Vol. 23/1 | 2021 Česko-slovenská historická ročenka pp. 37–56

DOI: 10.5817/cshr.2021.23.1.3

STUDIE

Geographic Information Systems as a tool of historical research/ GIS jako nástroj historického výzkumu

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GIS as a tool of historical research

With the development of computers and digital technologies in the second half of the XX century, new tools, and methods for analyzes appear. Among them are Geographic Information Systems (GIS), which benefit various fields including History. The analytical part of the GIS differs from classical Cartography concentrated on presentation information, and while regular maps are still developed, the amount of spatial analyzes rises. The Historical GIS (HGIS) operates as an interdisciplinary subfield using the historical approach to data collection and reviewing and the geographical methods of data processing and visualization. GIS software is a powerful tool to build and analyze spatial databases, yet it has its limitations and requirements for data. The archival sources are in analog form, with different levels of accuracy, and often incomplete, which calls for additional effort in data processing and reviewing, and information cross-checking. Overcoming those challenges, the outcome of HGIS is significant and enforces historical research. The following paper describes the GIS as a tool in historical studies. It outlines the development of GIS and HGIS and their origins in spatial analyzes conducted manually, their key features, functions, requirements, and challenges. Later the paper presents the practical application of HGIS, on an example of the research project, that analyzes the morphological development of post-socialist cities. By summarizing the methodology used to build a GIS database points out the process of data collection, reviewing, and processing. It describes the main cartographic sources and their characteristics that outline the challenges in using HGIS.

Keywords: HGIS, cartographic sources, data processing, spatial analysis.

Introduction

The rise of the information era started in the second half of the XX century is indicated by the development of new digital technologies. The computers allow to to process the data faster and in a more complex way. With the help appear new tools, and methods for analyzes not possible to conduct manually. Among them are Geographic Information Systems (GIS), spatial databases, where every information it holds has geographical coordinates. These allow to display the information on the map and to conduct spatial analyzes. The analytical part of the GIS differs from classical Cartography concentrated on presentation information in a static form. While regular maps are still developed and published, the amount of spatial analyzes rises. After a few decades of development, many analytical tools for GIS were created, and it found application in many fields of knowledge, including History.

The Historical GIS (HGIS) is an interdisciplinary subfield using the historical approach to data collection and reviewing and the geographical methods of data processing and visualization. GIS software is a powerful tool to build and analyze spatial databases, yet it has its limitations and high requirements for data. While the contemporary data is available in the form appropriate for GIS, the archival sources are in analog form, with different levels of accuracy, and often incomplete. That is why the researcher must put an additional effort into data processing and reviewing, and information cross-checking is necessary. Overcoming those challenges, the outcome of HGIS is significant in a way of conducting spatial and statistical analyzes, visualizing the information, reconstructing, and sometimes filling the gaps in archival data. While GIS is limited to quantitative analyzes, it allows later interpretation from the multilevel dimensions.

The following paper describes the GIS as a tool in historical studies. It outlines the development of GIS and HGIS and their origins in spatial analyzes conducted manually. It describes their main features, functions, and requirements. Using GIS bring also challenges, considering data collection and processing and the later analyzes conducted with the software.

Later, the paper presents the practical application of Historical GIS, on an example of the doctoral research project, that intends to analyze morphological changes in post-socialist cities with the help of digital geospatial tools. Because of the need for in-depth analyzes and a significant amount of data, the study concentrates on case studies rather than the description of whole phenomena. The subject of the research is the city of Košice in Slovakia and its development in the years after the fall of the communist regime in Czechoslovakia. Coming

from the historical context, and by referring to general concepts, the study analyzes the morphological development of the city and the socio-economic processes that lead to them. The paper concentrates on outlining the methodology used to build a GIS database, which points out the practicalities of data collection, reviewing, and processing. It describes the main cartographic sources and their characteristics that outline the challenges in using HGIS.

The development of Geographic Information Systems and Historical GIS

The spatial analyzes were conducted much earlier than the development of the computers, potentially as early as the first maps were created, but a more systematic and statistical approach was developed later. A classic example is a study by J. Snow from 1855 where he mapped and analyzed the cholera outbreak in London in1854. While mapping the cholera cases, he noticed the spatial correlation between the localization of the households with the highest number of fatal cases and the public water pump on Broad Street, which was detected as a source of the epidemic outbreak.

Other Examples come from German geographers and their urban studies, where mapping played a crucial role in spatial analysis. In his studies, W. Geisler analyzed the city of Gdańsk. Starting with the description of the physical, geographic, demographic, and economic conditions of the city, in the following part he focused on the spatial organization and the structure. In the research, he used various types of sources including cartographic, photography, demography statistics, which was an innovative approach at that time (Geisler 1918). The outcome of the study was the plans with the identification of land and building utilization, and the height of residential buildings in the city center.

