THE USE OF AERIAL PHOTOGRAPHY IN URBAN GEOGRAPHIC RESEARCH
– A GIS- & Photogrammetry-based analysis of the changes of a selected brownfield zone in Budapest –

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Abstract The present paper analyses the structural changes of one specific brownfield zone of Budapest, based on the GIS interpretation of archive and recent high resolution aerial photos. While the subject is related to former studies, the method used is considered novel in Hungarian urban geography. The results correspond with initial expectations: there is an interrelation between the potential of renewal and the type of land use sites were formerly under. The main contributions of this paper are the method for measuring changes and its possible application for brownfield rehabilitation.

Key words: Aerial photo interpretation, urban structural changes, measurement, brownfield rehabilitation.

1. INTRODUCTION

Brownfield zones – particularly their future and rehabilitation – are key issues from the point of view of sustainable urban development. As some East-Central-European cities have been heavily industrialized since the second part of the 19th century, and the development of a large group of other cities were turned to this direction during the socialist era, urban geographers and urbanists of this region should pay special attention to this topic.

Certainly, the turn of the millenium brought about a vivid period of exploration of brownfields in the Hungarian capital. While most of the aspects were described by conventional research methods, we believe that a different method (a ‘new perspective’) can provide additional spatial information. That is the reason why we have chosen the GIS-based interpretation of aerial photos. To our knowledge, this is the first paper to analyse in depth the structural and morphological conversion of brownfields in Budapest using this new perspective.

The paper is organized as follows: firstly our work is placed in context with other researches on the urban structure of Budapest and studies of brownfields. It is followed by the introduction of the field, the sources and methods. After a general analysis, the two main
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contributions are presented: Firstly, we give a kind of spatial measurement of changes; secondly, we show how our results might be used as a step towards the rehabilitation of brownfields.

2. RELATED WORK

The processes of brownfield conversion have been widely studied in postfordist western cities (Lever, W. F., 2001, Shaw, D. V., 2001, Fraser, C., 2003), ‘brownfield’ became a special notion in urban geography (Gregory, D. et al., 2009, Warf, B., 2006). The problem of industrial decline was artificially delayed in the socialist states, but during the transition period it hit several postsocialist cities (Harloe, M., 1996, Szelényi, I., 1996, Kostinskiy, G., 2001, Stanilov, K., 2007, Sýkora, L., 2009). Budapest, as a socialist city had to face the phenomenon during the 1990s. The first articles on the topic were published in different geographic journals (Kiss, É., 1999a, Kiss, É., 1999b, Varga Ötvös, B., 2003, Barta, Gy. – Lőcsei, H., 2003). A major source of our inspiration was the volume of studies published by the Hungarian Academy of Sciences after a general exploration and research was carried out on the brownfields of Budapest (Barta, Gy., 2004).

Further surveys carried out by geographers are becoming less frequent (Kukely, Gy. et al., 2006, Kiss, É., 2009), few independent articles are written about specific zones (Berki, M., 2012b) and few articles are published in English (Barta, Gy. et al., 2006, Kiss, É., 2002, Kiss, É., 2007, Berki, M. – Süle, M., 2010, Berki, M., 2012a). All in all, out of the studies mentioned above the ones concentrating on the role of brownfields in the urban fabric and on their potential for renewal agree that opportunities mainly depend on the location of the site (they should be close to zones of other urban functions), on the size of the site (they should not be too large) and the type of former use (it should be some lighter form of industrial production or logistic activity, which had not caused significant pollution). The question is: how does the conversion of the zone by Soroksári road meet all these requirements?

