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GEOSPATIAL ANALYSIS FOR MIDDLE EASTERN EUROPEAN URBAN REGIONS IN TRANSITION

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Abstract. *In the framework of this project we investigate of a transect of selected cities in transition with a negative growth pattern in Central and Eastern Europe (e.g. the Leipzig/Halle area in Germany, Poznan in Poland and Brno, Ostrava and Olomouc in the Czech Republic) are presented. The structural analysis of these urban regions is then used to derivate the European pattern spatial development of urban regions in transition. High spatial and spectral resolution satellite image data are used to drive vital information to monitor the following features: urban densities, new developments on the urban fringe and the creation of sub-centers, the spread of impermeable surfaces, soil erosion and the transformation of agricultural lands, changes in local microclimates, surface water flow and reservoir capacity, as well as primary productivity of local vegetation. Furthermore, existing socio-economic and demographic GIS data of each city will be integrated in the investigation to quantify the context of structural and socio- economic as well as demographic development and their mutual effects.*

Нетцбанд М., Буряк Я., Пасто В., Мірійовскі Я. **Геопросторовий аналіз Центрально- та Східноє-Європейських урбанізованих регіонів, що трансформуються**. *В рамках даної статті представлено результати дослідження окремих міст Центральної та Східної Європи, що трансформуються і мають негативну модель зростання, наприклад, регіон Лейпциг/Галле в Німеччині, Познань у Польщі, Брно, Острава і Оломоуц в Чехії. Структурний аналіз цих міських регіонів використаний для побудови Європейської моделі просторового розвитку міських регіонів, що трансформуються. Висока просторова і спектральна роздільна здатність даних супутникових зображень використовується для отримання важливої інформації щодо моніторингу таких особливостей: щільності міського населення, нового розвитку на міських окраїнах і створення субцентрів, поширення непроникних поверхонь, ерозії ґрунтів і трансформації сільськогосподарських земель, змін у місцевому мікрокліматі, потоків поверхневих вод і водосховищ, а також продуктивності місцевої рослинності. Крім того, існуючі соціально-економічні та демографічні ГІС-дані для кожного міста використані для кількісного визначення особливостей структурного та соціально-економічного, а також демографічного розвитку та їх взаємного впливу.*

INTRODUCTION. In the second half of the 20th and by the beginning of the 21st century the cities world-wide underwent a rapid growth tightly related to unrestrained exploitation of space, which has brought about numerous problems[0]. Regulation of urban development problematic is being attended by different institutions, on various levels of state and self administration, usually by means of municipal planning. Planning usually takes into account the current and previous states or different states over a period of time, for plotting the possible development scenarios of an area. Therefore, the studies of the state and dynamics of urban development can significantly benefit by using Remote Sensing methods[0]. They are particularly suitable for localization, spatial measurement and analysis of urbanized area.

In this research we have concentrated on the combination of image processing techniques directed toward extraction of the information that can be used for a successful monitoring and planning-managing of urban areas. The main goal of the study was to identify and quantify particular changes of urban and suburban space that took place in the past three decades (1985–2009) in selected cities in the Europe.

STUDY AREAS. Five cities were chosen in Middle Eastern European Countries (former Communist Bloc) for the analysis in order to capture and compare their post-soviet development. All these cities carry similar patterns of urban and industrial growth that occurred after World War II. Typical representatives from western countries of the former Communist Bloc were selected (Figure 1) Leipzig (Germany), Ostrava (Czech Republic), Katowice (Poland), Košice (Slovakia) and Székesfehérvár (Hungary). It is common for all the cities that they have been industry oriented with surrounding open pit mines areas (excluding Székesfehérvár) and have been important regional centres. The cities sample has been chosen with the respect to their size (in terms of total population) ranging from approx. 100,000 to 500,000 to cover scale invariance of the development process which is, however, very similar throughout the sample. Basic numerical characteristics of the cities are in Table 1.

Table 1 – Basic numerical characteristics of the cities

The City	Total Population (City Area)	Total Population (Metro Area)	City Area (km^2)
Leipzig	530,000	3,500,000	298
Ostrava	310,000	1,160,000	214
Katowice	308,000	3,680,000	165
Košice	240,000	560,000	243
Székesfehérvár	102,000	NA	171

There are other common aspects due to the cities industrial and urban history. At first, there are a lot of brownfields (abandoned and ruined industrial objects) within the city boundaries, even in its central parts. Secondly, one can find dispersion of residential areas that forms separated structures (cities within the city) from the compact city centre. It is very typical for all the cities that these residential

areas are densely populated with people living in prefabricated housing blocks. It is also common for the chosen cities that new light-industry areas were established over last decade (especially in Székesfehérvár and Leipzig). These are some of the major features that make the cities development process similar.

