The data matrix represents the fourth aspect of the methodology. Thus, brownfields and redeveloped sites in the model area were identified as rows of the data matrix. Subsequently, values of the analyzed attributes were added for all identified brownfields and redeveloped sites, represented as columns.

3.4 Methods of statistical analysis

Finally, the fifth aspect of the methodology is related to the evaluation of the data matrix. Two methodological approaches are used: (1) traditional methods of descriptive and inferential statistics – since the evaluated attributes are categorical in nature, we use the analysis of frequencies (Pearson's Chi-square and Cramer's V statistics) in our decisions on differences between brownfields and redeveloped sites, differences are related both to the number and total area of brownfields and redeveloped sites; and (2) broader relations between the evaluated attributes on the one

hand and brownfields and redeveloped sites on the other, were analyzed by the rough-set method. This method provides a robust theoretical framework for the interpretation of information of quantitative and qualitative nature (see e.g. Pawlak, Slowinski, 1994; Bruinsma, Nijkamp, Vreeker, 2002). In this article, the method was used to generate the so-called "if-then" decision rules. The "if" part contains conditions – a combination of the values of attributes. The "then" part is a decision conditioned by the combination. Thus, we dealt with the question what combinations of the values of attributes classify sites as brownfields.

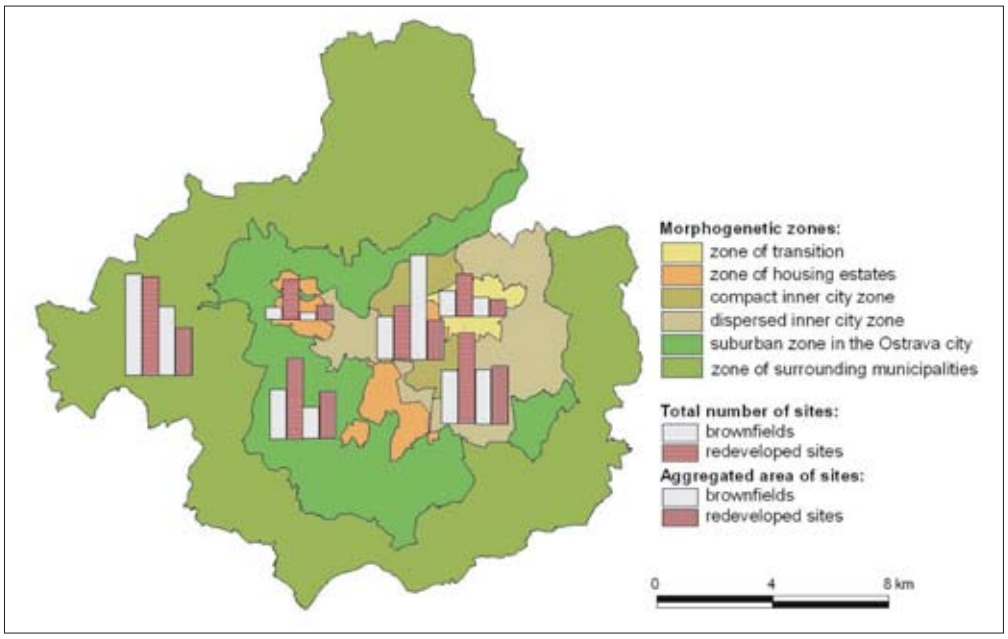

Fig. 1: Brownfields in morphogenetic zones of the Ostrava metropolitan area
Source: Authors' elaboration (based on Novosák, 2009)

Attribute	Values
Location in morphogenetic zones of the model area (see Fig. 1)	Zone of transition Zone of housing estates Compact inner city zone Dispersed inner city zone Suburban zone in Ostrava city Zone of surrounding municipalities
Transport accessibility (Source: authors' calculation of distances based on vector maps of communication – available from <http://geoportal.cenia.cz>)	Very good – direct connection to expressways Good – direct connection to first class road Bad – direct connection to second or third class road Very bad – other cases
Ownership structure derived from the number of owners and their shares in total site area (Source: authors' compilation based on data from the cadastre – available from <http://nahlizenidokn.cuzk.cz>)	Not complicated Complicated Very complicated
Threat of environmental burden derived from the former functional use and existence of environmental burden in official databases (Source: authors' compilation based on various cartographic and archival resources for particular sites and system of contaminated sites, available from <http://sekm.cenia.cz>)	Low Medium High Extremely high
Former functional use (Source: authors' compilation based on various cartographic and archival resources for particular sites)	Agriculture Mining Manufacturing and construction Services
Area (Source: authors' compilation based on data from the cadastre – available from <http://nahlizenidokn.cuzk.cz>)	Small – less than 5 ha Medium – 5-10 ha Large – more than 10 ha

Tab. 1: Evaluated attributes of brownfields and redeveloped sites
Source: adapted from Novosák (2009)

4. Empirical results – characteristics of brownfields and redeveloped sites

Our analysis is based on a sample of 181 sites. These include 74 brownfields with a total area of 699 hectares and 107 redeveloped sites with a total area of 529 hectares. Are there significant differences between brownfields and redeveloped sites, considering their location in the morphogenetic zones of the model area? Tab. 2 shows the results. The number and the total area of brownfields are relatively high in the inner city zones and suburban zones. However, the highest ratio between the area of brownfields and redeveloped sites is observed in the compact inner city zone. The ratio is relatively higher also for the zone of transition and the zone of surrounding municipalities. Corresponding figures for other morphogenetic zones are lower. On the other hand, there are no statistically significant differences between the numbers of brownfields and redeveloped sites if their location in the morphogenetic zones of the model area is analyzed.

Taking a closer look at the other characteristics of brownfields and redeveloped sites, Tab. 3 shows the results for the transport accessibility attribute. Two findings are noteworthy: first, there are brownfields with various qualities of transport accessibility. The location of brownfields close to the highway network may be an important development factor for relatively large brownfields in the model area. Second, there are not statistically significant differences between the numbers of brownfields and redeveloped sites if the quality of their transport accessibility is analyzed.

Tab. 4 differentiates brownfields and redeveloped sites according to their ownership structure. It is shown that a very complicated ownership structure is more typical for relatively large brownfields in the model area. Thus, the good quality of their transport accessibility is compensated by a fragmented ownership structure. However, there are not statistically significant differences between the numbers of brownfields and redeveloped sites if the ownership structure attribute is analyzed.

Morphogenetic zones	Brownfields		Redeveloped sites	
	Number	Area (ha)	Number	Area (ha)
Zone of transition	6	38.9	11	33.0
Zone of housing estates	2	9.9	8	28.2
Compact inner city zone	11	270.9	14	95.1
Dispersed inner city zone	14	134.4	25	143.8
Suburban zone in Ostrava City	13	71.2	22	113.3
Zone of surrounding municipalities	28	173.5	27	115.4

Tab. 2: Brownfields and redeveloped sites in the model area – location in morphogenetic zones
Source: Authors' calculations (based on Novosák, 2009)

Transport accessibility	Brownfields		Redeveloped sites	
	Number	Area (ha)	Number	Area (ha)
Very good	12	299.6	10	60.0
Good	12	111.1	28	146.3
Poor	34	198.3	54	279.0
Very poor	16	89.8	15	43.5

Tab. 3: Brownfields and redeveloped sites in the model area – transport accessibility
Source: Authors' calculations (based on Novosák, 2009)

Ownership structure	Brownfields		Redeveloped sites	
	Number	Area (ha)	Number	Area (ha)
Not complicated	30	173.7	51	182.1
Complicated	26	161.7	41	216.0
Very complicated	18	363.4	15	130.7

Tab. 4: Brownfields and redeveloped sites in the model area – ownership structure
Source: Authors' calculations (based on Novosák, 2009)

Environmental burden is regarded as an important barrier to brownfield redevelopment. Tab. 5 shows differences between brownfields and redeveloped sites if the threat of environmental burden is considered. There is a relatively low threat of environmental burden for a high number of both brownfields and redeveloped sites. However, an extremely high threat of environmental burden is very typical for large brownfields in the model area. It is noteworthy that differences between brownfields and redeveloped sites according to the variable of environmental burden are statistically significant at the 1% level.

Former functional use is the last analyzed attribute of brownfields and redeveloped sites. Tab. 6 depicts the structures of brownfields and redeveloped sites according to their former functional use. Differences between brownfields and redeveloped sites are obvious. Agriculture and mining are typical for brownfields, while manufacturing and services characterize redeveloped sites. In addition, large brownfields were used as former mining and manufacturing sites. It is also worth mentioning that the differences between brownfields and redeveloped sites according to their former functional use are statistically significant at a 1% level of significance.

5. Discussion – brownfields and redeveloped sites in broader relations

The preceding discussion revealed the main differences between brownfields and redeveloped sites in the model area according to the five selected attributes. Our findings may be summarized as follows:

- The highest number of brownfields occurs in the morphogenetic zone of the surrounding municipalities. Moreover, a relatively high number of brownfields were used for agricultural production. Tab. 7 shows that agricultural brownfields are overrepresented in the morphogenetic zone of the surrounding municipalities. Thus, a relationship between these two variables may be expected in this respect.
- Large brownfields are located especially in the compact inner city zones. Moreover, large brownfields are characterized by good transport

Threat of environmental burden	Brownfields		Redeveloped sites	
	Number	Area (ha)	Number	Area (ha)
Low	31	136.7	53	208.1
Moderate	14	122.0	31	152.5
High	4	24.7	12	101.2
Extremely high	25	415.4	11	67.0

Tab. 5: Brownfields and redeveloped sites in the model area – threat of environmental burden
Source: Authors' calculations (based on Novosák, 2009)

Former functional use	Brownfields		Redeveloped sites	
	Number	Area (ha)	Number	Area (ha)
Agriculture	26	112.1	21	47.7
Mining	21	203.2	5	23.7
Manufacturing and construction	13	330.3	39	267.4
Services	14	53.2	42	190.0

Tab. 6: Brownfields and redeveloped sites in the model area – former functional use
Source: Authors' calculations (based on Novosák, 2009)

Former functional use	Surrounding municipalities		Other zones	
	Brownfields	Redeveloped Sites	Brownfields	Redeveloped Sites
Agriculture	43%	26%	13%	19%
Mining	15%	4%	65%	15%
Manufacturing and construction	0%	21%	25%	54%
Services	7%	5%	18%	70%

Tab. 7: Brownfields and redeveloped sites in the model area – former functional use structure related to the location in morphogenetic zones. Source: Authors' calculations (based on Novosák, 2009)

accessibility, complicated ownership structure, high threat of environmental burden, and former mining or manufacturing functional use. It is remarkable that there are eleven brownfields in the compact inner city zone: six of them have the above-mentioned characteristics.

Based on this argument, it seems evident that there are two fundamental types of brownfields in the model area. Their location in morphogenetic zones may be regarded as an important differentiating factor is this sense. To verify these assumptions we decided to employ two methodological approaches. First, we statistically tested the significance of differences between the brownfields and the redeveloped sites in only two morphogenetic zones – the city and its hinterland. Second, we constructed the most common combinations of the values of attributes using the rough-set method.

