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URBAN LAND USE INVESTIGATION WITH GIS AND RS METHODS

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Introduction

Two historical events played a great part in the development of Szeged, the fourth largest town in Hungary. In 1879 about 95% of the buildings were destroyed by catastrophic flooding of the Tisza river. After the flood, and with the help of larger European cities (Brussels, Berlin, Moscow, Paris, etc.), a new structure for the city was planned and built. Avenues and boulevards can now be found in place of ancient streets and buildings.

After the First World War, the area of Hungary was reduced to one third its original size. Before the War, Szeged was relatively central in southern Hungary, approximately 150 km from the southern border. At present, the border lies less than 15 km from the town.

The changing inner and outer conditions were investigated utilizing GIS methods. With the help of the first maps taken after the flood, the changes in the structure of the town were analyzed, and the direction of the expansion in the last 100 years determined. One very interesting task was to compare the development of the town, which was based on natural conditions (geomorphology, river, agricultural lands, etc.) before the flood with the post-war development, which was determined by economic and political decisions (socialist planned economy). The most important factors of the post-flood development were the creation a new road system in a 4-6 m higher position, river regulation (Tisza and Maros rivers), and destroying the main geomorphological forms, etc. These effects changed the hydrogeological conditions of the town and created new engineering-geological conditions. The industrial and economical importance of the town changed in the country, and as a result of inner town development, functionally different districts inside town can be distinguished. The borders of the town have grown with suburban regions being developed and small villages merged with Szeged. The inner city preserved its civil aspects, while "modern" blocks of flats were built in the outer residential area.

Data sources

SPOT P and XS images were also applied together with airphotos and topographic maps (1:10000 and 1:25000 scale, Fig.1-2). Vector and raster based GIS were developed on an Intergraph system at the University of Szeged and the University of Liege, Laboratory SURFACES. The new direction in the development of Szeged was investigated with help of gravitational models.

Different data systems were used during the classification and urban fringe monitoring (Table 1).

type	date	scale	projection
topographic map	1965	1:10000	stereogrpahic
	1988	1:10000	EOTR*
airphoto	1972	1:10000	black&white VIS
	1981	1:10000	black&white VIS
	1982	1:10000	colour infrared
digital image	29.08.1988		SPOT XS 1,2,3 bands
	28.06.1990		SPOT panchromatic