Figure 1 – Overview map

DATASET. Dataset which was used for tracking changes of target Land Cover units in Leipzig, Ostrava, Katowice, Székesfehérvár, Košice region comprised of an assembly of 30 m resolution LANDSAT TM-ETM and TM images, involving several time splits from 1985–2012. Similar time intervals between them were chosen in order to track the changes gradually. Moreover, all images were taken at early autumn, so that the seasonal variations effects could be maximally suppressed. The resources for the dataset images involved open libraries of LANDSAT images[0, 0].

METHODS. To unfold the changes in urban/sub-urban development is to analyze their spatial relations with other units, i.e. to analyze the changes of a Land Cover map of the area of interest[0]. In such regard, the methodological framework that has been followed in this research could be split in two separate approaches. They both regarded image processing methods for image classification, resulting in the series of Land Cover maps, which were subsequently used for post-classification change detection[0].

Following the first order CORINE classification[0] and in respect to the expected Land Cover units in our study area, four classes, i.e. arable land, forest vegetation, urban area, and water body, were distinguished per each time split in both approaches.

Pre-processing and processing was performed by combining IDRISI Taiga and ERDAS Imagine 2011 packages.

A. Unsupervised Classification. Due to the substantial amount of images to be visually analyzed we herein turned to the automatic procedure of image classification by using ISODATA algorithm[0]. K-means is a clustering algorithm that

performs pixel-based classification, i.e. groups similar pixels together in an *n*-class feature space on the basis of pixel's spectral characteristics[0]. Principally it is sensitive only to the number of desired classes *n* and the threshold percentage of the stable pixels, which makes it convenient for trial-and-error manipulation in search for the optimal results. Such classification result is still very raw and it needs subtle refinement stage. Good results were achieved easier when the processing mask was introduced.

B. Classification Error Assessment. In order to provide classification reliability, all generated Land Cover maps were assessed by error matrix[0] on the basis of specified number of random points. For the purpose of this research approx. 200 control points were selected for all class, appeared to be sufficient for error estimation. This assessment was necessary not only to control the continuity of classification accuracy throughout the different time splits, but also to make preferences and exclusions of erroneous data. The classification accuracy ranged from 85,25 % to 98,5 % which is acceptable for unsupervised classification. The best accuracy was calculated for water bodies and urban land, the worst results were calculated for arable land and vegetation. The supervised classification could be used for better results.

RESULTS. Because of less precise distinction between vegetation and arable land due to the image acquisition period (e.g. arable land in 90s was recognized as vegetation in 00s) conclusions are made according to built-up areas evolution. Although the cities had generally similar development during communist era there are some significant differences among them.

These differences allow to sort the cities into 3 groups. The first group consists of Leipzig and Ostrava (Fig. 2, Fig. 3 and Fig. 7). This group is characterized by decrease of built-up area after end of communist era (1989) and increase of built-up area in the past decade. It is suggested that the decrease was caused by inhibition of industrial production and brownfield recultivation. Consequent increase of built-up areas was caused by establishing commercial and light industry areas which replaced old non-revitalised industrial areas or were built completely newly.

The second group consists of Katowice and Košice (Fig. 4, Fig. 5 and Fig. 8) and is typical by inverse built-up area development. The built-up area increase during 1980-2000 was determined by remaining of the city industry-driven importance not only within the region but in whole country. The decrease of built-up area during 2000-2012 represents the similar state of city development in the 2000s in the previous group (Leipzig and Ostrava). It is assumed that Katowice and Košice will follow the descending trend that appeared in the first group.

Székesfehérvár city (Fig. 6 and Fig. 9) represents an individual group. The city is characterized by decreasing built-up area in all observed decades. This trend has been influenced by the history and character of the city (rural area with numerous marshes).

CONCLUSION. The strength of satellite remote sensing is to structure and classify such large and complex urban areas as well as evaluating their spatial development by change detection studies. Since there are hardly or only very few GIS based map bases for these large cities available in India, the satellite-based

remote sensing represents a chance to structure and map such expanded urban residential areas at least approximately into different land coverage or land use classes.