The beginning of the GIS is marked by the development of computers and their analytical possibilities. Especially the development of the vector graphic allows the use of accurate coordinates and merges the spatial data with multiple statistics. The first fully functional vector-based GIS, the Canada Geographic Information System (CGIS), was developed in the early 1960s by Roger Tomlinson (Tomlinson 1969). Later he used for the first time the phrase Geographic Information System and is considered a "father of GIS" (Waters 2017). Up to the 1980s, the GIS was a technology developed and used mostly by academics and government institutions. At that time, the first commercial companies started. In 1986 the first GIS software for the PC (MIDAS, later renamed to MapInfo) was developed, and the technology started to be widespread.

The **Geographic Information Systems** are a digital toolbox for the creation and processing of spatial databases, where every information holds geographical coordinates and a unique location. These allow displaying the information arranged in the space that allows conducting spatial analyzes. This characteristic indicates not all of the data can be used to build a database in GIS. On the other hand, lots of information can be aggregated spatially, such as those collected during censuses (in that case the data is the information assigned to specific administrative units or addresses).

In comparison to classical maps, which are static representations of spatial phenomena, the GIS is more dynamic. Its features locate GIS between statistical and graphic editing software. While the visualization of the data is an important feature, and most contemporary maps are edited and published with GIS, its analytical tools differ from graphic software. The GIS software allows digitalizing analog data to raster and vector data, that can be processed in the software. While vector data is more precise (the vector data is created by points on a Cartesian plane that is accurate in every scale, while the raster data is limited by its resolution), in some cases the information is more fit to raster graphic (Digital Terrain Model, orthophotography, etc.). The data processing with GIS includes combining/joining/merging data, transforming, and creating new data, sharing the information, and preparing the outcome. The software helps conduct spatial analyzes and allows to do meta-analyses between different sets or types of data. This creates an opportunity for creating new data (like density, correlations, etc.).

Starting in the 1990s, historians use GIS and the interdisciplinary field of **Historical GIS** (HGIS) was created (Gregory and Ell 2007). HGIS refers to History in data collecting and reviewing, and Geography in information processing and visualizing. It allows not only to reconstruct former stages but also to create dynamic, tempo-spatial models. In case of lacking parts of the sources, it helps to estimate and fill up the blank spots (Knowles 2008). Presented in this paper is the example of urban studies, which is just one but the significant field of HGIS.

The challenges for the HGIS rise from its characteristics. As a database tool, it concentrates on the quantitative sources and methods, while History like all humanities, often uses qualitative tools and creates a narrative outcome. In The Routledge Companion to Spatial History, authors list the criticism over HGIS and quantitative history: [HGIS] *examines only questions for which quantitative data exist; handles qualitative data poorly; enforces consistency and logic that do not inhere in many data sources; computer-based analysis is uncreative; Historical information is too imprecise for sophisticated methods and theory* (Gregory,

DeBats, and Lafreniere 2018). Moreover, there is a problem with using HGIS by non-geographers, which can end in reducing its potential and using it just as a visualization tool. On the other side, there is the threat of embracing HGIS uncritically. A. K. Knowles (2008) points out that the challenges in using HGIS are the ability to recognize spatial information fixed in historical sources, the different accuracy in mapping over time, and missing standards in documentation.

An important problem is data quality and availability (Laycock et al. 2011). The archival sources are in analog form and need to be digitalized, a process that often can't be done automatically and requires appropriate attention. The historic approach poses several challenges in terms of the availability of data with sufficient accuracy and spatial detail. Among the characteristic of archival sources are their varying data quality and completeness. Due to lack of data or gaps in the documentation, it requires the use of multiple historical sources. Among the frequently used are different types of maps (cadastral, topographic, etc.), city plans, urban planning documentation, individual building documentation, iconography. Collecting and preparing historical data requires acute attention to crosschecking and usage of historical methods such as critical source analysis (Black and MacRaild 2007; Gregory and Ell 2007). Finally, to overcome the limitation of quantitative sources, HGIS should be used as one of the analytical tools, creating a context for other analyzes.

The application of the Historical GIS

To present the practical side of the HGIS, the following part will outline this method used in ongoing doctoral research: *Understanding of morphological changes in the post-socialist city using digital spatial tools. Case study of Kosice.* The study is a part of the bigger project: *urbanHIST History of European Urbanism in the 20th century*[1]. While the research uses an interdisciplinary approach and different methods for the reconstruction and understanding of morphological changes, this paper concentrates on the part using HGIS.

The title of the research informs on the mainframes of the studies: the timespan, the area, and the main methodological tool. Both urban space and social processes occurring in the cities are not uniform. This diversity is functional, as well as a characteristic overlook that makes them differ from each other. The

1 ***urbanHIST*** *History of European Urbanism in XX c.* is a project that has received funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 721933.

cities themselves changed their faces many times in subsequent stages of their development. Their spatial form is the resultant of various factors that shape them. Thus, their image at the moment is both an expression of contemporary processes and a legacy of historical times. That is why the study needs to refer to the context of the post-socialist transformation, the previous socialist period of its development. Hence, the main aim of the study is the identification and analysis of decision-making and development processes leading to the current state of the post-socialist city of Košice, represented by time-series of the spatial database representing historical stages of the city structure.