Tab. 8 summarizes the results of the first methodological approach, and the findings confirm the relevance of the above-mentioned assumptions. Thus, former functional use is statistically significant for both morphogenetic zones. Mining as a former functional use is typical for brownfields in the city zone, while agriculture is typical for brownfields in the hinterland zone. In addition, the threat of environmental burden represents a more important barrier for brownfield redevelopment in the city zone. Transport accessibility and ownership structure are not statistically significant attributes, but note that the former seems to play a more important role in differentiating brownfields and redeveloped sites in the city zone, while the latter plays the same role in the hinterland zone.

In the second methodological approach – the rough-set method – six attributes of brownfields and redeveloped sites were defined as independent variables. These included the five attributes analyzed above and the total area of sites as a sixth independent variable. The dependent variable provided the choice between the brownfield category on the one hand and the redeveloped site category on the other. Applying the rough-set method, the "if – then" decision rules were generated. Subsequently, we observed what combinations of independent variable values classified sites as brownfields.

Tab. 9 shows the results. The highest number of brownfields is classified if they meet the conditions of extremely high threats of environmental burden, complicated ownership structure, and mining as their former functional use (see DR1). Just mining as a former functional use seems to be the most frequent differentiating factor between brownfields and redeveloped sites in the model area (see DR1, DR4, D6, DR7, and DR9). The development potential of mining brownfields may be further worsened by extremely high threats of environmental burden (see DR1, DR9), by large area (see DR4), or poor transport accessibility (see DR7, DR9) of brownfields. Extremely high threats of environmental burden and relatively large area seem to be an important brownfield redevelopment barrier more generally (see DR8, DR10). Evaluation of the transport accessibility attribute is not so straightforward (see DR6). Altogether, these findings are fully in accord with the characteristics of brownfields located in the city zone as defined in Tab. 8.

There are three other decision rules in Tab. 9 – DR2, DR3, and DR5. Two of them, DR2 and DR3, describe a similar situation. Sites located in the zone of surrounding municipalities with a very complicated ownership structure are usually classified as brownfields (see DR2). The condition of low threat of environmental burden in DR2 closely relates to the former agricultural functional use of brownfields (see DR3). In addition, close links between relatively larger agricultural brownfields (see DR3) and complicated ownership structure (see D2) may be expected. It is worth mentioning the statistically significant difference between brownfields and redeveloped site in the hinterland zone, if one considers their former functional use (see Tab. 8). Agricultural brownfields are the most common type in this regard: the findings are fully in line with the characteristics of brownfields located in the hinterland zone as defined in Tab. 8.

Attributes	City		Hinterland	
	Pearson's Chi-square	Cramer's V	Pearson's Chi-square	Cramer's V
Transport accessibility	0.072	0.277	0.560	0.151
Ownership structure	0.877	0.054	0.070	0.243
Environmental burden	0.000*	0.522	0.070	0.280
Former functional use	0.000*	0.511	0.002*	0.401

*Tab. 8: Statistical significance of differences between brownfields and redeveloped sites – selected attributes; asymptotic significance of Pearson's Chi-square; * Statistically significant at 1% level of significance*
Source: Authors' calculations (based on Novosák, 2009)

Rule	Combination of independent variable values	Number
DR1	OS = complicated AND TEB = extremely high AND FFU = mining	8
DR2	LMZ = zone of surrounding municipalities AND OS = very complicated AND TEB = low	7
DR3	FFU = agriculture AND A = medium	6
DR4	FFU = mining AND A = large	6
DR5*	OS = complicated AND TEB = low AND TA = bad AND FFU = agriculture	6
DR6	TA = very good AND FFU = mining	5
DR7	TA = very poor AND FFU = mining	5
DR8	TA = very good AND TEB = extremely high AND A = large	5
DR9	TA = poor AND TEB = extremely high AND FFU = mining	5
DR10	LMZ = Zone of transition AND TEB = extremely high	4

Tab. 9: The number of brownfields classified by "if – then" decision rules; a review of decision rules with more than three classified brownfields
Note: LMZ – location in morphogenetic zones; TA – transport accessibility; OS – ownership structure; TEB – threat of environmental burden; FFU – former functional use; A – area
** This decision rule classifies six brownfields and seven redeveloped sites. It is not possible to differentiate these sites.*
Source: Authors' calculations (based on Novosák, 2009)

Altogether, our assumptions about the existence of two types of brownfields in the Ostrava metropolitan area were confirmed by both methods. There are relevant implications from these findings, which may be used especially in the strategic planning of brownfield redevelopment. Generally, specifics of particular brownfield sites should be considered in this regard.

First, there is a very limited redevelopment potential of large mining brownfields in the inner city. A complicated ownership structure and a high threat of environmental burden may further worsen the situation (see DR1). Even very good transport accessibility is not a trigger for redevelopment processes (see DR6). The "if – then" decision rules show no success story of redevelopment of these sites for any functional use of interest in the model area. However, some additional aspects must be added. The abandoned sites of this kind represent cheap properties for small and medium-size enterprises. The former Jan Šverma mine may be regarded as an example. Then, a question is whether it is desirable to think always of large-scale brownfield redevelopment projects. Moreover, some mining sites in the model area have been redeveloped for functional uses, which are not assessed in this paper (e.g. conversion for cultural purposes). Then again, our findings show that flexible territorial planning and support for non-manufacturing redevelopment projects should be considered.

Second, there is a very limited redevelopment potential of agricultural brownfields in relatively small municipalities in the hinterland of the Ostrava metropolitan area. Two aspects seem to be relevant in this respect when analyzing the decision rules in Tab. 9. The first aspect relates to bad transport accessibility (see DR5). However, a complicated ownership structure seems to be much more relevant (see DR2, DR5) because of several redeveloped sites in the hinterland of the Ostrava metropolitan area, which were previously used for manufacturing or services. In our arguments, agricultural brownfields are a legacy of the restitution processes and a consolidation of their ownership structure is necessary to plan for the redevelopment of these sites.

6. Conclusion

Brownfield redevelopment is an important research area because of its close links to the sustainable development concept. Several research themes are considered in this regard, but empirical knowledge of the differences between brownfields and redeveloped sites is rather scarce. This article contributes to the current state of knowledge by analyzing the differences between brownfields and redeveloped sites in the model area of the Ostrava metropolitan area. Spatial aspects are emphasised at the level of morphogenetic zones.

The compact inner city zone of the model area shows the highest ratio between the area of brownfields and redeveloped sites. Thus, the problem of brownfields may be perceived as very relevant in this morphogenetic zone. In addition, the highest number of brownfields is identified in the zone of surrounding municipalities. Thus, our analysis confirms the conclusions formulated by Sýkorová (2007) that the inner city of Prague and its suburban areas are most affected by the location of brownfields.

Some attributes are identified as statistically significant in explaining differences between brownfields and redeveloped sites. These include the

threat of environmental burden and former functional use. However, the spatial aspect must be considered as well because there are two fundamental types of brownfields in the model area. The first type includes agricultural brownfields in the hinterland zone of the model area, characterized by a complicated ownership structure. The second type of brownfields is located especially in the inner city zone and is characterized by potential problems with environmental burden. Several abandoned coal mines belong to the second type of brownfields.

Altogether, our findings confirm some more general considerations on the dynamics of changes in the internal spatial structure of metropolitan regions and on the low development potential of brownfields in a peripheral hinterland. On the other hand, there are some specifics related to the Ostrava metropolitan area, especially the legacy of abandoned coal mines. The findings from our research are rather pessimistic considering their future. Moreover, there are over 600 hectares of manufacturing sites in the compact inner city morphogenetic zone, still used by the same economic entity as in the early 1990s. This area may be understood as a dormant brownfield threat for the Ostrava metropolitan region.

Our findings show that it is necessary to consider spatial location and other characteristics of brownfields in their redevelopment process. There is not a "one-case-fits-all" solution. In this respect, the methodological approach applied in this article may provide worthwhile information on brownfield development potential.

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VARIOUS ASPECTS OF THE GENESIS AND PERSPECTIVES ON AGRICULTURAL BROWNFIELDS IN THE CZECH REPUBLIC

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Abstract

Abandoned agricultural objects from the period of large-scale agricultural production in the socialist era represent a peculiar topic in the former communist countries of Eastern Europe, surpassing the experience of the EU15 countries or USA that have extensive and long-standing practice in brownfields redevelopment. The question of brownfields resulting from the transformation of the agricultural sector during the transition period of the Czech Republic is presented in this paper. Agricultural brownfields are the most frequently occurring brownfields in the Czech Republic (especially in some regions), but their area share is much lower, indicating their spatial disposition in the landscape. Some aspects of agricultural brownfields regeneration, including possibilities of its funding, are discussed in the paper. We also deal with geographical, environmental and historical aspects of the existence of these localities in the Czech Republic in the context of potential financial resources and possibilities for funding their revitalization.

Shrnutí

Vybrané aspekty vzniku a možností využití zemědělských brownfields v České republice

Problematika dědictví areálů socialistické zemědělské velkovýroby je fenoménem postsocialistických zemí a částečně se vymyká zkušenostem EU15 či USA, které mají dlouholeté a bohaté zkušenosti s nástroji revitalizace lokalit typu brownfield. Článek je zaměřen na problematiku zemědělských brownfields, které jsou důsledkem transformace zemědělství v postsocialistických zemích. Opuštěné zemědělské areály jsou nejčastějším typem brownfields v České Republice, avšak jejich plošný podíl je mnohem menší, což poukazuje na jejich prostorové uspořádání v krajině. V příspěvku jsou diskutovány vybrané aspekty revitalizace zemědělských brownfields včetně možností financování. Diskutovány jsou geografické, environmentální, historické aspekty existence těchto lokalit na území České republiky v souvislostech potencionálních informačních zdrojů a dále v návaznosti na možnostech financování revitalizace.

Keywords: *agricultural brownfields, revitalization, rural development, Czech Republic*

1. Introduction

The topic of brownfields used to be related to urban and city lands, but due to political and economic changes in Eastern Europe brownfields resulted not only from industry but also from activities characteristic of rural sites (agriculture, closed-down facilities providing rural services – consumer cooperatives, provincial houses of culture, etc.). The period of political-economic transformation brought many changes into the agricultural sector of Eastern Europe. The transition to a market economy had to involve radical reconfiguration of land resources in the former socialist countries: changes in property rights (Lerman, 2004; Bartůšková, Homolka, 2009), as well as changes in land use patterns (Baumann, 2011; Bičík et al., 2001; Müller, 2009). The property rights changed and various land allocation and privatization strategies affected agricultural performance in the transition years (Lerman, 2004). Cropland abandonment became a widespread change in land use patterns in the post-socialist era in Eastern Europe and European Russia (Bičík et al., 2001; Ioffe et al., 2004; Prishchepov et al., 2012). Various regional studies reported and in some cases quantified the major drivers of agricultural land abandonment (Baumann, 2011; Müller, 2009; Prishchepov et al., 2013). Statistical models showed that ecological conditions (soil type, elevation) and socio-economic characteristics (rural population change, industrialization and mechanization rate, urbanization rate, unemployment) can explain the spatial heterogeneity of farmland abandonment. The relative influence and relations of these variables in

post-socialist farmland abandonment may regionally differ and generalization across countries is scarcely possible (Bauman et al., 2011; Müller, 2009). Benayas et al. (2007) reviewed the main problems and opportunities related to agricultural land abandonment. In the consequences of radical reconfiguration of land resources in the former socialist countries, some agricultural facilities lost their function (Svobodová, Věžník, 2009).