The scientific results are change maps of the urban agglomeration of the five chosen Middle Eastern European Cities between 2001 and 2009 using temporal transects of remote sensing data and applying up-to-date change detection techniques at different spatial and temporal scales. This is used for quantifying urban and peri-urban processes (land use / land cover changes of settlements, agriculture, industry, and landscape) in this urban agglomeration (growth rates, urbanization) and additionally, for predicting the development of urban fringes, rural settlements, informal settlements, urban and peri-urban agriculture.

However, the preliminary results of the change detection maps indicate that there is still some uncertainty in the classification procedure which has to be evaluated and improved possibly by integrating ancillry data. Thus, data of macroeconomic and demographic development, instruments of urban planning, and socio-economic settings shall be integrated as data are available. Furthermore, it is envisioned within this project to analyse high resolution satellite data for the same sample of cities in order to identify and evaluate more precisely and spatially in a finer spatial resolution 'hot spots' of change within these cities.
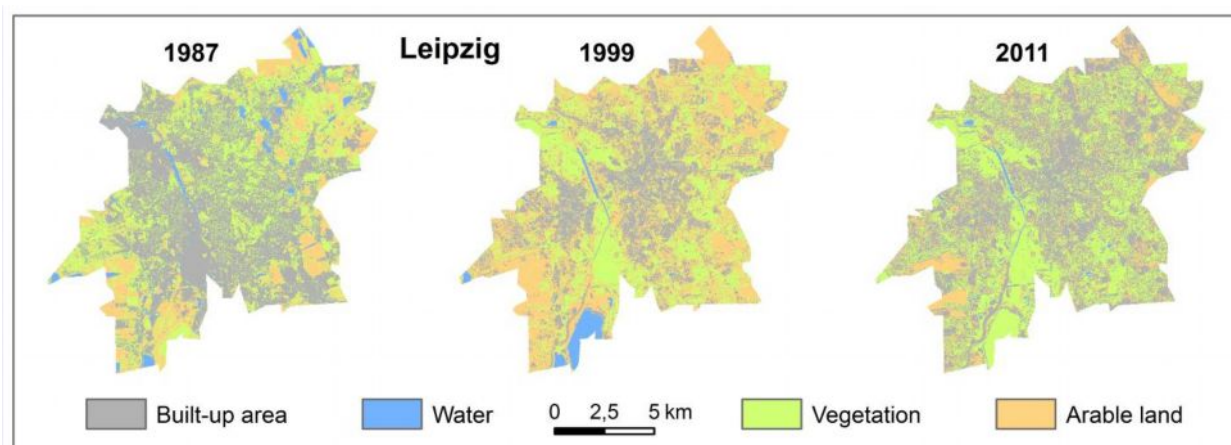
Figure 2 – Unsupervised classification results of Leipzig
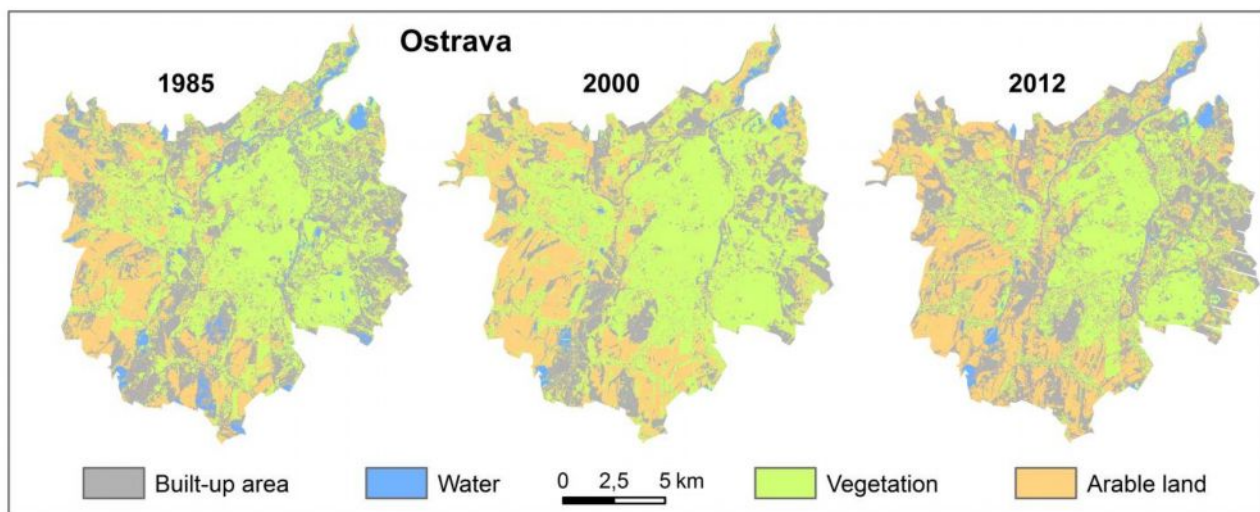
Figure 3 – Unsupervised classification results of Ostrava
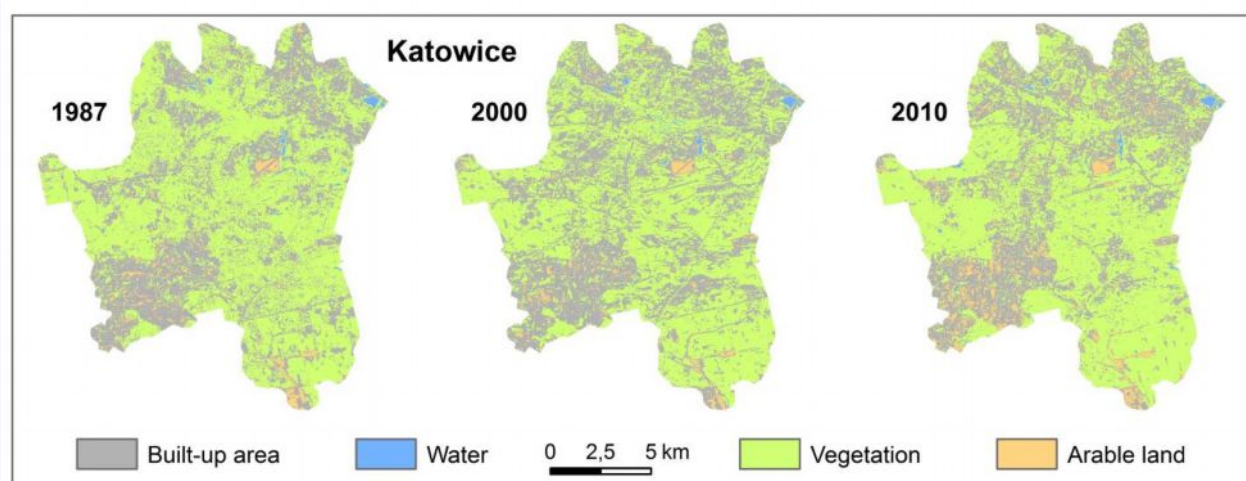