The socialist urbanism as a dominant form of urban space in Košice is an interesting canvas for the post-socialist transformation and brought many challenges for contemporary development. During the last three decades, the population changed little: from 235 000 in 1989 to 238 593 inhabitants at the end of 2019 (according to the National Slovak Statistical Office), but in this period the city has been going through a transformation from an industrial dominated, socialistic town to a contemporary urban organism developing in the free-market economy. Nowadays, Košice is the main economic and cultural center of eastern Slovakia, and thanks to its position, most of the transformation phenomena are focusing in the city.

The historical spatial data sources

The study of such complex phenomena as urban morphology requires the use of multiple historical sources, such as maps, city plans, urban planning documentation, individual building documentation, iconography, articles, with varying data quality and completeness. The sources used in the study belong to various types, and the number of categories depends on the analyzed aspect of the information, such as primary/secondary, digital/analog, archive/fieldwork, or qualitative/quantitative sources. The following part concentrates on the cartographic sources used for the GIS database. Moreover, it presents the methods used for collecting and reviewing the sources. Altogether, it points out the main challenges met during data collecting and processing.

Based on origin, both primary and secondary sources were used in the research, however, the division between them in History is not always clear (Black and MacRaild 2007; Dalton and Charnigo 2004; Kragh 1989). The same item/artifact/document can be treated as a primary or secondary source, depending on the context. While as a primary are considered the documents from the studied period and first-hand origin, the secondary sources are not only those

created later but also the compilations, reports, analyzes, etc. prepared in the examined time. To this unclear category belong the archival maps. At one point they are primary sources presenting the knowledge from the analyzed period, but they also are a not-objective compilation edited by their authors. Since a map is a reduced and generalized representation of the space, the editors decide which elements will be outlined and which will be loosened. A good example is the maps from the socialist period where some parts, covering strategic objects (like airports, military barracks, or some factories) are intentionally left blank. This characteristic has to be considered during source review.

The basic sources for building a digital model of morphological development of Košice are the **cartographic documents**. Those used in the research came from different origins. For the socialist period, most of the cartographic sources are analog and available in paper form, later scanned. The same characteristic has the data from the first decade of post-socialist transformation. For those periods the collected information comes mostly from the maps with two examples of ortophotomap from 1949-50 and 1990. Starting from the year 2000 the characteristic of cartographic sources changes. The GIS databases replaced printed maps. The new type of sources, the satellite pictures from Google Earth software, became available. The number of orthophotomaps grew and, together with the cadaster and OpenStreetMap database, are the highest quality sources (Figure 1).

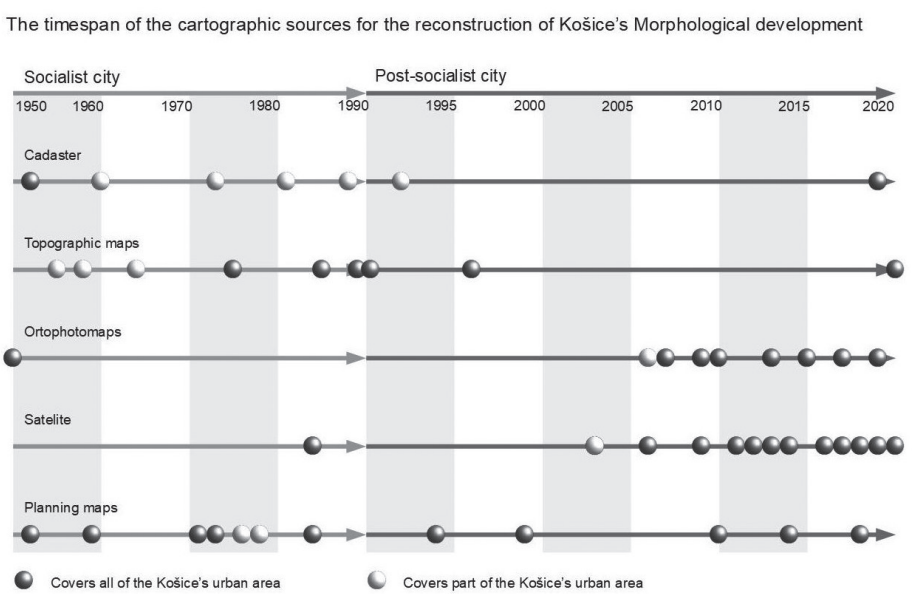

Figure 1 Timespan of the cartographic sources

The digital, contemporary sources are available online via Web Map Service (WMS) servers. The Slovak National Geoportal provides online the contemporary database but also some archival documents. The archival maps are in the form of georeferenced color scans. They cover the different areas of Slovakia, and not always the whole Košice. The topographic maps come from the period 1952-1990, but the exact dating is problematic since the single sheets are not dated but just the whole map. This situation wides the dating from those maps to the entire period when the map was created.