*EOTR = Unified National Mapping System

Table 1 *Characteristics of Data Used*

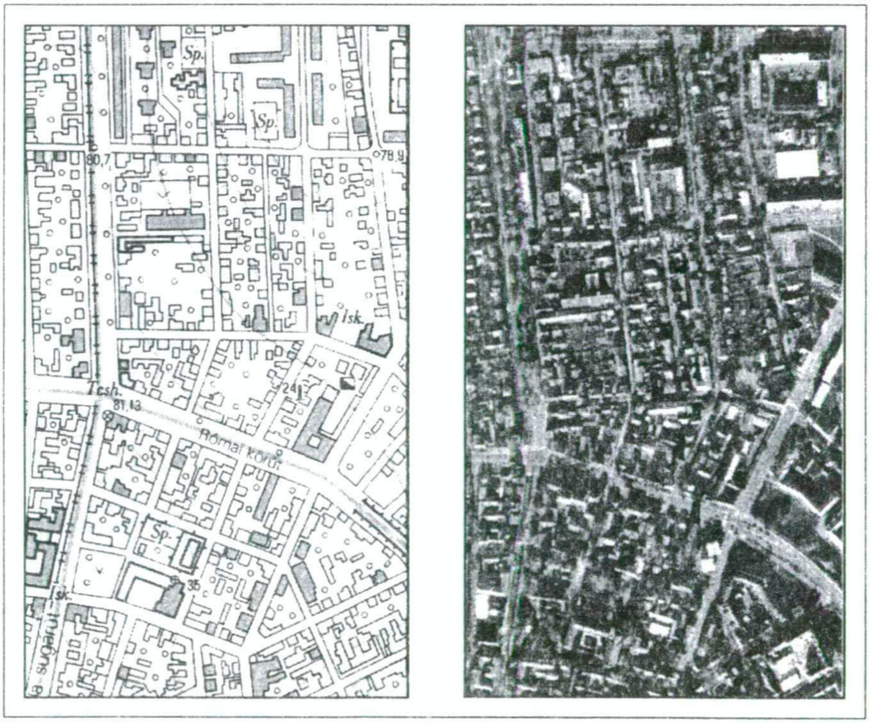


Figure 1 *Topographical map and airphoto as data sources*

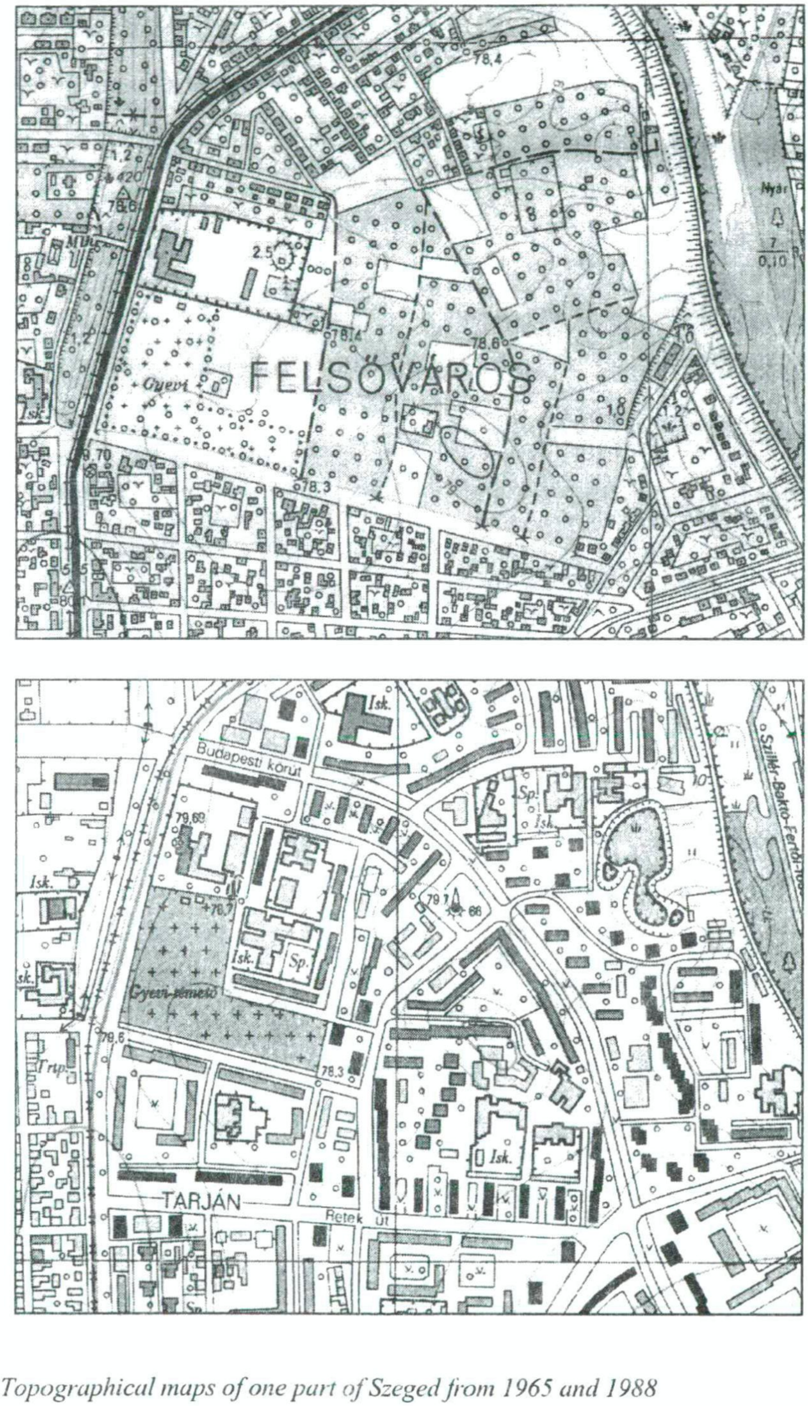


Figure 2 *Topographical maps of one part of Szeged from 1965 and 1988*

Results

The aim of this study was to detect changes in land use from agricultural land to a construction site or housing development.The structure and development of the town of Szeged (South Hungary) have been studied to investigate the possibility of remote sensed data for urban monitoring and change detection. This city and its rural surroundings were chosen because we could investigate areas where urban development has been relatively rapid over the last 20-30 years. Applications forming part of this research include urban fringe monitoring (fringe is an area under constant pressure for change), discrimination of urban classes, prediction of residential housing density, estimation of urban quality measures, socio-economic variables, and population density.