Figure 4 – Unsupervised classification results of Katowice
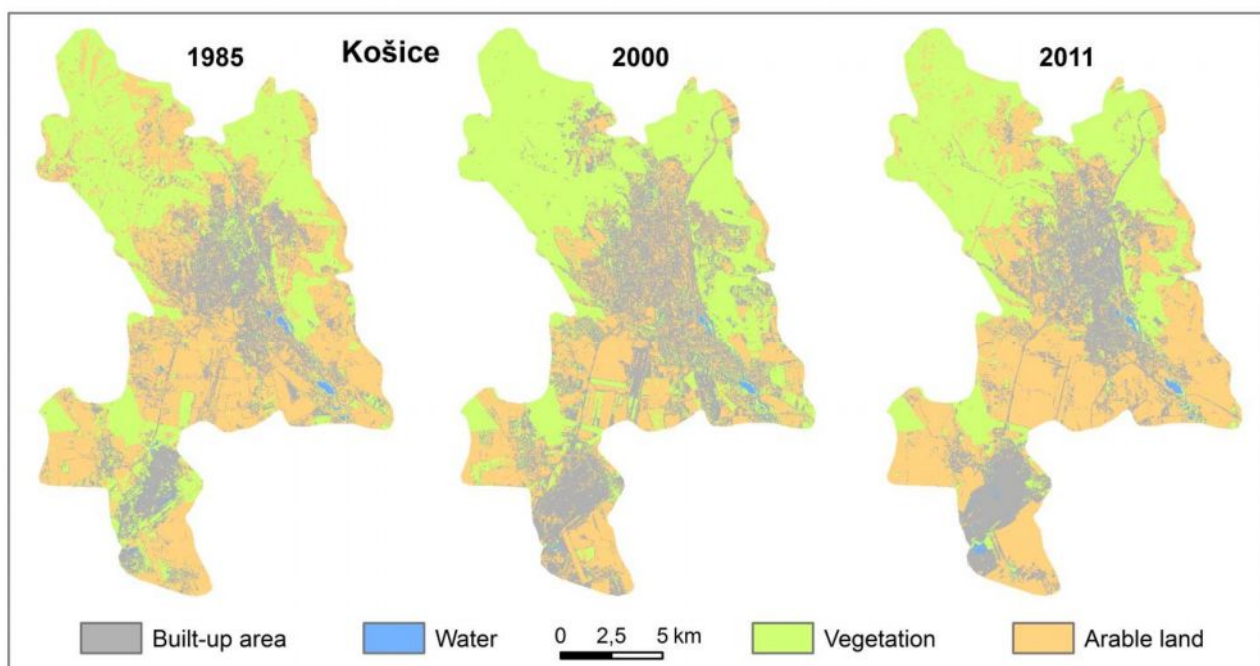

