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Urban ecology: case study in Szeged

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Summary

In 1879, 95% of the buildings were destroyed by a catastrophic flood of the Tisza river in Szeged. New city-structure was planned and built, so nowadays avenues and boulevards can be found on the place of the ancient streets and buildings. The changing geoecological conditions were investigated from urban ecological point of view. The author analysed the green areas by satellite images, and GIS methods were used to combine census data with thematic maps.

1. Introduction

If somebody does not know the history of Szeged and looks at the up-to-date map of the city, he could believe Szeged is a young town with a modern structure. The road structure is very similar to Paris´

s, which was developed according to the plans of Haussmann in the mid-19th century. The special structural characteristics of the post-industrial city can be found in Szeged. Concentric boulevards and wide avenues coming from the city centre, are the most important elements of its structure. While in Paris the absolute power of III. Napoleon, the strong administrative system, one excellent architect and organiser, and a very important tool - the law of dispossession - were in the background of the huge reconstruction, till in Szeged natural forces - especially the river - took „very effective" role in the dead and reborn of the city in 1879.

2. History and the Great Flood of Szeged

In the mid-19th century, Szeged was a dominant commercial centre of the Austrian-Hungarian Monarchy, but the city preserved its medieval characteristics: e.g. old, uncomfortable houses, small streets, huge market places, separated ancient city cores were common.
On the Holocene alluvial plain of the Tisza river (80-85 m a.s.l.), the small Pleistocene and Pliocene loess „islands" were the cores of the historical city - Uptown, Palánk (The Bank), Downtown -, which had different characteristics and development during centuries.
Among these settlements, there were oxbows of the Tisza river, which were cut off by natural processes (approximately in every 200 years). These oxbows were partly filled by the alluvial sediments of the river, but some had open water surface till the 19th century. The most important commercial product was salt, which was carried on ships from Transylvania on Maros river. The Maros river links to the Tisza river in the vicinity of the city (1 km to the North). The rivers and the lake system were the base of the fishing. Something remained of this traditional activity, especially its result, the „Fish soup of Szeged".
The river regulation project started in 1846 according to the plans of Vásárhelyi and Paleocapa, mainly on the upper part of the river. Great bend-cuts were developed, and levees were built up along the river, narrowing the flood plain. Though, the regulation work was continuous, it reached the central part of the Great Hungarian Plain just in the 60’s in the last century, because of the huge volume of the dug and carried materials,
Before completing the regulation on the southern part, but after an extreme climatological period of the winter of 1878, the old bank was destroyed by a flood on 5th March 1879. The catastrophe happened toward north of the city, and against the defence the river

reached the city on 12th March at night. More than 95% percent of the buildings were demolished (265 remained, 5458 were destroyed). The reconstruction started in 1879 autumn according to the plans of Lechner L., the main organiser was Tisza L. The new town was planned for 200.000 habitants. With the help of European capitals (Rome, London, Paris, Brussels, Berlin, etc.) the city was reborn (Fig. 1). The consequences of the reconstruction, and the effect of the last 120 years development will be analysed from urban ecological point of view using GIS methods.

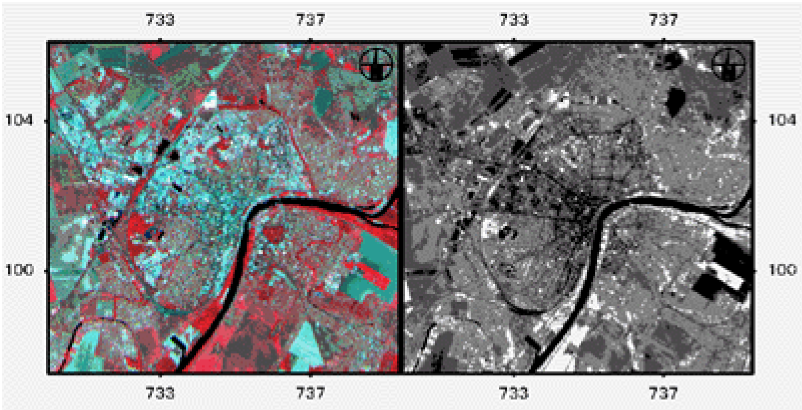

Figure 1 Szeged on SPOT multispectral satellite image
(acquired at 29.08.1988)

(321 RGB colour composite on the left, , infrared band on the right)