3. FRAMEWORK

3.1. General information about the structure of brownfields in Budapest

According to the general survey on brownfields carried out by the Hungarian Academy of Sciences (Barta, Gy., 2004), nearly 70 km² – one third of the morphologically urban zones of Budapest – was considered brownfield area on the turn of the millennium. The former industrial sites and traffic zones of the Hungarian capital city (due to the physical geographical conditions) formed a semi-ring around the inner residential districts. In fact, there are two factors that predominantly influenced this structure. One of the two was the strict urban planning that forced factories out of the residential zone (Csanádi, G. – Ladányi, J., 1992, Gyáni, G., 2000). The other reason is that Budapest became the focal point of the Hungarian railway system and an industrial town of international importance at the same time, so the inner transport network of the city and the sites of industrial production developed simultaneously (Beluszky, P. – Győri, R., 2004b). Later, during the
interwar period and the four decades of communist regime, this structure became fixed. However, by the beginning of postsocialist transition it had become rather outdated (Barta, Gy., – Kukely, Gy., 2004, Beluszky, P. – Győri, R., 2004a).

The industrial zones have never formed an uninterrupted ring around the inner parts of a city, but with the morphological conversion caused by the economic transition, the brownfield zones became mosaic-shaped, their functions mixed. The northern part of the ring has been transformed to an office-district, while the eastern part can still be characterised as an industrial zone. It is the southern part that experienced the strongest decline (Barta, Gy., 2004). However, the 2000s brought about remarkable changes in this last zone. One of the most restructured (at the same time most fragmented) part of it is located by the Soroksári road, and this is the area the present paper focuses on. (See Fig. 1.)

![Fig. 1. Map showing the brownfield zones in Budapest, and the location of the zone analysed. (source: own editing based on Barta, Gy., 2004)]
3.2. The zone of interest: Soroksári road

The outer part of the 9th district (Outer Ferencváros), where Soroksári road is located, was where food industry in Budapest was present in the highest concentration. Here the railway lines arriving from the Great Hungarian Plain met the Danube, creating an ideal site for processing the agricultural goods transported to the capital city. Mill industry, slaughterhouses, distilleries were built in the last decades of the 19th century, and marshalling yards were also expanding. At the beginning of the 20th century other more specialised food-industries, and factories processing the by-products of food-industry were erected. In the interwar period the zone grew in a southern direction: large chemical factories appeared, and new railway zones were built (Xantus, J., 1992, Gegesy, F. et al., 2010). This zone was the first to be attacked during the bombardments in the 2nd World War. In the socialist era the plants were restored, production continued, but by this time the technology had already become outdated, so during the transition (at the beginning of 1990s) the zone quickly fell into passive decline.

Due to partial rehabilitation and functional changes this zone is now mostly heterogenous. As the inner city of Budapest is also growing (Kovács, Z., 2005a, Kovács, Z., 2005b) in the southern direction (Baji, P., 2012, Berki, M., 2012b), areas closest to the city have already found new functions. Nevertheless, the re-development of the entire zone still remains an important issue with regards to the sustainable development of the city. To understand the long-term trends and their influences on the actual processes, an in-depth structural analysis is required. This is what this paper is eventually aiming at.

3.3. Sources of GIS- & Photogrammetry-based analysis

The brownfields of Budapest have already been analysed using several methods (field surveys, questionnaires, statistics of the firms etc.), but this paper finds a ‘new perspective’ to study the position and role of former industrial sites in the urban fabric: we use archive\(^1\) and recent aerial photos\(^2\) for recognising the structural conversion of urban fabric and for analysing the recent state of the sites. (See Fig. 2.)

The first aerial photos date back to the 1920s. (At this time in history, parts of the Soroksári road which are closer to the inner city were densely built-in already, so even older maps were needed to study the previous periods of construction.) The most detailed archive photos are from the 1940s. As the most important changes around the outer part of Soroksári road happened during the interwar period, the above mentioned two series of aerial photos present good sources of information. Some photo series from the socialist decades (1953, 1962 and 1987) helped to confirm the assumption that during this period the site did remain relatively unchanged. The latest series (2011) of high resolution aerial photos about the surroundings of Soroksári road facilitated not only the description of the changes, but also the analysis of the environmental condition of the sites.