Specific statistical data to quantify the number of abandoned farm buildings, however, are lacking across Europe. The decrease of agricultural enterprises is demonstrated to be a widespread structural change in European agriculture (Verhoeve et al., 2012; Jaarsma, de Vries, 2013). Jaarsma and de Vries (2013) used the decrease in the number of farm enterprises 1990–2007 (dairy farming in six EU countries) as a rough estimate of the number of abandoned farm buildings. The inheritance of the objects of large-scale socialist agriculture surpasses the experience of western countries that have extensive and long-standing practice in brownfields redevelopment. Whereas abandoned farm buildings are a consequence of the enlarging scale of agriculture in Western Europe (Jaarsma, de Vries, 2013), the transformational shift from collective to individual agriculture was attended by general downsizing of corporate farms in Eastern Europe (Leerman, 2004). Large farm sizes and collective organization of production sharply distinguished socialist agriculture from the agriculture in market economies, and this common heritage of agricultural production suggested a fairly uniform conceptual framework for agricultural reform in all transition countries (the former socialist countries in Europe and Central Asia) (Leerman, 2004). The framework determined the specific conditions for the abandonment of agricultural buildings and their future evolution. The processes of transformation from collective to individual agriculture in Eastern Europe occurred against the backdrop of macro-scale driving forces of global trade liberalization, joining agrarian policies such as the European Common Agricultural Policy (Doucha, Foltýn, 2008; van Meijl, 2006) and of new understandings of the countryside and its functions (Noe et al., 2008).

The topic of brownfields in urban areas is widely discussed in many countries; however, the topic of agricultural brownfields is at the edge of research interest. The problem of agricultural brownfields is neglected for many reasons: the marginal interest of developers (Hudečková, 1995) or problematic projects contrary to the needs and interests of municipalities; a scanty attention by research teams (city planners, geographers, economists); peripheral location; and commonly small-scale area size and low environmental loads (as compared with industrial or military brownfields). However, they can represent a serious problem for rural regions, considering the size and developing potential of the involved sites. Agricultural brownfields are usually located near a settled area and open landscape interface and in some cases in the open. Agricultural buildings belong to the dominating features of settlements and rural landscape; this is why the situation of agricultural estates can markedly affect the urban and landscape character (Mackovič, 2003). Their progressive deterioration eventually leads to their complete state of disrepair (Garcia and Ayuga, 2007), and the idled and desolated agricultural objects become a negative element in the rural landscape disturbing the landscape pattern as well as the architectural character of villages.

Spatial planning for rural brownfields in Europe is geared to questions of preserving the cultural heritage of traditional agricultural buildings (Garcia and Ayuga, 2007; Taasia), to diversification potential and acceptability of non-agrarian functionalities in the countryside (Verhoeve et al., 2012), or to land protection potential of rural brownfields revitalization (Garcia, Ayuga, 2007). The issue of the duality between traditional and modern agricultural buildings (duality between architectural and aesthetic quality and economic aspects), observed across Europe (Fuentes et al., 2010; Ruda, 1998; Tassinari et al., 2010), is greatly manifested in the former socialist countries (especially in terms of material, shape and technology unification of building collective farms with poor landscape consistency).

The topic of brownfields is usually linked with ecological risks and brownfields become a synonym for environmental load. Environmental hazards are widely discussed in the topic of industrial brownfields because the nature of the environmental load is significantly determined by the mode of former industrial production (Page, Berger, 2006), and economic impacts of the ecological burdens of urban brownfields are well documented (Howland, 2004; Schoenbaum, 2002). Agricultural brownfields can pose serious environmental hazards in some cases. The risks can follow from former area utilization: storage of potentially hazardous material (preparations for plant protection, pesticides, fertilizers, petroleum and oil products storage); spillage of liquids from agricultural machines; unsuitable agricultural waste treatment; or from activities following the object abandonment – illegal dumps, hazardous waste storage. The ecological burdens of obsolete pesticide storage sites have been documented from various localities (Dvorská et al., 2012).

2. Material and methods

The problem of brownfields was tackled based on various potential information sources. A general insight into agricultural brownfields in the Czech Republic was gained from the Research Study for Localization of Brownfields in the Territory of the Czech Republic (2007) conducted by Czechinvest (Investment and Business Development Agency of the Czech Republic). However, the Czechinvest study targeted all brownfield types (except for mining areas) and only brownfields more than 1 ha in size were studied. Agricultural brownfields are often small areas or idle parts of larger areas. This indicates that other potential information sources should be used to complement the issue of agricultural brownfields. The Czechinvest (2007) study was used to analyze the regional structure of brownfields on various regional scales – meso-regional, micro-regional and local. For the micro-regional analysis, brownfield data were used for small districts[1] from three administrative regions (Ústí, Vysočina and Pardubice).

The local study of agricultural brownfields was based on the identification of brownfields using orthophotomaps and the LPIS (Land Parcel Identification System). The local study was made in three districts of model regions. We investigated the evolution of agricultural facilities from the chronological sequence of orthophotomaps (available for 2003, 2006, 2011 at: www.mapy.cz) and using the database of agricultural facilities from LPIS (agricultural buildings not included in the LPIS database, whose evolution was indicated as brownfields succession, were marked as potential brownfields – see Fig. 1). Supplementary information sources were used for the identification of potential agricultural brownfields – especially the Contaminated Sites Database System ("Systém evidence kontaminovaných míst" (in Czech) – available at: www.sekm.cz) covering the potentially contaminated sites and the "Database of extinct villages" (available at: www.zanikleobce.cz) with valuable information targeting, among other things, historical farm yards and granges. The Czechinvest (2007) agricultural brownfield localities were revised for their actual condition in three case studies of districts using the LPIS database and the chronological sequence of orthophotomaps. Revitalised former brownfields were analyzed to elucidate common driving forces of the revitalization process. The methodology of using various remote sensing data was used for the identification of non-registered agricultural brownfields to supplement the existing information sources.

3. Results and discussion

The Research Study for Localization of Brownfields conducted by Czechinvest revealed some 2,355 brownfield localities in the Czech Republic (2007). The total area of identified brownfields is 10,362 ha. However, the total number of brownfields is estimated to be between 8,500 and 11,700, and an estimated total area of these localities is 27,000–38,000 ha. Although the emergence of brownfields was first put into the public eye with the restructuring of the industrial sector, the Czechinvest study (2007) showed that the most frequently occurring

Fig. 1: Visualisation of methodology framework for the identification of potential agricultural brownfields using various information sources

[1] Municipalities with Extended Competence (obce s rozšířenou působností; also third-level municipalities, unofficially also called "small districts" which took over most of the administration of the former district authorities

type is represented by brownfields that came into existence after the transformation of the agricultural sector (34.9%), whereas their area proportion is half (17.8%). This indicates that the agricultural brownfield sites are very frequent but cover a small area (compared to industry or military brownfields in Fig. 1). According to Czechinvest (2007), about one half of the brownfields (48.6%) are located in municipalities with up to 2,000 inhabitants (simplified definition of rural area) in the Czech Republic.

3.1 Regional differentiation aspects of agricultural brownfields in the Czech Republic

The socioeconomic transformation period after 1989 brought many changes into the agricultural sector in the Czech Republic. The transformation impacts were regionally conditioned as well (Věžník and Bartošová, 2004; Bičík and Jančák, 2005). Proportions of regional brownfields follow the structural characteristics of the region and the impacts of transformation processes. The regional scrutiny of the brownfields (Fig. 2) shows that the Olomouc and Zlín Regions have the highest proportional share of agricultural brownfields, exceeding 50%. The Plzeň, Pardubice and Vysočina Regions have about a half share. In typically industrial regions (Karlovy Vary, Liberec and Moravian-Silesian), the agricultural brownfields are rare.

The micro-regional and local differentiation of agricultural brownfields is depicted in Figs. 3–5. The micro-regional study based on small districts data from the Czechinvest study (2007) indicates a high geographical variation of agricultural brownfields. The geographical variation can follow geographical conditions for agriculture (see Fig. 3 for the Ústí Region) with a distinct differentiation of small districts between mountainous and coal field areas, and small districts along the boundary with the Region of Central Bohemia with suitable conditions for agriculture and traditional agricultural production (hops, cereals). The regional differentiation of agricultural brownfields in the Pardubice Region follows the differences between urban and rural parts of the region. The lowest share of agricultural brownfields was in districts with traditional manufacturing industries (Hlinsko, Vysoké Mýto, Lanškroun) and in small mountain districts (Králíky, Žamberk). A higher share of agricultural brownfields was in districts with favourable conditions for agriculture and outside urban areas – Přelouč, Holice, Polička (see Fig. 4).

The regional structure of agricultural brownfields in the Vysočina Region (Fig. 5) is more complicated; however, extremes in the share of agricultural brownfields were found in small districts, where the ratio was deformed by low data availability – Humpolec (only two brownfields), Náměšť nad Oslavou (three brownfields) and Světlá nad Sázavou (two). A higher proportion of agricultural brownfields was in districts with favourable conditions for agriculture (Moravské Budějovice, Třebíč, Velké Meziříčí) and in the traditional agricultural district of Pelhřimov with the production of potatoes.