3. 1. Town structure and urban ecological conditions

An urban ecological study can be based on different theories. Among the European researchers, mainly the Germans (Sukopp 1990, 1993, Wittig 1991), are investigating the flora and fauna of the towns with biological methods. According to Lichtengerber (1993) urban ecology is part of the system as well, which should also contain socialgeography (sociology) and ecological urban planning. The American researchers are dealing with this field in the frame of sociology (Park 1926) and architecture (Hahn 1984). In my opinion, the urban ecology does not mean only the ecology of urban environment. In the frame of urban ecology, the relationships between bio-, geo- and human-ecological functions have to be investigated, especially the environmental conflicts in the urban-industrial ecosystem-complex should be in the centre of attention of

an urban ecological study.
The urban areas can not be investigated as a uniform ecological surface because there is an effective role of urban topography on climatical and ecological conditions through special climate-characteristics of the town (e.g. heat islands), physical and chemical properties of urban soils (para-rendzina, high humus and heavy-metal content, etc.). Different patterns of biotope types can be studied according to the changing land use types. These urban ecotopes are homogeneous, the „natural" ecological conditions are losing their weigh and modified by land use. Therefore, the urban ecological mapping is based on spatial classification of land use types.
The post-flood reconstruction contained 7 different activities, which have enormous effect on the development of urban ecological conditions until today (Table 1.).

ACTIVITY	EFFECT
1. Destroying the forest in the city centre	More place for development of residential areas and public services
2. Filling up the city up to the level of the highest water level (present surface level is higher by 3,0-0,2 m than the highest water level) using 16 billion m^3 materials, and construction of the Circle Dike (11,7 km long and 10 m height, protected area is 16 km^2)	• a, changing hydrological system b, accumulation of natural materials c, accumulation of artificial materials (mainly from the forest) d, different surface elevation in different areas - migration of groundwater e, architectural, engineering problems

	f, limit of the urban development g, potential ecological corridor
3. Development of road structure (avenues and boulevards)	• a, increasing buried, artificial surfaces, b, tree-lines along the avenues as ecological corridors c, 40 m wide boulevards as ecological barriers d, segmented green area patterns e, inner levee system
4. Bridge over the river (Eiffel planned it)	Urban development of rural areas
5. Water pipeline and channel system	Independent pipeline system has to be created, because of protection of the unified road system as dikes. Wastewater was not cleared till 1997.
6. Green areas programme	9 ha parks, forest inside the Circle Dike
7. New buildings for public services	Harmonised urban view in the inner city

Table 1. Post-flood development and their urban ecological effect

3.2. Quantitative analysis of green areas using GIS methods

a, Data sources

SPOT P and XS images were also applied together with airphotos and topographic maps (1:10,000 and 1:2,000 scale). Vector and raster based GIS were developed on Sun Ultra 1 workstation using ERDAS IMAGINE 8.2 and ARC/Info 7.0.3. at the University of Szeged, in the Applied Geoinformatics Laboratory (AGIL).
Different data sets were involved into the study of green areas (Table 2).

type	***date***	***scale***	***projection***
topographic map	*1965*	*1:10,000*	*stereographic*
	1988	*1:10,000*	*EOTR**
digital city map	*1990*	*1:5,000*	*EOTR*
airphoto	*1972*	*1:10,000*	*black & white VIS*
	1981	*1:10,000*	*black & white VIS*
	1992	*1:10,000*	*colour infrared*
digital image	*29.08.1988*		*SPOT XS 1,2,3 bands*
	28.06.1990		*SPOT panchromatic*
	21.06.1992.		*Landsat TM (7 bands)*

**EOTR = Unified National Mapping System*

Table 2. Characteristics of used data

b, NDVI as indicator of green areas

If the categories of land use are utilised in the quantitative green area analysis of the city, then because of the homogenising effect of the categories, - e.g. the so called residential urban suburb contains special mixture of family houses, other buildings, gardens, grass lands, roads, etc. - just small area will be investigated, like parks, forest, cemeteries, etc., and large areas which are containing green surfaces are missing from the measurement. Consequently, the GIS methods were combined with RS analysis of SPOT XS images.
The digital satellite images were rectified into the Unified National Mapping System according to 1:10,000 scale maps. Nearest neighbour method was used at the resampling, the RMS value was less than 1 pixel. Because of the geometric resolution (20*20 m), small urban area units were involved into the investigation independently of their official land use category. Normalised Vegetation Index (Fig.2) was calculated from the pixel values, according to the following equation:

$$NDVI=(IR-R)/(IR+R)$$

where IR is the pixel value in the infrared band and R is the pixel value in the red band. The NDVI values are ranging from -1 to 1 indicating the effect of green area in the given spatial unit.
According to the analyses of the NDVI map together with the original satellite map, the following facts can be realised.

a, there is a high density continuously developed residential area with public services in the west-east axis of the city, which joints to the area of industrial/commercial activities.

b, according to the road system developed after the flood, there are very small green surfaces in the inner city, and they are separated from each other.

c, relatively small, not continuous green areas can be found on the residential garden suburbs.

d, there are large unused green surfaces between the old city border and the area of apartment block residential areas.