\(^1\) The archive aerial photos are from the Map Archive of the Hungarian Institute and Museum of Military History.
\(^2\) The high resolution (10cm/pixel) recent aerial photos are from the data repository of Interspect Ltd.
Changes in landuse (intensification in the interwar period and recent conversion of brownfields) are clearly visible on the aerial photos. (From left to right: aerial photos from 1927, 1944 and 2011.)

4. IMPLEMENTATION

4.1. Photogrammetric processes

This section describes the method for the analysis of aerial photos. The project started with photogrammetric processes. As a first step, georeferencing was carried out; the reference system for this process was a collection of appropriate sections of the Hungarian Unified National Map System (EOTR). After this, linear or second-degree polynomial transformation was used, depending on the number and the location of precisely identifiable ground control points. This was followed by cubic convolution resampling, aiming to sharpen the line features that have a predominant importance in the analysis of urban fabric. The last step in the photogrammetric process was mosaicing.

4.2. GIS processes

The next stage was the geoinformatic process, when raster images were vectorised to build a GIS database based on the surveyed area. During vectorisation the level of generalisation followed the visible heterogeneity. On a similar note, the disadvantage of this type of approach, however, is that it cannot explore or reflect the inside fragmentation of different urban functions. With these considerations in mind, the attributes assigned to the vectorised objects were in connection with the visible types of use (e.g. intensive or extensive use of the sites, unexploited or demolished sites, rehabilited and revitalised sites etc.). These databases were constructed for each key date (the dates when the series of aerial images were taken). To ensure reliable GIS operations (spatial and temporal comparison), the topologic accuracy for each database was crucial.
The aim of the automatised detection of differences between the databases was to reveal the progress (or regress) during the different periods of the urban evolution. The results of the processes detailed above provided basic information for the description of the conversion of the zone of Soroksári road.

5. EVALUATION

5.1. Territorial aspects of the conversion

As demonstrated by the automatised detection of changes, the following trends can be observed: the conversion of zones connected to railway transportation (marshalling yards, side tracks, connected warehouses and depots etc.) was recognisably more dynamic than that of the zones of factories and other storehouses. This trend can be considered unique compared to other zones of the same function. Here the interwar period was a period of growth for the railway infrastructure (Fig. 3.), while in other parts of the city railway zones were already fixed; no significant expansion could be discerned (Budapest főszázados fejlődése, 1925, Preisich, G., 2004). However, during the transition period the majority of these railway zones were converted into areas with other types of landuse (Fig. 4.), while in other parts of the city zones similar to these have remained intact (Fábry, Gy., 2004). This leads to the following conclusion: areas where the railway was dominant have a better chance for renewal for two reasons: on the one hand, the built infrastructure is less massive (easier to demolish), on the other hand, due to the fact that the interconnection between water and railway transportation used to be important, proximity to some kind of water surface as environmental amenity is already given (compared to other railway zones in the city that are farther away from the Danube, this is an important advantage).

3 For more detailed information on the process see our existing article (in Hungarian language) on this research (Tolnai, G., 2012).
We should also mention a more recent, but no less significant difference between the northern part (which is closer to the inner city) and the southern part of the area: rehabilitation and revitalisation have been mainly focused on the first, while in the second...
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there are still several demolished sites waiting for investors as well as factory buildings and warehouses that are either empty or are operated alternatively. We would like to place a strong emphasis on the relationship between the proximity of the inner city and the dynamic nature of conversion.

![Changes of land use in the zone of Soroksári road](source: own editing)

**Fig. 5.: Chart showing the changes in land use in the zone of Soroksári road**

The method of the analysis allows for the measurement of the extension of rehabilitated, emptied or unchanged sites. This provides overall information about the degree of renewal regarding the entire zone. Fig. 5. clearly indicates a significant shrinkage in railway zones (almost halved between 1989 and 2011), but at the same time draws our attention to the relatively high proportion (nearly 30%) of empty sites, which could be important for investors. Eventually these pieces of information will be meaningful and relevant once other brownfield zones have also been analysed using the same method, and the results of surveys can be compared.