Topographical maps (1965,1988) were digitized and developed on an Intergraph Microstation system at. the University of Szeged and the University of Liege, Laboratory SURFACES. Vector and raster GIS were developed on Intergraph and IDRISI to compare the differences between these systems.

Airphotos were scanned and used as a raster base system. The original photos were magnified to the scale 1:10000 in the photo laboratory of FÖMI (National Remote Sensing Laboratory). The above mentioned topographic maps (image to maps) and SPOT panchromatic image (image to image) were utilized for the geometric correction of airphotos. These photos were acquired on 1972,1981 and 1992.

SPOT XS (1988, 3 bands) and P band (1990) were applied (together with airphotos, and topogrpahic maps, Fig 3.) for supervised and unsupervised classification, and for the investigation of urban change detection. Base problem was that the SPOT images were not acquired at the same time, therefore we were not able to utilize the special XS+P image and different colour composition of XS and P bands (3P1, 32P, etc.). We had to apply XS 321 (RGB) colour composition with 20 resolution and P band independently. Housing density represents a useful input to urban land information systems and inter-census population change studies, but it is not directly observable from spaceborn sensor systems because of their resolution. Even with SPOT's 10 meter resolution P mode data this is still the case because the average low density housing is about the same size as the pixel, and cannot be positively discriminated without an IFOV nearer to 5 meters, Nevertheless, the 10 and 20 meter resolution of SPOT offers the potential of using textural variables for housing density studies (Froster, 1987). The P band image was used for geometric correction of the XS 321 image and for the identification of different buildings and structures.

Our principal task was to detect changes in the structure and development of the town from the latest, most detailed topographic map (published in 1988 but drawn in 1983), and with the help of airphotos and digital images, to complete and refresh the topographic maps on the scale 1:25000. We also tried to classify the urban, rural and agricultural areas. The range of the investigated area was 16*11 km.

Discrimination of highways and estates

Although the inner structure of the town is clearly arranged, especially on the XS3 band (infrared, 0.79-0.89 mm), the difference in the temperatures and infrared reflectance of main streets, buildings, and green surfaces on P band (0.51-0.73 mm), the classification is not so easy. On the 20 resolution XS bands, the greater buildings (Opera, Theatre, Stadium, large workshops, block of flats) can be discriminated, but their form and range cannot. On the P band image we have a better view from these features, but due to the acquisition date difference between the XS and P bands, we had to utilize this P band independently.

Figure 3 *SPOT P image overlaid by topographic map*

On XS 321 (RGB) colour composite, boulevards and avenues are clearly discriminated visually. The classification of the highways is difficult. These road are the most popular region from traffic and geographical potential point of view, therefore housing estates and tall buildings can be found along the wider streets. The SPOT 2 HRV XS and P images were acquired at 09 hour 43 minutes, consequently long shadows of buildings can be detected due to the low angle of incidence of solar radiation. The effect of this phenomenon is extraordinarily strong along streets of N-S direction. According to the colour composite the classification of the Grand and Outer Boulevards, the Kossuth and Kalvaria Avenues is not so difficult because of the 20-30 meter wide asphalt and concrete pavements. Although in this case, the shadow effect of the taller buildings and row houses can disturb the classification, especially along the Outer Boulevard. These new, ten-storied houses were built in the last two decades. Consequently, the main roads can be classified by pixel by pixel method on the XS 321 colour composite, or (2) on the XS 3 black and white image. In the first case more than 20 classes were used with very low standard deviation. Among the older buildings (Tarjan housing estate, Fig 4.airphoto to the rigth) the vegetation has grown stronger, which is favourable for living conditions, but their shadow increases the standard deviation of pixel values of boulevards and avenues. The pixel value of greater green surfaces among the new blocks of flats are very similar to the pixel values of meadows and pastures on the surrounding agricultural regions, therefore a special mask was utilized for delineation of the urban area from the agricultural land. The shadow effect not only disturbs the classification but also gives a good application for the tall building discrimination. Airphotos and SPOT P scene were investigated for the measurement of shadows of different buildings. The simple rule which states that a taller building has a longer shadow than a lower structure (Fig. 4.) can be statistically proved. On raster base GIS this rule can be expressed by the following: there is greater distance between the centre of a pixel meaning a house and pixel meaning the end of the shadow. These measurements were used for the discrimination of the building of a new estate (Fig. 5.), which cannot be found on the newest topographic maps. This method can be applied to the 5- 10 years old settlements, because the gardening is frequently delayed or does not happen after the finishing of construction.