Part of the sources was found during an archive search at Central Archives of Geodesy and Cartography (ÚAGK) in Bratislava in June 2018 from two publications, Základná Mapa SR (54 sheets) and Štátna Mapa (23 sheets). The maps, originally in printed version, were scanned by the Archive and color (Základná Mapa SR) or monochromatic (Štátna Mapa) scans were received. Both maps cover the land in a fixed order and the sheets with the same header show the same area in every edition. Each edition of the maps was signed with the exact date for which they present information. Those characteristics made them, together with ortophotomap from 1949-50 the main cartographic sources for the reconstruction of urban development in the socialist period and the beginning of the post-socialist period (Figure 2).

Štátna Mapa (the State Map) was published on a scale of 1: 5000 from 1952 until the early 1990s. Their typography was derived from the original cadastral maps. The first edition from 1952 shows the original cadastral state of private property from before the collectivization was done systematically in the 1950s. The received set of Štátna Mapa sheets comes from the years 1952, 1960, 1973, 1981, 1988, and 1992. Only the first set from 1952 covers the entire urbanized area of Košice at that time. The other editions are incomplete and consist of single sheets. The maps' details are on a high level, but during the cross-check with other sources came up that the quality of the information was not always the best. Several times the maps in their fragments had objects copied from earlier editions and not existing at the time marked in the sheet.

Základná Mapa (the Basic Map) is a topographic map published in the scales from 1:10 000 to 1:200 000. For this research, only the scale 1:10 000 was used as the most detailed. The first edition found for the area of Košice comes from the year 1976 (representing the situation in 1975) and was followed by new editions in 1986, 1990, and 1996. The edition from the year 2000 was mostly a copy of the situation from 1996 and was considered useless for the research. Later, with the development of digital cartography, Základná Mapa was replaced with the digital database available at Slovak National Geoportal. For all the editions full area of Košice was covered. The level of detail in the maps was

changing between the editions. For example, the sheets and allotments did not appear in earlier editions. The generalization of the map is higher than in cadaster and Štátna Mapa, which was a challenge for the merging and interpretation with other maps, but the full coverage and the set created for the year 1989 was an advantage to map the exact moment of transition from socialist to post-socialist period and dived the morphological development in those two periods.

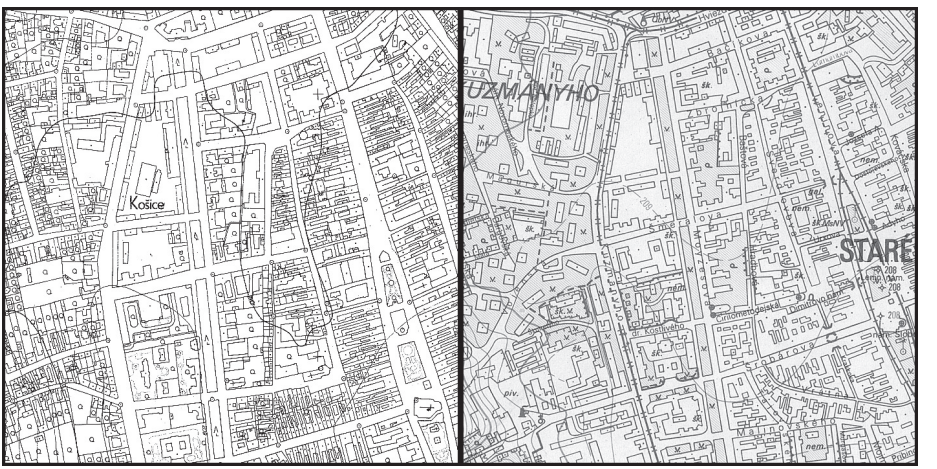

Figure 2 The fragments of Štátna Mapa from 1952 (left) and Základná Mapa from 1989 (right)

The archival **planning documents**, including maps, were received from Košice's Municipality office in June 2017 in form of scans and photographs. They cover the planning process in Košice for the period from 1959 to 2014. The name and description of the scans were sometimes misleading. The map called 1952 was in fact from the master plan done in 1959, which came up in later analyzes when the plans from 1952 were found in other sources (Sekan 2015). The scale of the maps was 1:10 000 for general plans covering the whole Košice. The detailed maps of the city center from the 1970s were done on the scale 1:5 000 and 1:1 000. Their level of details was different, from single buildings to just zoning the urban space. Since the planning maps concentrate on visualizing future development, the data quality of the existing situation was often questionable, especially for older maps. The crosscheck with other sources showed that sometimes the information was outdated. The quality of maps, especially the photographs was not always the highest and sometimes their usage was limited or required additional processing in the GIS software.

The **cadaster** map was available from the WMS of the National Geoportal of Slovakia. The register showing such details as the ownership, boundaries, is available online for the present moment, while the archival information was limited. The quality of the data is the highest publicly available and served as a basic reference point for other cartographic sources. Using the cadaster data from **OpenStreetMap** (OSM) database was built. The data in vector format are open source available and were used in the research as a base layer for later processing and analysis. The dataset from OpenStreetMap was downloaded on 16.06.2019 in shapefiles from the dedicated portal GeoFabrik (www.download.geofabrik.de).