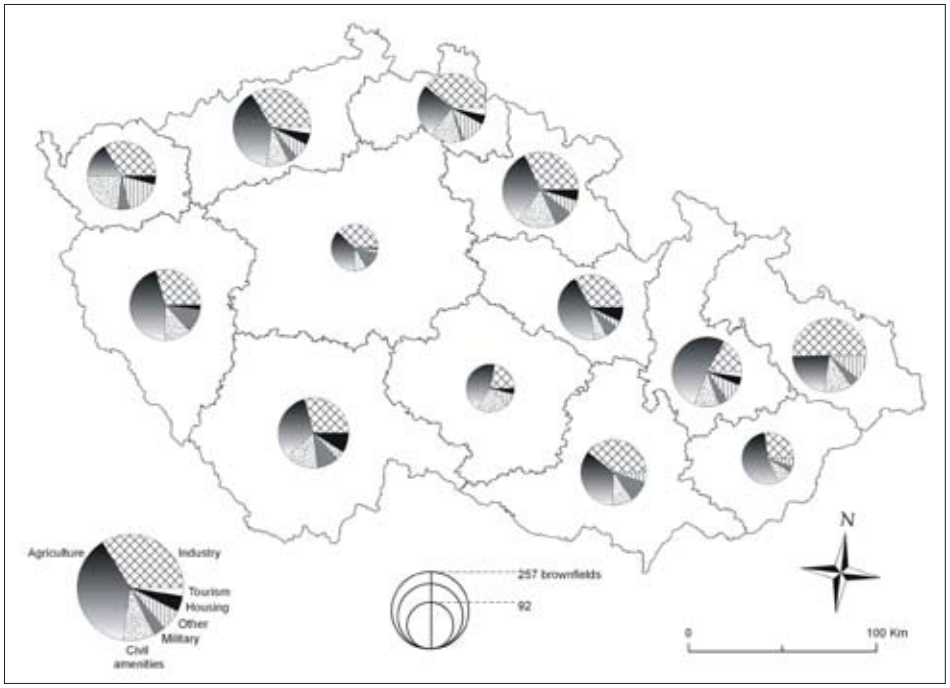

Fig. 2: Regional scrutiny of the composition of brownfields according to their former use
Data source: Czechinvest (2007)

However, the strategy for the reclamation of agricultural brownfields is primarily embedded in the programmes of rural development. Regional Operational programmes can better reflect the composition of regional brownfields and hence urgency of redevelopment and priorities for each region. Spatial location seems to be a significant factor for the redevelopment potential and possibilities. Possibilities of revitalization and interests of municipalities can significantly differ in different geographical locations.

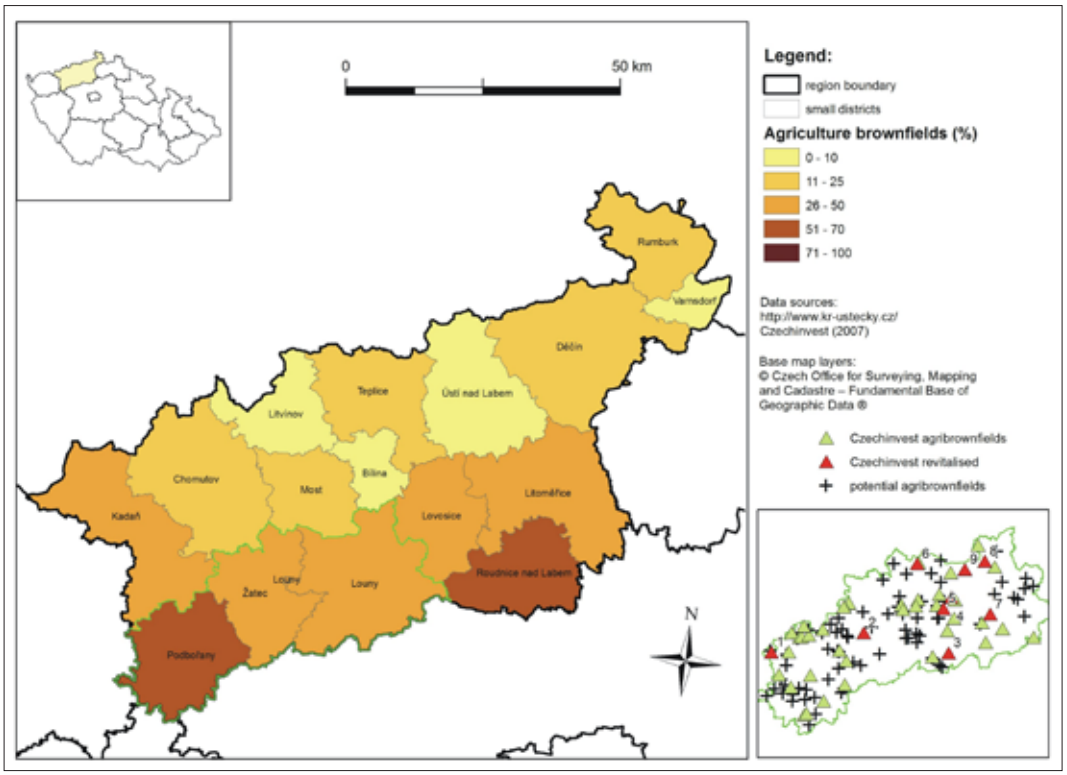

Fig. 3: Micro-regional and local differentiation of agricultural brownfields in the Ústí Region

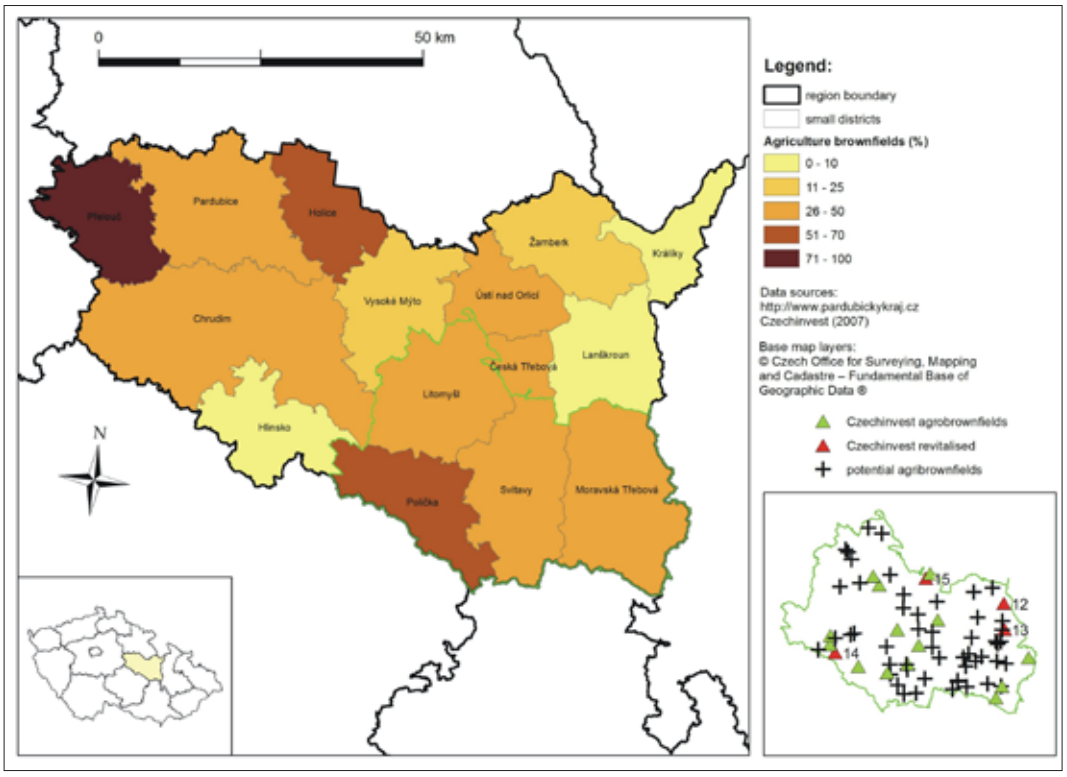

Fig. 4: Micro-regional and local differentiation of agricultural brownfields in the Pardubice Region

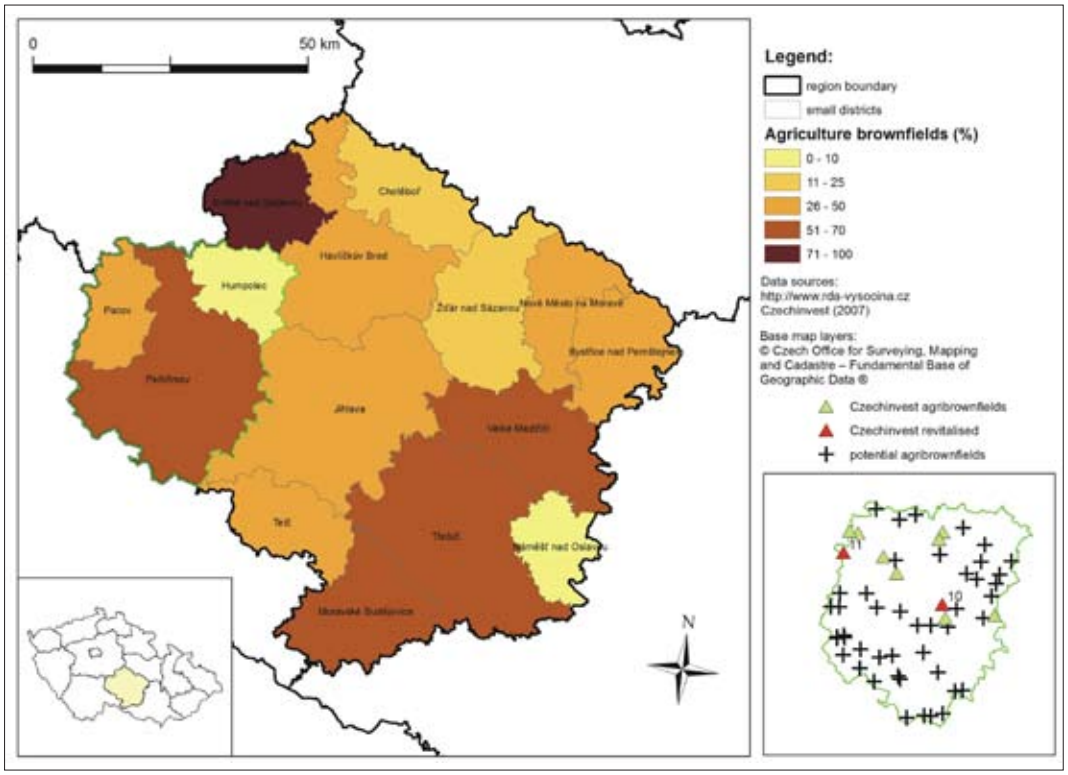

Fig. 5: Micro-regional and local differentiation of agricultural brownfields in the Vysočina Region

3.2 Revitalization of agricultural brownfields

The revitalization of brownfields brings about additional costs according to the economic and political imbalance between brownfields and greenfields projects, the additional costs covering environmental loads and structural matters. The favourable localization of urban brownfields can partially compensate for any additional costs thanks to the advantage of their typically prominent position (Bardos et al., 2001), contrary to rural brownfields that are usually situated in marginal locations away from developing trends (commercial, production, residential). It is important that the issue of disadvantaged (i.e. commercially, spatially, environmentally) brownfields is incorporated into the priorities of local, regional and national strategies. Optional re-use of agricultural brownfields is affected by the current condition of the site – in the positive (use of existing infrastructure) as well as in the negative sense (incidence of ecological load, technical conditions of buildings). According to the Czechinvest study (2007), a change of use in the future is typical of agricultural brownfields; only a very small part of the originally agricultural brownfields is repeatedly used for agricultural purposes. Farm buildings are usually unsuitable for agricultural use given the process of modernization or specialization in agriculture (Birkkjaer, Pedersen, 1996).