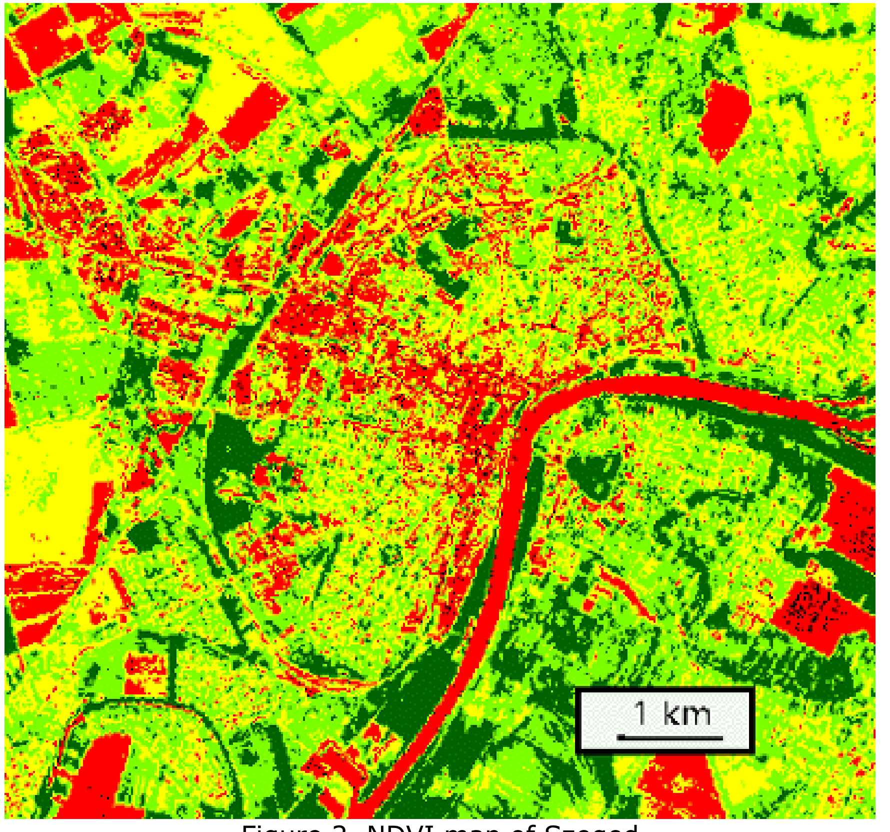

Figure 2. NDVI map of Szeged

red - high density continuously developed residen- tial area, industrial/commercial activities, water surfaces, soils on the agricultural areas with very low NDVI value

- yellow - buildings of residential garden suburbs, non continuous residential areas, agricultural fields with low NDVI value

- light green - gardens of residential garden suburbs, orchards, agricultural fields with medium NDVI value,

dark green - developed green surfaces in the city, parks, cemeteries, forests on river flood plain, agricultural fields with high NDVI value NDVI map was used to draw the so called urban morphological zone (EUROSTAT 1996) which contains a continuously developed areas and their 200 m surroundings (Fig. 3). Because of the undergoing development of the city in the last 120 years there are no „holes" in the urban morphological zone, the city has very compact structure.