Figure 5 – Unsupervised classification results of Košice
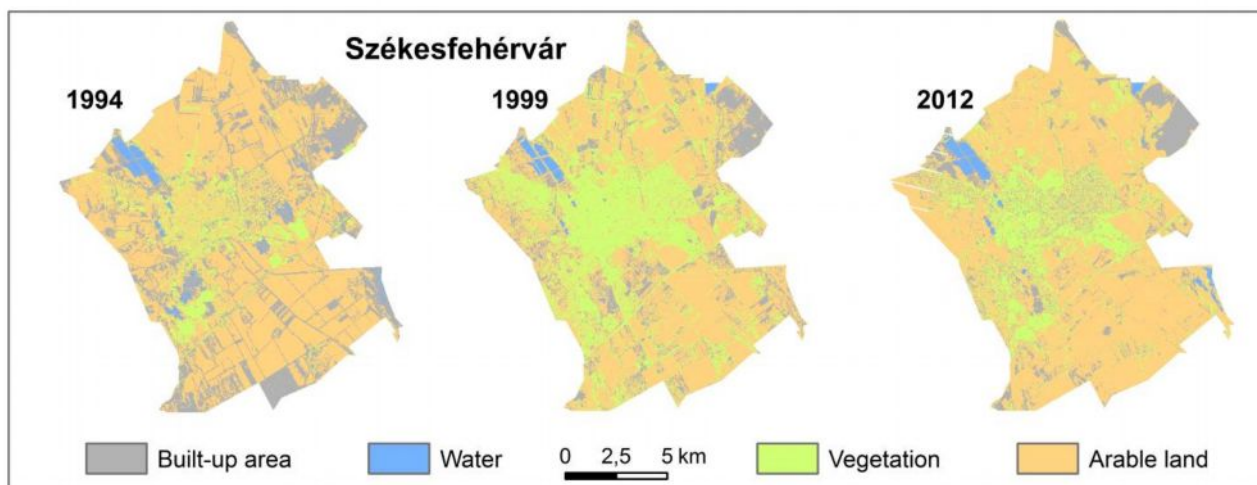
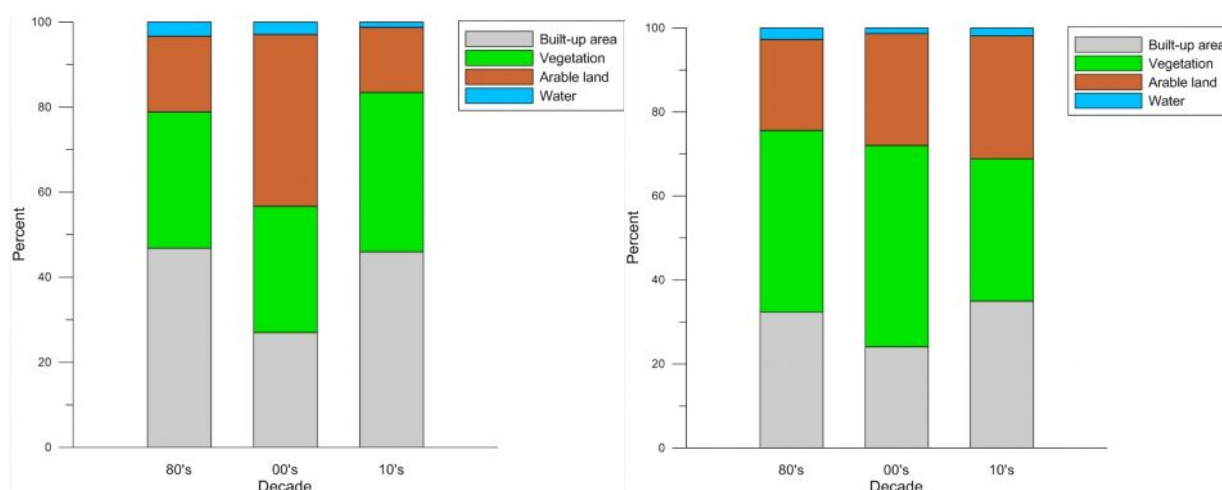Figure 6 – Unsupervised classification results of Székesfehérvár