Verhoeve et al. (2012) and van der Vaart (2005) discussed the processes of diversification in the rural economy with re-use of rural buildings by non-agricultural entrepreneurs in the BENELUX region. The most common new use were residences or non-agrarian use by the service sector (trade or commercial companies, landscapers, transport companies) or woodworking companies. This re-use is changing not only the rural economy but also social structures and spatial and environmental quality (Verhoeve et al., 2012). Mackovič (2003) describes some of possible reasons for changes in the future use of the original farm buildings in the Czech Republic. According to him, the reasons include: imbalance in the supply of agricultural objects over actual demand, the vague position of agriculture in the society, general forces of the spatial diversification of residential and agricultural functions of settlements, territorially-technical limitation of the re-utilisation and modernization of agricultural facilities within built-up areas, problematic returns on investments in agriculture or complicated proprietary rights. Jaarsma and de Vries (2013) explore consequences of the abandonment of farm buildings and their new economic use for traffic on minor rural roads, emphasizing the necessity of spatial planning for rural shrinkage processes.

The existing capacities (including under-used buildings and localities) in rural areas contribute to a significant potential for the diversification of activities in the Czech countryside (Hron, 2007). The countryside is becoming a multi-functional space with new functions

connected with non-agrarian functions and especially agro-tourism (Sharpley and Vass, 2006). Agricultural brownfields situated in favourable localities (production areas, growth zones, suburbs) can be used for industrial, residential or public service functions and their geographical position is a crucial factor for their re-use potential. Agricultural utilization of brownfields can lead to conventional agriculture (livestock and plant production) or to alternative agriculture (organic agriculture, agro-tourism). Unemployed farms can be used for other functions including modern technologies (composting plant, biogas station) or in the sector of renewable energy production (solar parks) (Adelaja et al., 2010). However, the acceptability of non-agrarian functionalities in rural areas and their effect on future spatial planning in rural space is currently a moot issue (Verhoeve et al., 2012; Jaarsma, de Vries, 2013).

The Czechinvest (2007) localities in the three small districts in our case studies were revised for their actual state and the revitalized former brownfields were analyzed to show the development of agricultural brownfields recorded by Czechinvest (localities are marked with red triangle in the maps). Characteristics of the sites are depicted in Tab. 1. The trends of a shift in future utilization were confirmed in the study. The residential and service economy sectors are the main re-use strategies; however, some other future uses were observed – a small photovoltaic power station (Opatov) or a public gallery (Těchobuz). Successfully revitalized former agri-brownfields are usually located in built-up areas, more often brownfields with buildings from the period before the socialist collectivization. Settled proprietary rights (non-fragmented ownership, clear ownership rights) were the common feature of revitalized localities.

3.3 Institutional framework for using agricultural brownfields

In the Czech Republic, the support for brownfields redevelopment is implemented on the basis of two operational programme types – sector operational programmes (SOPs) and regional operational programmes (ROPs). SOPs deal with the issue of brownfields from the aspect of responsible authority priorities (business supporting, environmental risks, rural development), and ROPs reflect regional specifics and needs (NUTS II regions). The sector operational programmes available for agricultural brownfields redevelopment support are listed in Tab. 2.

Future use is a crucial determinant of funding possibilities for brownfield revitalization from public funds. Basic programme synergies are defined in the National Strategic Reference Framework of the Czech Republic 2007–2013. SOP Enterprise and innovation covers the projects of re-using brownfields for the purposes of production and business; SOP Rural development covers brownfields intended for agricultural re-use. ROPs are intended to serve primarily as subsidiary complements to SOPs, especially in activities the support of which is more effective at a regional level. Questions of jurisdiction concerning the use of modern renewable energy resources are addressed through agreements concluded by central authorities. The SOP Rural Development supports biomass treatment as an extension of agricultural production.

No.	Locality	District	Ownership	Situation	History	Use
1	Podbořanský Rohozec	Louny	private limited company	built up area	historical	non-agricultural
2	Milčeves	Louny	private limited company	built up area	historical	agricultural
3	Solopysky	Louny	private	built up area	historical	non-agricultural
4	Březno	Louny	private	built up area	historical	non-agricultural
5	Malnice	Louny	private	built up area	historical	non-agricultural
6	Blažim	Louny	private + public (munic.)	built up area	historical	non-agricultural
7	Chlumčany	Louny	private	built up area	historical	non-agricultural
8	Charvátce	Louny	private	built up area	historical	non-agricultural
9	Hrádek	Louny	private	built up margin	historical	agricultural
10	Pelhřimov	Pelhřimov	private limited company	suburb	socialist	non-agricultural
11	Těchobuz	Pelhřimov	public (municipality)	built up area	historical	non-agricultural
12	Petrušov	Svitavy	private	open landscape	socialist period	non-agricultural
13	Gruna	Svitavy	private	built up area	historical	non-agricultural
14	Korouhev	Svitavy	agricultural cooperative	built up margin	socialist	agricultural
15	Opatov	Svitavy	private limited company	open landscape	socialist	non-agricultural

Tab. 1: Selected characteristics of revitalized agricultural brownfields

SOP	Provider	Priority Axis	Specific Prerequisite
ENTERPRISE AND INNOVATIONS	Ministry of Industry and Transport of the CR	Priority Axis No. 5 – Environment for enterprise and innovation	future use restricted to manufacturing, research and development projects, technology centres or business support services centres
ENVIRONMENT	Ministry of the Environment of the CR	Priority Axis No. 4 – Improvement of Waste Management and Rehabilitation of Old Ecological Burdens	severely contaminated localities of Old Ecological Burdens
ENVIRONMENT	Ministry of the Environment of the CR	Priority Axis No. 6 – Improving the State of Nature and the Landscape	brownfields reclamation in conservation areas, reclamation of the biological value of idle areas – revegetation of brownfields in settlements
RURAL DEVELOPMENT	Ministry of Agriculture of the CR	Priority Axis No 1 – Improving the competitiveness of agricultural, food and forestry sectors – modernization of agricultural holdings with emphasis on brownfields utilization	municipalities with up to 2,000 inhabitants agricultural brownfields
RURAL DEVELOPMENT	Ministry of Agriculture of the CR	Priority Axis No. 3 – Improving the quality of life in rural areas and encouraging the diversification of economic activities	municipalities with up to 500 inhabitants
RURAL DEVELOPMENT	Ministry of Agriculture of the CR	Priority Axis No. 4 LEADER – partnership projects of rural development	partnership projects – LEADER project rules

Tab. 2: Sector operational programmes available for redevelopment of agricultural brownfields in the Czech Republic
Source: www.mze.cz, www.mpo.cz, www.mzp.cz, www.czechinvest.org

4. Conclusion

Soil is regarded as a renewable natural resource and further soil appropriation is inconsistent with the principles of sustainable development. Revitalization of brownfields is considered an active implementation of soil protection. Abandonment of agricultural farms is a widespread European issue; however, the transformation shift from collective to individual agriculture in the former socialist countries in Europe determined specific conditions for the abandonment of agricultural buildings and their future evolution. The duality between the traditional agricultural building of architectural and aesthetic quality and agricultural objects from the period of large-scale socialist agricultural production, is seen conspicuously in the former socialist countries. Similar trends of rural economy diversification with the re-use of rural buildings for non-agricultural activities described from Western Europe were recorded also in the Czech model regions. However, successfully revitalized former agri-brownfields are usually located in built-up areas, brownfields are more often revitalized with buildings from the period before the socialist collectivization and in localities with settled proprietary rights. A solution remains to be found for idle agricultural objects from the period of large-scale socialist agricultural production. It is important to incorporate the issue of disadvantaged (i.e. commercially, spatially, environmentally) brownfields in the priorities of local, regional and national strategies for the regeneration of brownfields and spatial planning in rural areas.

One half of brownfields (48.6%) is located in municipalities with up to 2,000 inhabitants (simplified definition of countryside) in the Czech Republic. Thus, rural brownfields are considered as vacant capacities that can be utilized for the diversification of activities in Czech rural areas. Agricultural brownfields are the most frequently occurring brownfields in the Czech Republic (35%) and especially in some regions (Olomouc and Zlín Regions). However, their area share (18%) indicates their spatial position in the landscape – the agricultural brownfield sites are very abundant but cover only small areas. The regional differentiation of agricultural brownfields is increasing with geographic scale and is conditioned by factors much similar to the processes of cropland abandonment in the post-socialist countries of Eastern Europe, particularly by natural conditions for agriculture (soil productivity, relief) and by socioeconomic factors (urbanisation rate, a region's economic structure).

A crucial step in the revitalization of brownfields is their stable identification and inventory. The inventory of brownfields entails a range of methodological difficulties, including the deficient

legislative framework and the lack of central holistic approach. Although the valuable Czechinvest database (2007) registered 2,355 brownfield localities, the estimated number of brownfield sites ranges between 8,500 and 11,700. Thus, other potential information sources should be used to supplement the record of brownfields. Potential information sources and potential methodological tools for the identification of agricultural brownfields are suggested in this study. The institutional framework is presented for the utilization of brownfields of agricultural origin. Funding programmes for the revitalization of agri-brownfields are available in the Czech Republic. Future utilization is a crucial determinant of the funding possibilities for the revitalization of brownfields from public funds. The strategy for the reclamation of agricultural brownfields is primarily embedded in the Rural Development SOP, however the Regional Operational programmes can better reflect the composition of regional brownfields and hence urgency of redevelopment and priorities of regions. The re-use of former agricultural buildings is changing not only the rural economy, but also the social structure and spatial and environmental quality (Verhoeve et al., 2012), and this is why the consequences of the emergence of agricultural brownfields are a relevant research topic as well as one of practical importance.

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USING MULTI-SCALE SPATIAL AND STATISTICAL ANALYSIS TO ASSESS THE EFFECTS OF BROWNFIELD REDEVELOPMENT ON SURROUNDING RESIDENTIAL PROPERTY VALUES IN MILWAUKEE COUNTY, USA

Wenjie SUN, Brendon JONES

Abstract

Brownfield redevelopment has gained support in the U.S. as an essential ingredient of urban revitalization. Assessing the effects of such projects is important as government budgets tighten recently. Through multi-scale spatial and statistical analysis, this study shows the spatial patterns of residential property values and their changes, and investigates linkages to the presence of different types and sizes of nearby brownfield redevelopment projects, as opposed to neighborhood demographics and property characteristics. While the results of this study suggest brownfield redevelopment does play a positive role on the surrounding residential property values in general, there are quite different statistical significances found at the two levels of analysis and the type of redevelopment found to determine the direction of this effect.