The **satellite imagery** used in the research was taken from the Google Earth software. The data covers the period from 2003 to 2019. The data advantage is the ability to get a daily date when the picture was taken and the maps are joined with the Google street view tool that allows seeing the mapping of the public space (also with the exact date when the pictures were taken). The satellite imagery resolution varies from 15 m of resolution to 15 cm and not for every set the full coverage of the entire Košice is available.

The method and the outcome

The GIS database created in the research was prepared with the QGIS software. It is an Open-Source Geographic Information System licensed under the GNU General Public License, that allows uploading, transforming, and analyzing spatial data, together with creating new data and visualizing the outcome. The functionality of QGIS can be expanded by plugins that add new processing tools. During the research, several of them were used: OpenLayer plugin, Georeferencer GDAL, OSMDownloader, mmqgis, and Hotspots Analysis. The program can use online data by connecting to the WMS servers.

The created database is a compilation of various sources. The analog data were digitalized and used in form of raster layers. The digital data was available in both raster and vector form. As a starting point, the vector layer OpenStreetMap database (OSM) was used. Next, the WMS maps were added, creating the canvas for the local archival data. The procedure of uploading the archival maps started with verification of the data quality and preparation for the import to QGIS. The scans from Central Archives of Geodesy and Cartography were in great quality, resolution, and needed just a few adjustments. In the case of some planning maps, because of their quality, it was needed to cut them into pieces for better matching in QGIS. The received scans were often a merged mosaic of

separate pieces that its borders didn't match exactly. The frames of the maps were cut off and, if needed, their orientation was aligned.

The prepared maps sheets were imported to the QGIS with the Georeferencer GDAL plugin tool. It allows importing the rasters and references them to geographic projection coordinate systems by creating a new *GeoTiff* file or by adding a world file to the existing image[2]. The georeferencing of a raster is done by locating points on the raster for which accurate coordinates can be set. It can be done by writing the coordinates or pointing them out on the map. In the case of Základná Mapa and Štátna Mapa the borders of the sheets are set, and the guidelines are available via WMS from National Geoportal of Slovakia. For other maps, the georeference points had to be marked based on specific objects (streets junctions, characteristic buildings, monuments, etc.) visible on the maps and the already georeferenced layers (from WMS or local maps). In this situation, a higher number of points is needed to get a high-quality outcome.

Figure 3 The example of chronological mapping of the buildings in Kosice's center.

The *building's* layer from OSM was the base for the mapping. Every object was mapped according to the year when it was built (specifically: by the moment of first appearance/lack of appearance in cartographic sources) (Figure

2 https://docs.qgis.org/2.8/en/docs/user_manual/plugins/plugins_georeferencer.html

3). The challenge was the differences between maps. The topographic maps consist of a higher generalization level and the shapes or exact location of the buildings don't match the one from cadaster and OSM. I those cases, the researcher had to decide how to identify and match the objects from different sources. The challenge was also with matching the information from planning maps with other sources. In case of missing objects in the vector layer, new were drown according to cadaster and other sources (especially orthophotomaps). The same way every object was mapped according to its main function (housing, industry, service, infrastructure).

The OMS layer consists of only buildings physically existing in 2019 and the creation of the *demolished buildings* layer was needed. Every object in this category was mapped twice, by the year of the first appearance, and by the lack of appearance in cartographic sources. With the starting point from the 1950 ortophotomap and 1952 Statna Mapa, the missing buildings were drowned. Because of the levels of details of those sources, and blurry edges of the buildings, some of them were drowned together as one object. Later, chronologically new buildings were added or mapped as demolished. By using the layers overlying it was possible to combine structures from past stages and analyze the changes of the urban tissue.

If the data was available, the mapped objects were crosschecked with other sources and the dating was corrected. The problem was the data availability and the lack of information for the years between the used sources. This situation was especially problematic for the earlier periods when the gaps between cartographic sources were bigger. Another challenge appeared with verifying the maps, that in some areas or even single objects were outdated or misleading (for example the Dargov shopping center according to maps was mapped as a post-socialist object and in fact was built in the late 1980s). This problem didn't appear in the case of orthophotomaps and satellite pictures, which are just georeferenced and not edited. However, with this type of source, the challenge is vertical development. The tall buildings are shown in a perspective and can be seen partly outside of their footprintThe information processed in GIS data was analyzed thru many aspects.