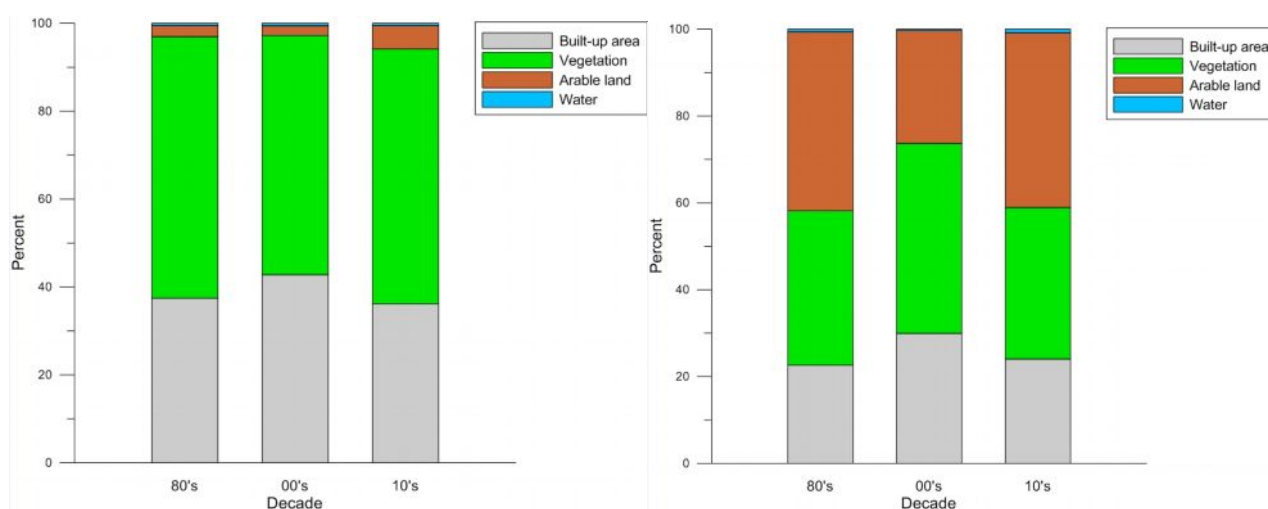Figure 7 – Ratio of land cover classes of Leipzig and Ostrava city

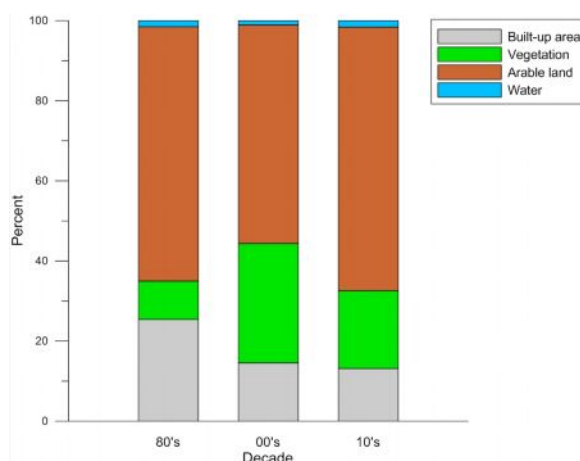Figure 8 – Ratio of land cover classes of Katowice and Košice city

Figure 9 – Ratio of land cover classes of Székesfehérvár city

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