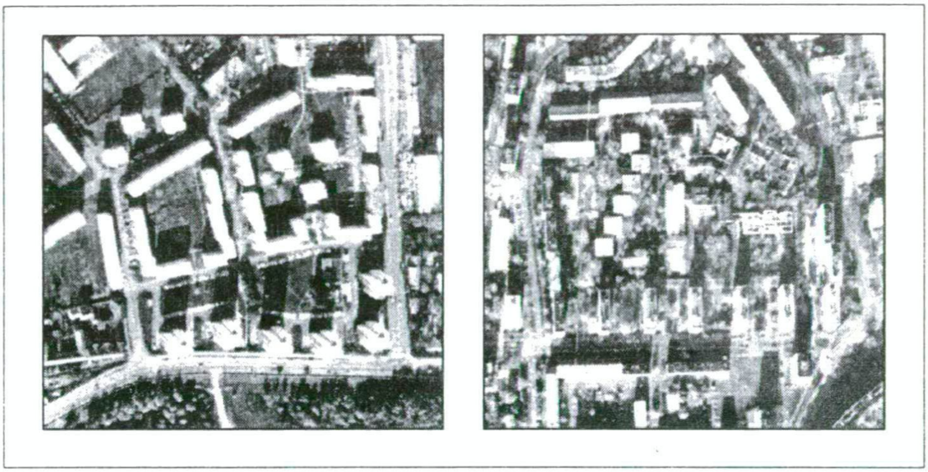


Figure 4. *5 years old (A) and 20 years old house of estates in Szeged*

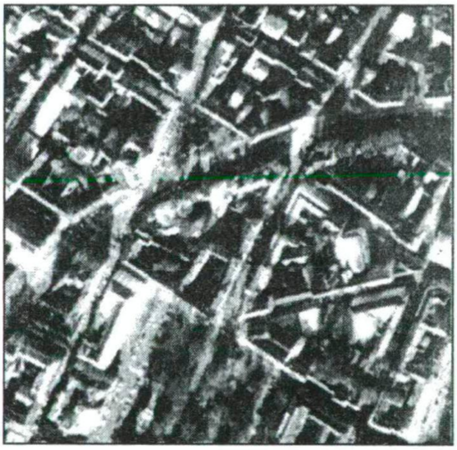
Thus, the following hypothesis (Froster 1987) is not exactly true: "...low density areas would normally have a higher vegetation content than high density areas". It is true only for downtown or CBD's (Central Business District). In the case of Szeged, the central area's delineated by the Grand Boulevard

Monitoring of other urban and rural encroachment

Different types of urban land use can be detected on the investigated area.(1) During the last 25 years, the most important process was the building up of the open space areas in the inner city. Not only the open space areas were used, but also the old, uncomfortable houses were destroyed, especially those on the outer ring between the Grand and Outer Boulevards. On Fig. 2. (upper map) there is an old district near to the Stadium (before 1965). This area is already destroyed (1983, Fig.2. lower map) and a new estate region can be seen on this area on the airphoto (1992, Fig. 4, rigth image).

(2) Aerial and structural changes can be discriminated on those districts which can be characterized as a rural area inside the town. These types of houses are located on the southern part of the town between the Grand and Outer Boulevards (Mora town), The changes can be seen only on the airphotos. On the SPOT P image and airphoto (see image to the ritgh), the aerial development was measured, but the inner structure development cannot be detected due to the 10 m resolution. On this region, the former network of streets did not change, but new blocks of appartements (6-8 families) replaced the old buildings. Similar development occurs outside the circle bank (Petőfi telep, Hattyas, etc.).

(3) On the inner part of the town, the oldest part of the town, insignificant changes can be detected due to the protection of the historic buildings. During the renovation, the material of the roofs changed thus the characteristics of the remote sensed data also changed. On the SPOT P scene greater blocks can be discriminated, but due to the narrow streets between the blocks, the delineation is difficult. The discrimination is possible using airphoto (see image to the ritgh).