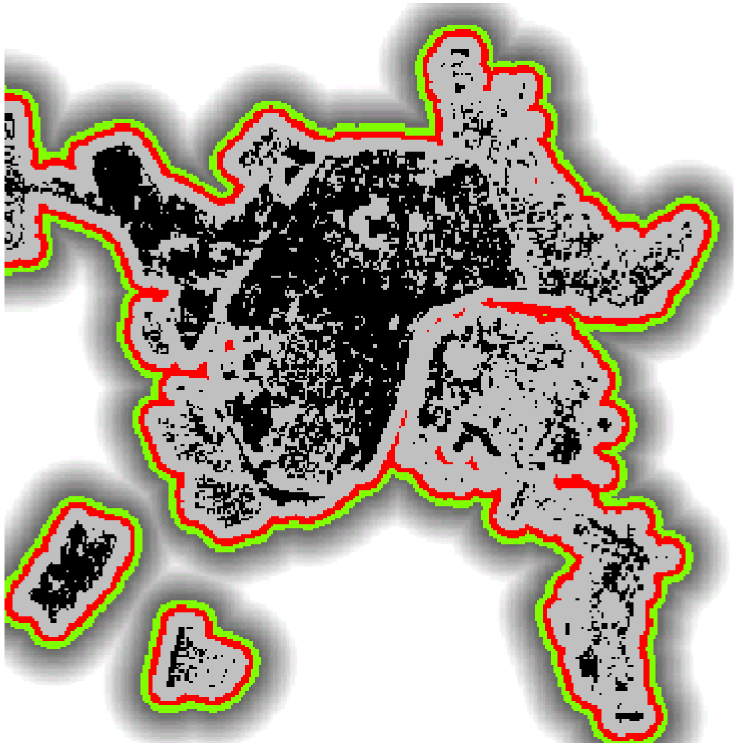

Figure 3. Urban morphological zones of Szeged

black and grey - continuously developed areas and their 200 m surroundings = urban morphological zone

red - 200-300 m zone of the urban morphological zone

green - 300-400 m zone of the urban morphological zone

Because of the importance of the residential garden suburbs in the ecological condition of the city, the inner development of these areas was analysed by GIS methods as well. Old airphotos and land office maps were integrated with the new digital map of the city, and with our own measurements. According to the results of the investigation, very dramatic change can be seen: in the last 15 years, on the place of the old family houses and gardens new apartment houses (for 8-14 families) were built up. The base size of the new houses is greater a little bit than that of old houses, but behind the buildings, large areas are covered by pavement in front of the garages, on the former place of the gardens. The area of the gardens and other green surfaces was 60-70 % of the total land area, and now it decreased to 10-15 %. This process is very dangerous, and because of luck of the large parks and forest in the inner city, these gardens are taking important role in the clearing of the air of the city (Fig. 4).

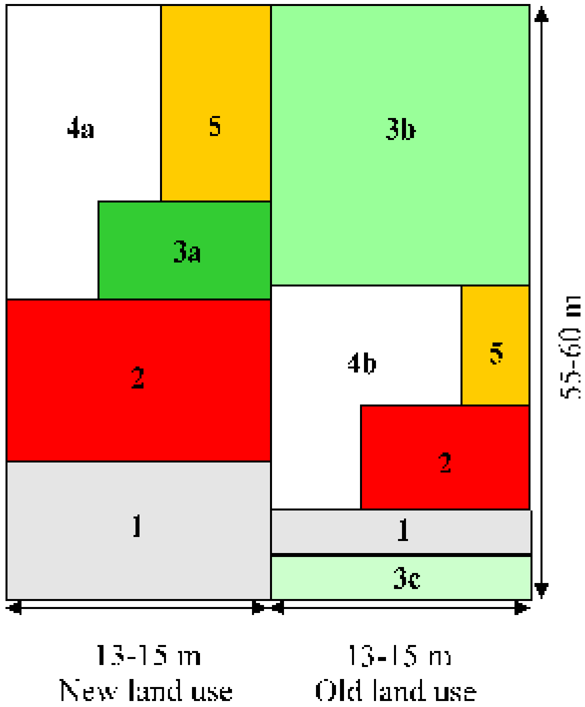

Figure 4. Changing land use on residential garden suburbs in Szeged

Legend:

1. Pavement,

2. Residential building,

3. Green area

- *3a grass,*
- *3b garden,*

- *3c trees, channel*

4.Covered surfaces

- *4a asphalt surface,*
- *4b compacted soil surface,*

5. Other buildings (e.g. garage)

4. GIS in decision making and urban planning

The applied GIS method can help in urban ecological investigation, but in the same time it is very useful tool for decision makers to demonstrate the ecological condition of a city, who are sitting in local governments and who are not experts of GIS or remote sensing. Sometimes the decision is not only an ecological decision, but political as well and the member of the government has to known the social, economic and ecological conditions of his/her districts.

a, Green area supply in census districts

The ecological conditions can be explained from human ecological point of view. To estimate its value, we have measured the green area supply of the inhabitants in all census districts in Szeged. The census data (1990) were linked to ARC/Info polygon attributes, and with the help of NDVI map as a thematic map, the green area supply was calculated in m^2 for 1 habitant (Fig 5.).
As on Fig. 5. it can be seen, in the high density continuously developed residential areas, there is less than 5 m^2 green area for one habitant, who is living in one of these districts. The most critical situation can be found in the surrounding area of Grand Boulevard (4 white patches on city centre). Outward from the centre the green area supply is increasing continuously, but the highest values do not mean always a real supply, because the green area can be an old cemetery, or an undeveloped grassland.

b, Distance between green areas and residential areas

The value, which explain the distance between green and residential areas, can be also interesting in human ecological point of view. The weighting evaluation of the distance between green and residential areas, and the recreational value of the green surface are taken into consideration at the planning of new green areas, or they are not taken into consideration at the building up of potential place for green area (e.g. a huge supermarket built on one of the largest free inner area of Szeged in 1998).