Shrnutí

Využití vícerozměrné prostorové a statistické analýzy pro hodnocení efektu revitalizace brownfields na cenu okolních rezidenčních nemovitostí v okrese Milwaukee, USA

Revitalizace brownfields získala v USA podporu jako podstatná součást revitalizace měst. Hodnocení efektů takovýchto projektů je důležité, neboť státní rozpočty se v poslední době stále snižují. Tato studie uvádí pomocí vícerozměrné prostorové a statistické analýzy prostorové změny cen residenčních nemovitostí a studuje jejich závislost na projektech revitalizace brownfields různých typů a velikostí realizovaných v jejich blízkosti. Přestože výsledky studie nasvědčují, že revitalizace brownfields v blízkém okolí má na cenu rezidenčních nemovitostí obecně pozitivní vliv, při dvouúrovňové analýze bylo zjištěno, že existují zcela odlišné statistické významnosti závislé na typu revitalizace, který směr tohoto efektu určuje.

Keywords: *brownfield redevelopment, spatial analysis, statistical analysis, residential property values, Milwaukee County, USA*

1. Introduction

The creation of the EPA's (Environmental Protection Agency) brownfield programme in 1995 changed the views of people looking at contaminated properties in the United States. Brownfields are officially defined as "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". The U.S. Government Accountability Office (2000) has estimated there may be between 130,000 and 450,000 brownfields throughout the United States. Municipalities and neighbourhoods share similar concerns about fallow property, the only differences are the risks assessed by each investor (Ellerbusch, 2006). One observation by Greenberg (1998) states that "idle sites have led to decay; the decay has lowered neighbouring property values, which has led to more property abandonment, or in other words the neighbourhood equivalent of cancer". Having abandoned properties in a neighbourhood lowers property values along with other negative consequences. "Abandoned sites have been used for illicit activities; have increased crime that has resulted in more blight and therefore more decay" (Greenberg and Schneider, 1996). Brownfield properties are also subject to more attention from local police and fire departments as maintenance efforts are required. By redeveloping brownfield sites, we can make them more productive and make cities safer.

The rewards of brownfield redevelopment are vast and have the capability to last well into the future – environmentally, socially, and economically. "Possible benefits from brownfield redevelopment include revitalization of inner city neighbourhoods through job and tax revenue creation, control of green field encroachment and urban sprawl, and the use of existing infrastructure" (Amekudzi, 2003). With the ever-increasing population of the United States, it becomes more and more necessary to use land to its fullest potential. This equates to "recycling" properties and not contributing to urban sprawl. Brownfield redevelopment is part of "smart growth" principles. Smart growth principles involve using land in more efficient ways. This entails mixed land use, including constructing commercial and residential buildings together. Mixed land use makes cities more centralized and cuts down on transportation and other costs.

There is an increasing but still limited literature about brownfield redevelopment and about the benefits they create. One way to measure the economic benefit of brownfield redevelopment is to calculate the value of redeveloped land parcels and the associated increase in direct property taxes (De Sousa, 2005). Another way is to gauge the spillover or ripple effect on the surrounding community by measuring the impact of brownfield redevelopment on neighbouring property values (Simons, 2005; Simons and Saginor, 2006). Simons (2005) looks at whether existing brownfield sites have a significant effect on nearby property values and how this effect changes after the sites are redeveloped. While comparatively earlier studies have focused on commercial and industrial properties, more recent ones have started to investigate surrounding residential properties, and in general brownfields have been shown to lower the value of surrounding residential property, whereas redevelopment allows it to increase (Kaufman and Cloutier, 2006; Simons and Saginor, 2006). We know that brownfield redevelopments affect the values of surrounding properties, but to what degree? People are still unfamiliar with the benefits that brownfields have on communities, especially on residential and commercial properties. When people are unfamiliar with the brownfields, it is difficult to gain and attract funding. "The main barrier to brownfield redevelopment constantly shown in literature is the lack of funds. A significant barrier to attracting funds is the lack of specific information about the benefits that brownfield projects create" (De Sousa et al., 2009). Spatial analysis and mapping provide an effective way of visually showing the consequences of redeveloping brownfields. This study will hopefully give municipalities, private investors, and other forms of government the necessary tools to make informed decisions about investing in brownfields.

Past literature illustrates a considerable gap when it comes to the use of Geographic Information Systems (GIS) to study and analyze brownfield developments. Many earlier research projects have focused heavily on statistical and survey methods to study the effects of brownfields and their redevelopment. While the statistical analysis is a powerful and widely accepted way of quantitatively determining the impacts of brownfields and their redevelopment, it may seem perplexing to the average person by itself. Survey methods may seem to be an intuitive and direct way of quantitatively and qualitatively measuring effects, but the efforts to design, test, and administer a survey are far less cost effective and the response rate and representativeness of the survey results cannot be guaranteed. Significantly fewer studies have used GIS to its fullest potential concerning urban planning. "A review of all articles appearing in the Journal of Urban History and the Journal of Planning History from January 2002 to December 2009 revealed that while maps are frequently incorporated, maps created with GIS are rare" (Hillier, 2010). GIS allows users to incorporate multiple attributes at once, to be able to discern spatial patterns and infer underlying processes. Users can also map a wide variety of data, even attributes that seem incomparable juxtaposed, e.g. coffee shops and historic battlegrounds (Lejano, 2008). Seemingly the general public, certainly municipality and other governmental employees, should be able to identify, through maps created with GIS, the effects of brownfield redevelopment in a more effective and straightforward way. Digital data are also widely available for GIS mapping and analysis through reputable sources. The U.S Census Bureau, the U.S Environmental Protection Agency, State Departments of Natural Resources, and other government agencies have data readily available for download regarding brownfields and socio-demographic attributes.

While GIS may be an important tool in studying the redevelopment of brownfields, it is imperative not to get so focused on mapping that users forget about other applicable factors. "One of the faults of GIS is that users may fall into a state of hypostatization – taking the concepts they see through mapping and involuntarily believing them to be the truth" (Lejano, 2008). Users of GIS may read too much into the maps they create or misinterpret them. GIS analysis should never be a substitute for real "on the ground" analysis. There are factors that may not appear through GIS that would be ignored if the ground analysis of a site was not performed. GIS should be used as a complement to field analysis, as a useful tool to identify spatial patterns and seek possible spatial explanations.

This study has the potential to contribute significantly to the brownfield community. Outside of the environmental field, few people are familiar with brownfields. This study will investigate spatially the benefits brownfield redevelopment projects have on local neighbourhoods at multiple levels of analysis. If this study can show that surrounding property values will increase as a result of redevelopment projects, funding will be easier to generate for future projects. Communities and residents near a site will be more willing to help and join together on a project they know will impact them positively as well. This study may also be used as a guide for the selection and prioritization of future redevelopment projects. Through GIS we can target individual neighbourhood factors (e.g. distance to parks, income and unemployment) and determine what types of redevelopment increase property values the most and thus promise a better return on investment.

2. Methodology

To address the question of what effects brownfield redevelopment projects cast on surrounding residential property values in Milwaukee County, GIS and statistical analysis were employed in this research. A variety of data from different sources was used and analyzed through the ArcGIS and SPSS software. This research will hopefully help give guidance and expand the state and nation's brownfield programme through increased knowledge and funding.

2.1 Study Area

This research study focuses on Milwaukee County, located north of Chicago and on the west coast of Lake Michigan. Milwaukee, like many other cities in the Midwest, was a 'Mecca' for industries during the early 1900s. As years went by and the economic structure evolved, industrial companies moved away or went out of business, leaving behind numerous abandoned buildings and properties. Thus, Milwaukee County, particularly the metropolitan area, presents itself as a relevant venue for this study due to its large amount of brownfield sites and redevelopment projects (Fig. 1), according to the Wisconsin State Department of Natural Resources (DNR).

2.2 Data Acquisition

For this project, brownfield redevelopment projects with some public funding completed between 1997 and 2003 in Milwaukee County were used to examine their effects on surrounding residential property values. These data were gathered through the Department of City Development and the Milwaukee property files database. The data were given in a GIS compatible, shapefile format. The shapefile contains

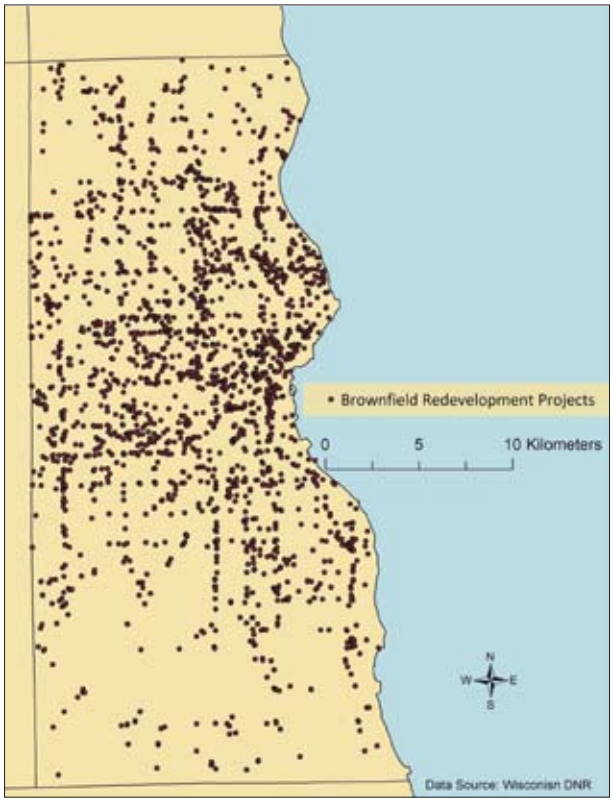

Fig. 1: Map of Milwaukee County showing all brownfield redevelopment projects from 1996 to 2004
Source: Wisconsin DNR

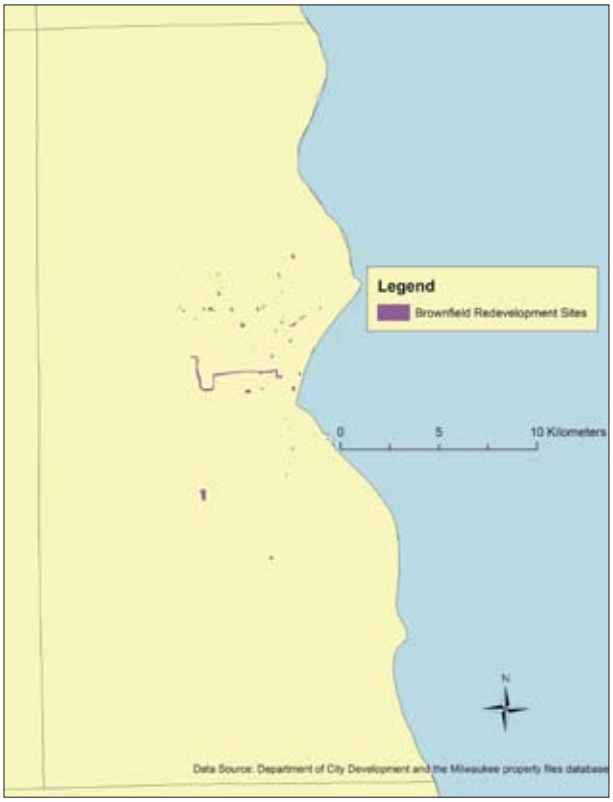

Fig. 2: Location of 45 brownfield redevelopment projects completed between 1997 and 2003 in Milwaukee County
Source: Department of Milwaukee City Development

a total of 45 varying sized polygons (Fig. 2). Each polygon contains a list of different attributes such as redevelopment cost, start date, and the building area.