Conclusions

With the help of remote sensed data (airphotos and SPOT XS,P images) different urban and rural changes can be investigated. The airphotos were utilized for the detection of structural changes, especially in rural regions, and XS,P images were used for the aerial measurement and topographical map correction (1:25000 scale, Fig. 5.).

On raster and vector base GIS the urban development can be investigated automatically.

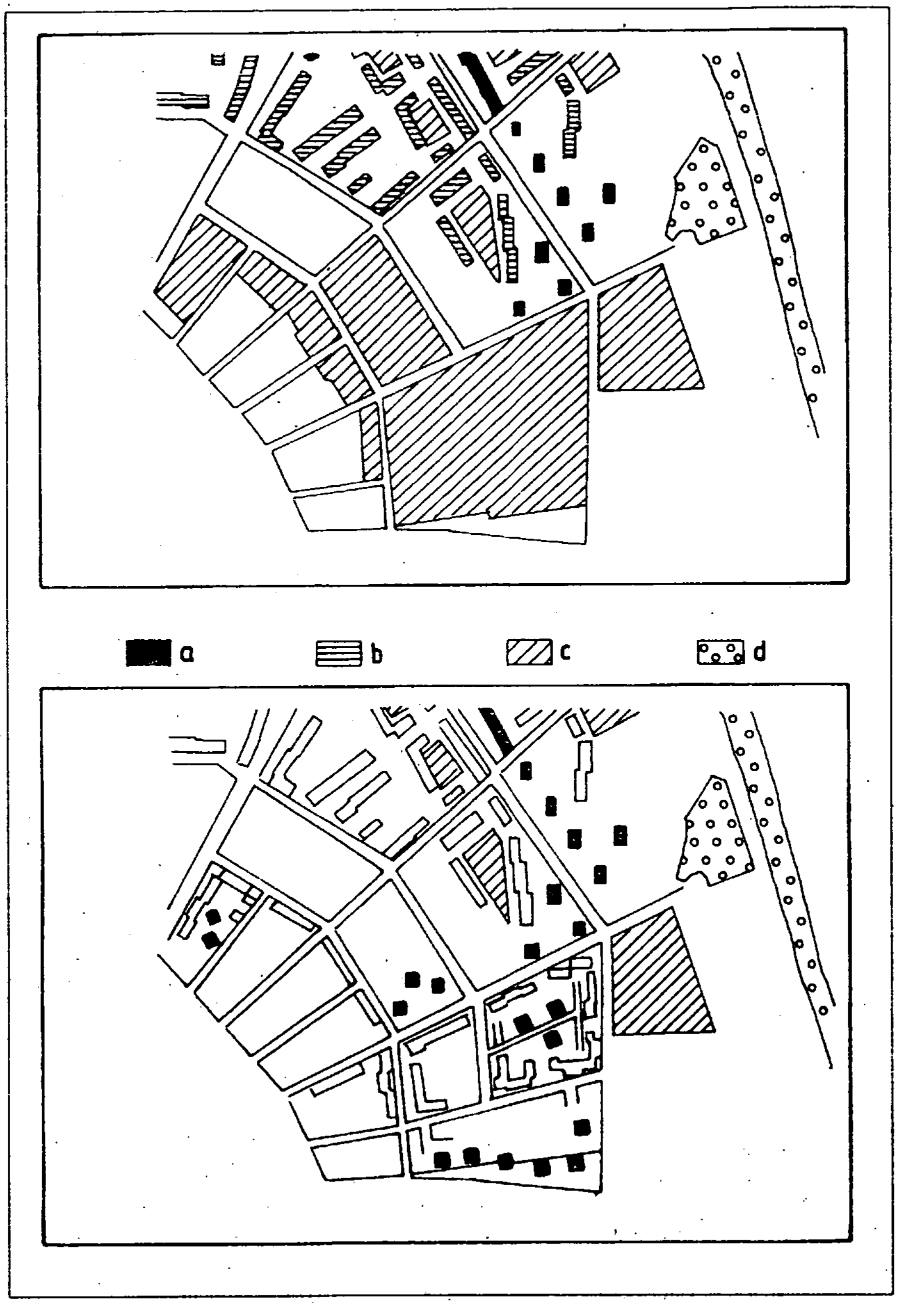


Figure 5. *Topographic map from 1983 and its updated version used by SPOT XS, P images and airphotos a= 8-10 storied houses, b= 4-5 storied houses, c= open field, d= forest*

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