The mapping of the historical urban development in Košice was followed by the delimitation of the functional areas within the city, detection, and categorization of the active areas in the post-socialist period, and statistical analyzes of urban morphology. The GIS is a sufficient tool for statistical analyzes, yet the specific of the research and the used archival, often qualitative, sources limit them. QGIS software was used to conduct several quantitative analyzes, and the visualizations of the database (showing different aspects), enforced by other

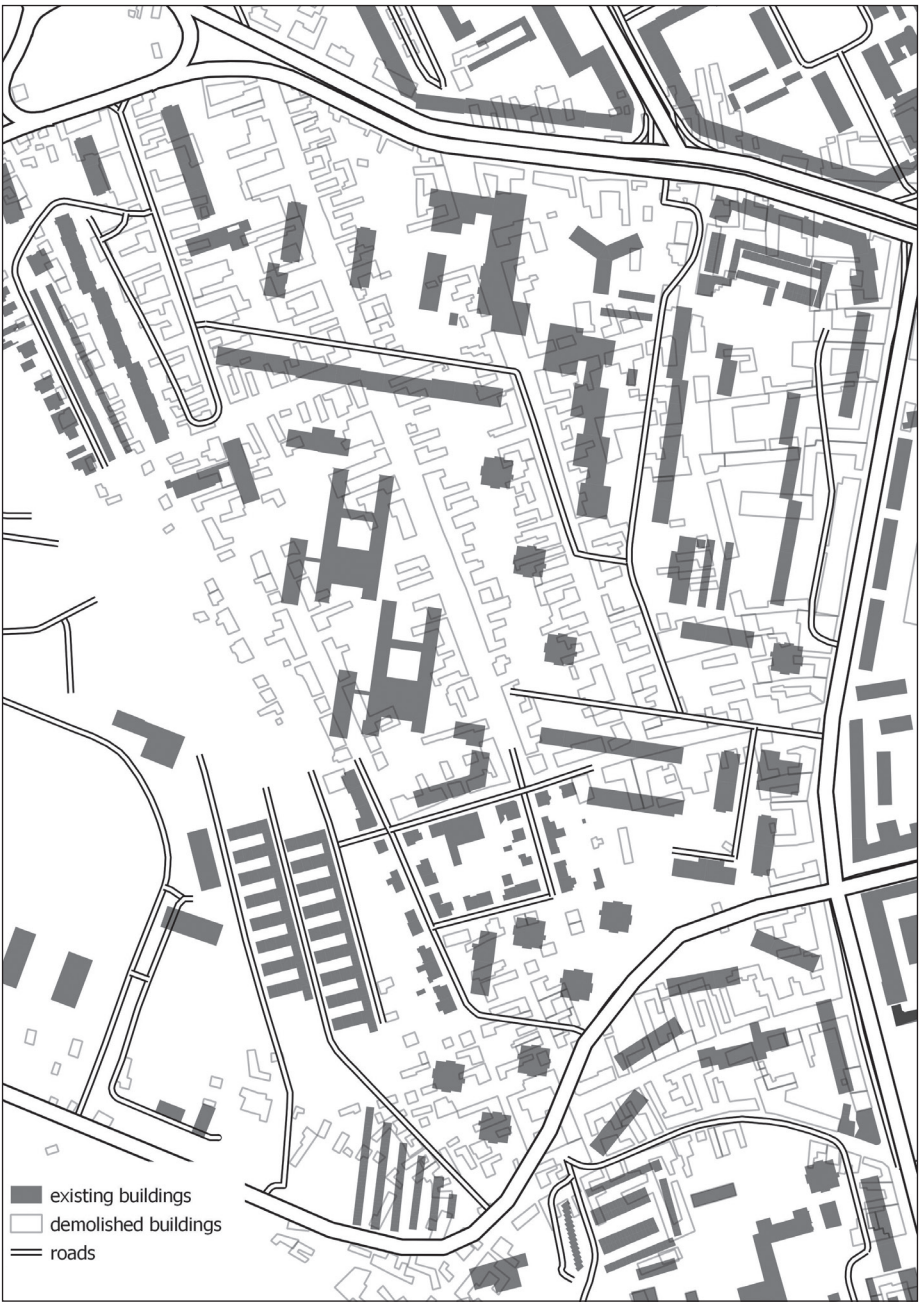

Figure 4 The comparison of urban structures.

Figure 5 The buildings density in Košice

sources, were a base for the qualitative analyzes. The statistical analyzes conducted in the research concentrate on the physical development of Košice, especially the construction and demolition of buildings. The functional categories were also considered for measuring the spatial concentration of the different forms of activities.

The density of the buildings within the city was measured (Figure 4). While the administrative units are in most cases consisting of areas not always spatially close, and different types of urban and rural space, their application for the spatial analyzes is limited. As a spatial delimitation, the geometrically fixed grid (squares with the size 0,25 km^2) was used. In the case of the buildings crossing the grid borders, the objects were divided for land coverage analysis. The data were analyzed as a whole and divided into periods. The specific categories of the development (housing/suburbanization, industry, office buildings, retail, etc.) were also analyzed separately.

The basic analyzes were made with defining the centers-of-gravity (centroids), which is a geometrical center for the object or the object's matrix. The centroids were counted for all of the buildings in Košice and separate for each analyzed period (mapping the presocialist, socialist, and postsocialist development). The difference between them marks the overall direction of urban development. Additionally, each functional category of the buildings (housing, industry, infrastructure, etc.) was analyzed separately.