Taking into consideration the characteristics of Soroksári road, the still operational but rather underutilized marshalling yard located in the southern part of the zone easily evokes the idea that if cleared away, a continuous, valuable building site could be created near the Danube. The strikingly massive sector of brownfield sites stretching parallel with the brownfields on the other side of Soroksári road are likely to remain in their unfavourable state for a longer period of time. Nevertheless, this presents just one possible scenario, the development of the northern part, or the rehabilitation of the marshalling yard do not represent an automatic solution for the renewal of the whole area. (The proximity of the inner city and the efforts carried out in the mid 90s aiming to clean up the area for the –
never realised – Expo’96, and the governmental decision to build the National Theater and Palace of Arts here have all provided an exceptional opportunity for this sub-zone.)

5.2. Possible contribution to brownfield rehabilitation

The study presented above on the conversion of the urban fabric around Soroksári road and the change in functions could help measure the feasibility of the plans of investors. Besides the depression caused by the real-estate crisis of 2008, which blocked the capital investments flowing into the construction sector in the whole area of Budapest, the conditions of the sub-zones, determined by their environment is also an important factor that is worth taking into consideration. The southern part of Soroksári road and its surroundings is considered to be behind a barrier in the city scape (Lynch, K., 1960), and being in the shadow of mental maps eliminates all chances of success.

However, in case during an upward period of urban rehabilitation this zone may return to the focus of attention, the remediation of brownfields would be highly recommended. The analysis of aerial images could provide valuable assistance during the preparatory phase, especially as it greatly facilitates the identification of certain types of soil contamination – particularly those that are connected to railway functions.
Fig. 6. The tracing of polluted brownfield sites.

Our hypothesis was that dark spots connected to tracks are caused by oil and iron powder, which are the two most important pollutants (Pajor, I. – Mezei, I., 2002). An on-scene survey on the site verified our assumption. Turning back to aerial photo interpretation, potentially polluted spots can be traced using histogram modification, contrast amplification and the separation of certain colour ranges. Where there is an overlap between separated parts of the raster image and the railway objects (the tracks) themselves on the vectorised layer, we can expect the presence of contamination (Fig. 6.).

Even though finding spots that are most probably polluted using this method could be just one of the first steps of rehabilitation – actual investigations carried out in the site as well as field studies are absolutely required – these could be important sources of information for the analysis of under-utilised railway zones. Since many of these sites are close to residential or recreational zones, their rehabilitation is clearly an important part of sustainable brownfield rehabilitation.

6. CONCLUSION

Our GIS- and photogrammetry-based analysis on the long term changes and postsocialist conversion of functions and morphological characteristics of the zone of Soroksári road seeks to confirm the following hypotheses:

(1) The trends described in related works (articles and studies on the situation of brownfields in Budapest during the period of postsocialist transition) seem to be realised: proximity to the inner city, or at least to sites of central functions (business, services) is a predominant factor; furthermore, accessibility and environmental amenities can strengthen the favorable status of locations.

(2) The special feature of the zone of Soroksári road is that here the evolution of railway zones is contradictory to (or at least significantly different from) other railway zones of brownfield areas in Budapest. Both the period of growth in the interwar period, and the conversion after 1989 were strikingly more dynamic than elsewhere. The reason for this is the proximity of the Danube.

(3) High resolution aerial photos provide an opportunity for analyzing the current environmental state of brownfield sites. Certain types of soil contamination become easily identifiable. These findings could prove to be useful during the preparatory phase of the rehabilitation of under-utilised brownfields (former railway zones).

Continuing the above presented type of analysis in our future work, we plan to explore the characteristics of other brownfield zones of Budapest, and more aspects of possible use of aerial photos for recognizing special features of this type of urban landuse.

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