Housing sales transaction data (from local Multiple Listing Service offices) located near brownfield redevelopment projects in Milwaukee County from 1996 and 2004 were utilized as the "before" and "after" measurements of residential property values. These point data were also given in shapefile format accessible in ArcGIS. The real estate transaction data contain a variety of attributes with each property, including selling price, and a detailed array of physical properties of the house such as square footage, number of bedrooms, year built, etc.

Population Census data from the U.S Census Bureau were acquired at the block group level for Milwaukee County. Within the county of Milwaukee there are 881 individual block groups. Data from the census year 2000 was downloaded from the U.S Census Bureau website. For our study we gathered a selection of demographic, social and economic variables. They included median household income, unemployment rate, poverty rate, education attainment, ethnicity, and population density. Data from the 2000 census were used mainly because they fit the time frame of both brownfield redevelopment and real estate transaction data, as it is the middle year.

Other complementary data were also acquired from the Wisconsin DNR and the National Land Cover Database. Every brownfield redevelopment-related activity in the state of Wisconsin from 1980 to present was included in the Wisconsin DNR database. Land Cover data were used to show the change in land cover within the county of Milwaukee from 1992 to 2001.

In order to keep all the spatial data layers lined up with one another before analysis, each was projected to the UTM Zone 16N. This projection best fits the study area of Milwaukee County and minimizes distortion for distance calculations.

2.3 Field Visits

The study started with field tours of several brownfield redevelopment sites, representing each of the different redevelopment types (residential, commercial, industrial, etc.). These tours were useful to get a ground level breakdown of the different sites and a chance to interview local inhabitants about the area and redevelopment project. The field visits and interviews are something that cannot be duplicated in a lab and are invaluable in this research by offering a fundamental contextual understanding of what makes a brownfield redevelopment project successful. For example, Fig. 3 shows a former brownfield site redeveloped into a condominium.

2.4 Spatial Analysis

The spatial data were analyzed through the ESRI ArcGIS software. Once the data were added into the map, the first step was to spatially join the housing point data to the census block groups. When this was done, the next step was to summarize the housing data by block groups so that we could average the selling price at a block group level. After the 1996 data were computed, the same procedures were followed for the 2004 housing transaction data. Following the computation of the average selling price for 1996 nd 2004 by the block group, a percent change was calculated. At this stage, inflation was accounted and adjusted for the average

Fig. 3: Photo of a residential brownfield redevelopment project (Photo: Brendon Jones)

selling prices by block group. The inflation rate was taken from the Bureau of Labour Statistics. Once the percent property value change from 1996 to 2004 was plotted on a map of Milwaukee County, there appeared to be some clustering of high values of percent change. This could not be certain, however, because any map can appear to have clustering by simply adjusting the classification scheme. In order to explore this spatial pattern further, three questions were posed in sequence:

1. Is there any spatial clustering of percent housing price change by block group?
2. If there is clustering, is it clustering of low or high values?
3. If there is clustering of high values, where are the clusters (hot spots)?

In order to answer the first question, a spatial statistics tool in ArcGIS called Global Moran's I was run. The Global Moran's I statistic measures spatial autocorrelation based on feature locations and attribute values. Given a set of features and an associated attribute, the spatial autocorrelation tool

evaluates whether the pattern expressed is clustered, dispersed, or random. When the z-score or p-value indicates statistical significance, a positive Moran's I index value indicates tendency toward clustering, while a negative Moran's I index value indicates tendency toward dispersion.

When it was determined there was a spatial clustering, the next step was to ask whether there are high or low spatial clustering values? In order to answer this question another tool in ArcGIS called General G was run to investigate the values. The General G tool measures concentrations of high or low values for a study area. A high index value as a result of the General G tool indicates clusters of high values. A low index value indicates clusters of low values. Like the Global Moran's I, the z-score or p-value determines how statistically significant the results are.

The final question was to see where the clusters of high values are located within the study area. The final tool to run within ArcGIS is called the Hot Spot Analysis tool. Unlike the previous tools that give a graph and a statistic, the hot spot analysis tool will show on a map the clusters of high values, also known as the hot spots. This tool works by looking at each feature in relationship with its neighbouring features. If a feature's value is high, and the values for its neighbouring features are also high, it is referred to as a hot spot. Once the hot spots were shown on the map, the next step would be to overlay this map with the redeveloped brownfield polygons to see if there is a spatial correlation.

2.5 Statistical Analysis

For the statistical portion of this study, both Ordinary Least Squares Regression (OLS) and Geographical Weighted Regression (GWR) were performed (see e.g. Legg, Bowe, 2009), first at the block group level. Regression is used to evaluate relationships between two or more variables. OLS creates a single regression equation for all features (block groups). GWR differs by creating a regression equation to fit each feature (block group) in a study area. The dependent variable for the regression models was the percent housing price change from 1996 to 2004. A variety of independent variables was used, broken down into three categories:

1. Aggregated housing characteristics: Average house age and average number of bedrooms per house by block group;
2. Demographics: Population density, percentage African American, percentage Hispanic, median household income, percentage below poverty line, percentage below high school education, and unemployment rate; and
3. Near-by brownfield characteristics: Distance to nearest brownfield redevelopment site, size of brownfield redevelopment, and the type of brownfield redevelopment (residential, commercial, industrial – coded as dummy variables).

The study started by investigating possible contributing factors of housing price change at the block group level, particularly along the lines of neighbourhood demographics and nearby brownfield characteristics. A SPSS step-wise regression was used to determine the most statistically significant independent variables for the study. However, the individual house or property level may actually represent a more natural scale of analysis, given that many meaningful effects of brownfields and their redevelopment on residential property value ultimately operate at this level. Therefore, regression analyses (OLS and GWR) were then conducted at the property level in order to gain more specific insight at a finer spatial scale. For 1996, each house's selling price was used as the dependent variable, and the total number of bedrooms per house, the distance to the closest brownfield, the age of the house, the square footage of the house, and other location factors (distances to water, rail, roads, etc.) were incorporated as independent variables. For 2004, each house's selling price was used as the dependent variable, and the same set of variables as in the 1996 model, plus the redevelopment type (recoded as dummy variables) and the investment cost of the closest brownfield redevelopment, were incorporated as independent variables.

3. Results

3.1 Exploratory Mapping

According to the data that were acquired from the Wisconsin DNR, brownfields started to be redeveloped in Wisconsin from 1980 and have continued to the present day. It was determined that between 1996 and 2004 was a time period of increased brownfield development (Fig. 1).

When looking at the land cover change map between the years of 1992 and 2001 (Fig. 4), there are certain areas of change in Milwaukee County. These changes mostly tend to be found in the outer edges of the county but not in the urban core. Most changes occurred in agriculture, going from agriculture to forest, agriculture to urban, etc.

3.2 Spatial Analysis

The results of the Spatial Autocorrelation (Moran's I) analysis showed there was a statistically significant spatial clustering of block group level percent housing price change 1996 to 2004, and the confidence level was very high – meaning that users can be sure this clustering is not a result of random change.

Based on the results from the General G analysis, there was spatial clustering of high values of percent property value change. Much like the previous step, the results also carried a high level of statistical significance and confidence level.

The hot spot analysis (Fig. 5) did indeed show areas of high values of percent property value change clustering in the north of the city centre. In other words, the north of the urban core area has seen a concentration of greater property value increases from 1996 to 2004. By performing two simple 'select by location' queries in ArcMap, we find that 73 out of 73 (100%) identified hotspots of housing price changes are within one mile (1.6 km) of the 45 brownfield redevelopment sites, whereas only 201 out of 398 (51%) of the non-hotspots are within the same distance. Figure 6 shows a zoomed-in view on these hot spots overlaid with redeveloped brownfield sites.

3.3 Statistical Analysis

For the statistical analysis, four sets of regressions were run, two at the block group level and two at the property level. The results generated from both the OLS and GWR regression at the block group level did not seem to offer a worthwhile explanation (i.e., a low R2 value) for the percent change in housing values from 1996 to 2004. The brownfield redevelopment-related independent variables were not found to be as statistically significant as the neighbourhood demographics and aggregated physical attributes of the houses.

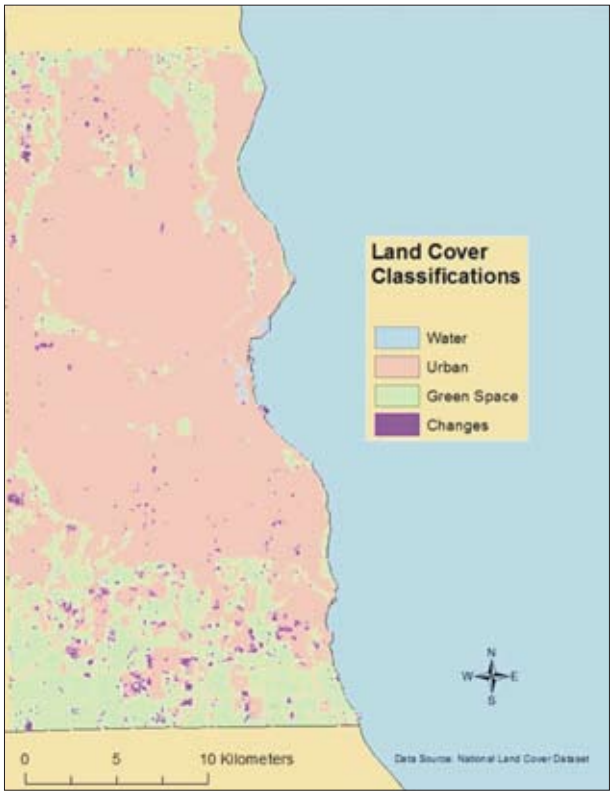

Fig. 4: Land cover change in Milwaukee County from 1992 to 2001

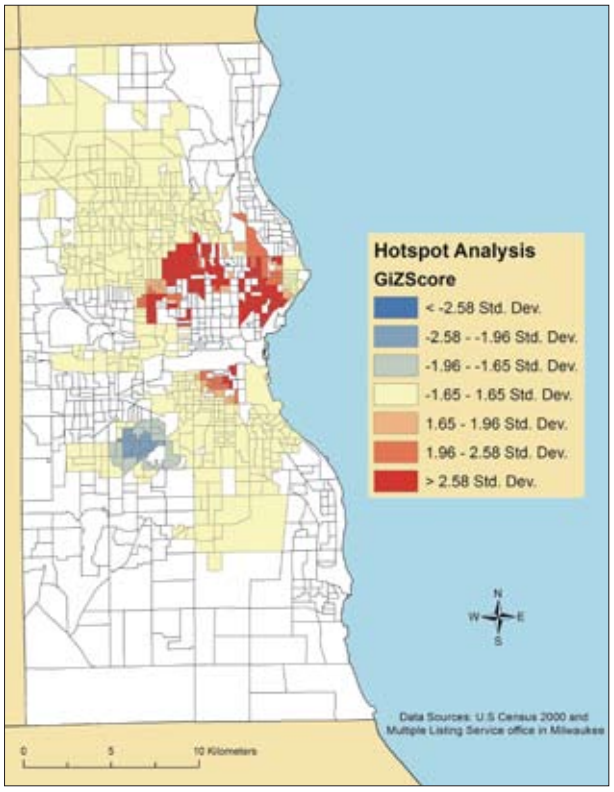

Fig. 5: Map of Milwaukee County hot spot analysis of percent housing price change 1996–2004 by block group