The trends in urban development were analyzed using the Local Indicators of Spatial Association (LISA) method (Anselin 1995). It identifies local spatial association patterns that can be interpreted as clusters (hotspots) of the same category objects. The LISA is created based on Moran's I autocorrelation and is used to determine spatial systems. It enables the determination of the similarity of spatial units concerning adjacent units and the significance of this relationship. As a result the study detected several hotspots of the post-socialist development (Figure 6) later divided by their dominant form and function.

The morphological changes mapped with GIS were analyzed from the perspective of several methodological concepts, especially the English School of urban morphology, with its *morphological region* concept, that divides urban space into zones of unified morphological form and different from surrounding areas (Conzen 1960; Whitehand 2001). The Conzenian approach also points out the role of plot and infrastructure patterns in urban development (Oliveira 2016).

The detected urban patterns were interpreted by referring to general concepts of urban and social development such as industrial city well described by the *sector model* of the city by H. Hoyt (Hoyt 1939), and *postmetropolis* (Soja

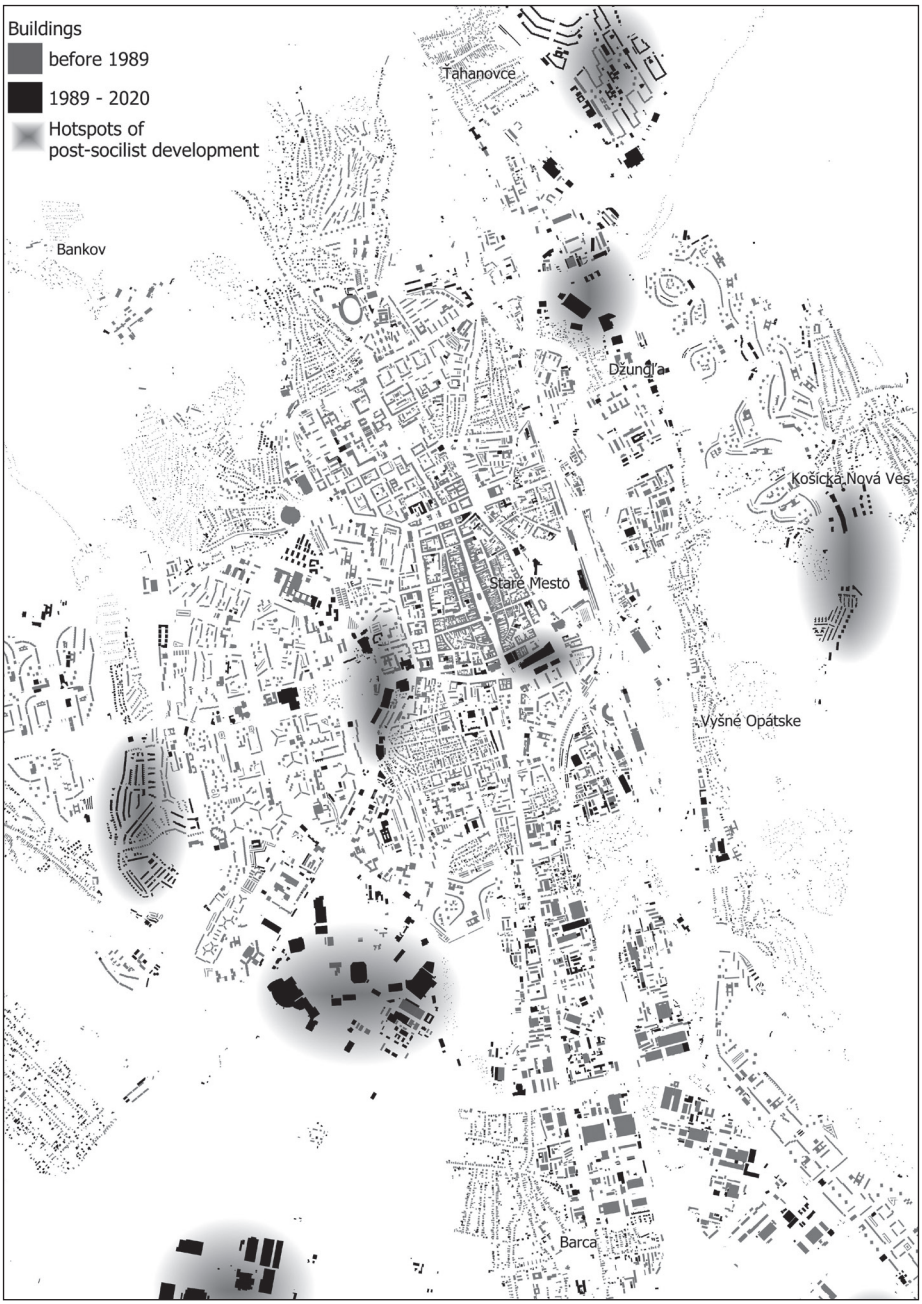

Figure 6 The post-socialist hotspots within Kosice's urban core

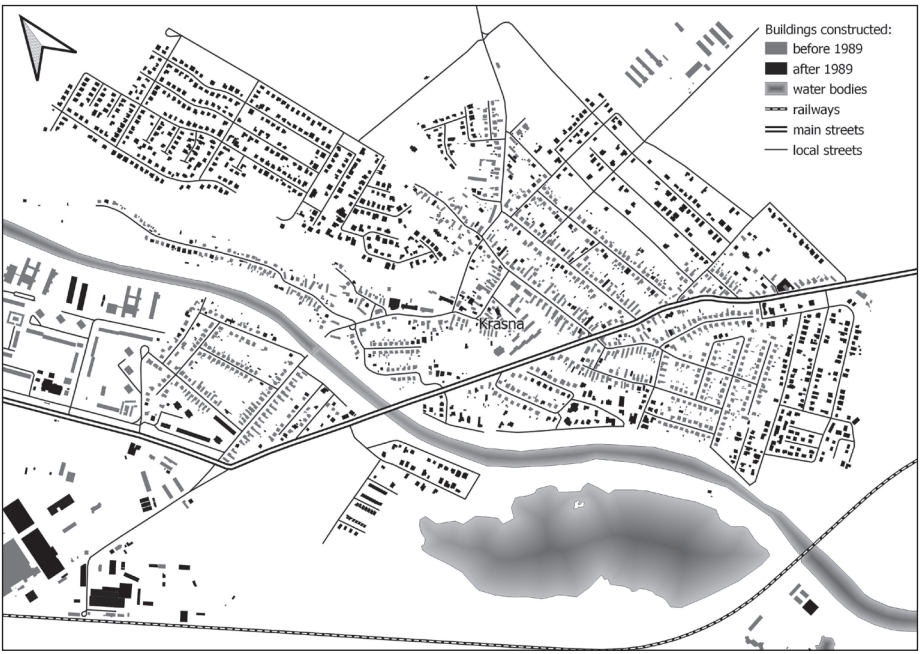

Figure 7 The suburbanization hotspot in the Krasna neighborhood.

2000) originating in *multiple nuclei* model of the city by C. Harris and E. Ullman (Harris and Ullman 1945). The global trends together with the development of mobile technologies create new city structures with fast-growing suburbs (*urban sprawl*) and random localization of sub-centers (*edge cities*) and services within the metropolitan area (*keno-capitalism*) (Knox and Pinch 2010). In Košice, all those features were detected and the analyzes with GIS allow to delimit them (Figure 7). One of the study hypotheses was that Košice's postwar development must be revised thru the Path dependency theory (Gwosdz 2004), which was reflected in the non-linear development of the urban structures. The development and later transformation of the industrial zones in Košice were a good example of how the window of possibilities mechanism works in practice.

Conclusions

Historical Geographic Information Systems is a powerful method to conduct research. Although spatial analysis started far in analog times, with the development of computers the possibilities grow rapidly. The referred studies from