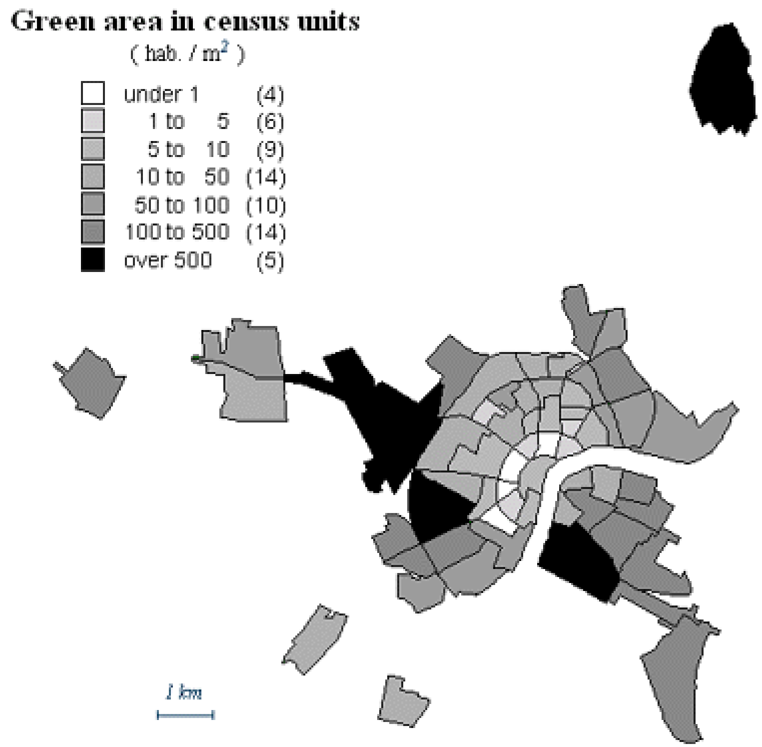

Figure 5 Green area supply in census units, calculated from census data and satellite image classification of Szeged (1990)

Green areas were classified on SPOT satellite image in ERDAS IMAGINE 8.2., and the distance value explains the distance to the closest green area from the given pixel.

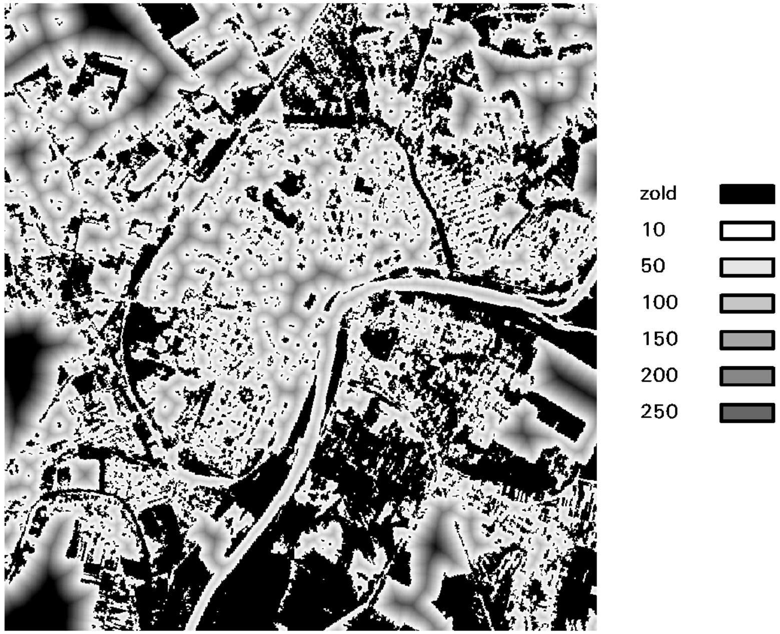

Figure 6 Distance to the closest green area (m) in Szeged
(zold = green area)

Conclusions

Applied GIS methods can be very effective tools in urban ecological research. The combination of historical data with modern measurements and data management help the urban ecological planning and decision making. The examples show the way of presentation of numerical data for endusers.

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