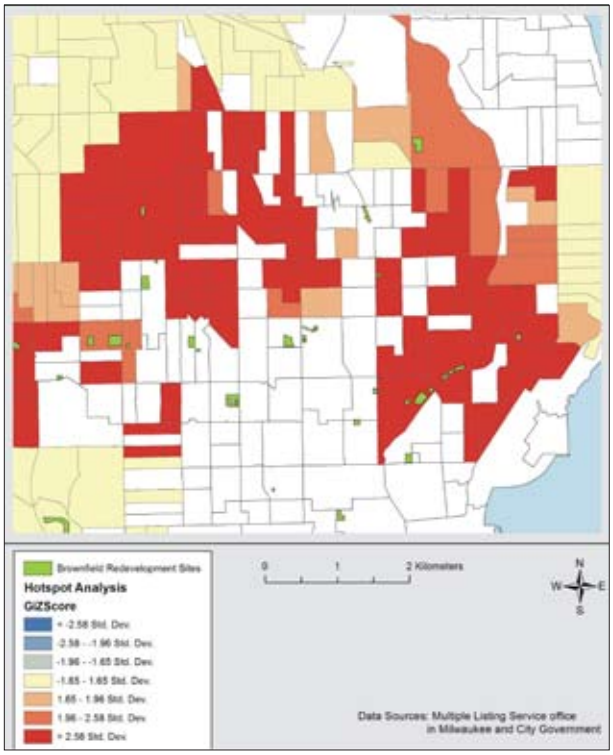

Fig. 6: Zoomed-in map of Milwaukee County hot spot analysis of percent housing price change 1996–2004 by block group with brownfield redevelopment sites

Property level OLS and GWR regressions were able to achieve a much more successful and promising explanation of property values with significantly higher R2 and reasonably randomly distributed residuals over the study area: refer to Tables 1–3 for the detailed OLS step-wise regression results of 1996 and 2004. In 1996, square footage, age, number of bedrooms, distance to water, and distance to rail, were found to have a statistically significant impact on the values of individual properties, with an overall R2 of 0.626 for the model. In 2004, a few more variables were found statistically significant, including the closest brownfield redeveloped into residential use (positive effect), commercial use (negative effect), redevelopment cost (negative effect), distance to closest brownfield site (positive effect), distance to road, and closest brownfield redeveloped into industrial use (negative effect). The regression model achieved an R2 of 0.651. Figure 7 shows the range and distribution of local R2 values of the 2004 property level GWR fitting, which seemed to suggest that there were better fits of the model north of the city centre.

4. Discussion and Conclusion

4.1 Summary of Main Findings

The results of the spatial analysis at block group level do seem to suggest that brownfield redevelopment projects play a positive role on surrounding property values. When looking at Fig. 6 we see that 42 out of the 45 total brownfield redevelopment projects are within one mile of the clusters of high percentage increase in real estate selling price between 1996 and 2004. 37 of 45 are within one half-mile (0.8 km) of the hotspots, and 28 are within one quarter-mile. We also find that 100% of the

Model Independent Variables	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
(Constant)	67,058.351	5,008.749		13.388	.000
SqFootage	77.705	2.082	.834	37.319	.000
HouseAge96	– 932.960	47.430	– .398	– 19.670	.000
# of bdrm	– 7,520.305	1,396.521	– .117	– 5.385	.000
DistToWater	– 2.040	.310	– .135	– 6.592	.000
DistToRail	1.213	.294	.084	4.130	.000

Tab. 1: Property Level OLS Regression Coefficients 1996
Note: Dependent Variable: Inflation Adjusted Sold Price in 1996

Model Independent Variables	Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
	B	Std. Error			
(Constant)	92,316.282	9,440.241		9.779	.000
SqFootage	129.425	2.960	.763	43.719	.000
HouseAge04	– 907.548	61.276	– .278	– 14.811	.000
RedevRes	24,979.900	6,682.792	.124	3.738	.000
# of bdrm	– 16,133.914	1,714.935	– .159	– 9.408	.000
RedevCom	– 39,332.022	5,222.553	– .249	– 7.531	.000
RedevCost	– .001	.000	– .154	– 7.012	.000
DistToRail	3.945	.446	.158	8.848	.000
DistToWater	– 4.016	.432	– .170	– 9.293	.000
DistToRedev	1.430	.226	.129	6.334	.000
DistToRoad	– 3.749	.742	– .084	– 5.055	.000
RedevInd	– 13,938.780	5,280.576	– .073	– 2.640	.008

Tab. 2: Property Level OLS Regression Coefficients 2004
Note: Dependent Variable: Sold Price in 2004

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1996	.791	.626	.625	30,345.243
2004	.807	.651	.649	46,777.342

Tab. 3: Property Level OLS Regression Model Summary 1996 and 2004

identified hotspots of housing price changes (increase) are within one mile of the 45 brownfield redevelopment sites, whereas only 51% of the non-hotspots are within the same distance.

However, the regressions at the block group level offered little explanation (low R2) statistically for the variation in house value change between 1996 and 2004. In addition, brownfield-related variables were not found to be as statistically significant as neighbourhood demographics and aggregated physical attributes of the houses. In comparison, property level regressions were able to achieve a much better fit with a significantly higher R2. Understandably, square footage and age of the house entered the model as primary determinants on the list of statistically significant independent variables affecting the property values. Brownfield redevelopment-related independent variables followed in strength of explanatory power. Among different types of redevelopment, "residential" was found to positively impact the property values, whereas "commercial" and "industrial" had negative effects. Interestingly, total redevelopment cost/investment was shown to have an adverse effect. Distance to the closest redeveloped brownfield had a positive effect, as expected. To sum up, smaller-scale redevelopment that led to residential use would bring about the most favourable effects on the surrounding property values.

4.2 Challenges, Limitations, Lessons

When looking at both the spatial and statistical analysis results, there are uncertainties. Environmental and geographical processes can have effects on the data. The analytical tools chosen could introduce further uncertainties. When considering the diverse metropolitan area of Milwaukee, it is important to acknowledge that no models will be a truly complete representation of reality, in other words, there will always be missing variables not captured by a seemingly sophisticated model. This is supported by the spatial variation of local R2 results from the GWR runs. An interesting discovery was made during one of the field visits to a brownfield redevelopment site. During the tour of our first site, it was concluded that the brownfield redevelopment site might have been disrupted during redevelopment because it was not flourishing by any means. In fact, the site looked like it had not been touched in many years and was overgrown with weeds. There is the potential that a site like the one toured is similar on paper to another site on the list of 45 redeveloped sites. Similarly captivating findings were made at some seemingly flourishing sites by talking to the locals. For instance, at a commercial redevelopment site, a social worker reflected some insights against the big and nice-looking chain grocery store by pointing out that because of cheaper liquor

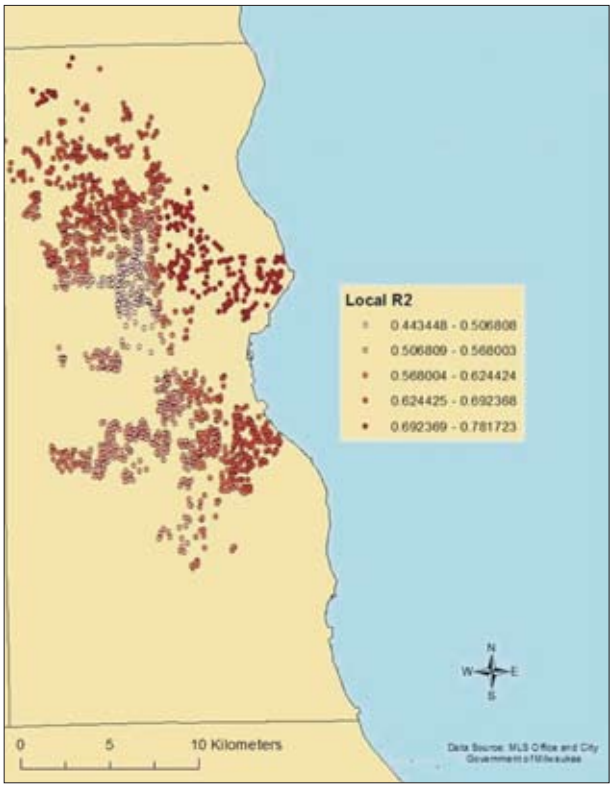

Fig. 7: GWR in 2004 showing local R2

and unhealthy food sold here, the redevelopment has actually made the existing social problems in the neighbourhood worse and thus contributed to further decay of the community. Again, it is unlikely that deeper social dynamics like this could be picked up by sophisticated models and analyses through a computer. Due to financial means and the scope of this study, only a small number of sites could be visited, but the gain in understanding is well worth the effort.

4.3 Future Outlook

The advancement of the brownfield program within the state of Wisconsin and the U.S. is critical to slow down the spread of urban sprawl. With cities growing and populations increasing, it is vital that we use land to its potential and in the most efficient ways possible. This research will assist municipalities, other forms of government, and private investors with more detailed knowledge and operable analytical techniques to evaluate the economic effects that brownfield redevelopment projects generate. Further research is needed to examine environmental and social impacts and eventually determine what equates to ideal locations for brownfield redevelopment along these multiple dimensions.

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Fig. 2: New residential areas in Dębowa Góra district: a new housing estate, Nowa Wanda, located on derelict greenfields and partly on brownfields (abandoned textile factory in the background)

Fig. 3: Abandoned orchards in the southern part of quarter Sosnowiec-Dańdówka

Fig. 8: Hotels Ibis Style and Mercure under construction (the Mercure hotel encompasses the historic building of a mine power station) Photos Robert Krzysztofik

Illustrations related to the paper by Robert Krzysztofik, Iwona Kantor-Pietraga and Tomasz Spórna

Fig. 6: Derelict grounds of previous agricultural cooperative in the municipality of Brodce (Mladá Boleslav district)

Fig. 7: Abandoned agricultural grounds in the municipality of Polabec (Kolín district)

Fig. 8: Abandoned agricultural grounds in the municipality of Sány (Nymburk district) Photos Jan Skála

Illustrations related to the paper by Jan Skála, Jarmila Čechmánková, Radim Vácha and Viera Horváthová