J. Snow and W. Geisler show the pre-GIS spatial analyzes – with its main limitation to a small amount of data that a scientist can process manually. The development of computers allows us to move those limits and build more sophisticated analytical tools. The development of GIS tools dates from the 1960s, and the HGIS became independent, an interdisciplinary subfield in the 1990s. In the last decades the number of historical studies using GIS is rising, yet still, for many historians GIS is unknown or used in a limited way. The development of GIS emphasizes that it can be a powerful tool of data processing and not only visualization. It is important to acknowledge the possibilities that HGIS brings in working with archival sources. Yet, the tool requires specific types of data that can be spatially identified. And the more detailed and accurate the source is, the better results HGIS provides. This leads to the main challenges in work with HGIS: data completeness and accuracy.

The difference between GIS and HGIS is the nature of the sources, hence the process of collecting, reviewing, and processing. While GIS was originally developed to deal with natural science issues, the HGIS is working within social science. The division between primary and secondary sources is of high importance. Natural sciences usually use raw data and deal mostly with primary sources. In History, secondary sources are more common, especially in archival cartography. They require a special approach and analysis of their content and the context of creation. This paper gave examples of how misleading archival maps can be, not only by their lower accuracy but also by the generalization or intentional editions by their authors. In those cases, the History is helpful with its methodology (critical source analysis, crosschecking, etc.). Even if the data is treated with the same tools in the software, the difference is in the data collection, review, and initial processing in GIS software.

Nevertheless, without the help of other sources, this tool is limited and helps mostly with quantitative analyzes/interpretation, which is far not enough to understand such a complex phenomenon as city development. Yet the information that GIS and statistics bring is significant. It helps to visualize and measure the timespan and the character of the changes. The table 1 sums up the main characteristics and challenges of HGIS.

The presented research project outlines this approach in practice. Working with archival sources requires high attention to the review attention to the review process. Due to the limited historical sources and their different quality, it was necessary to recall multiple types of cartographic documentation: cadaster, maps, planning documents, ortophotomaps, satellite imagines. The maps can be considered as primary historical sources, yet at the same time, they are a compilation of the information. They differ in the chosen set of data, the ge-

neralization level, and even a map projection can bring challenges in work with them. While each type of source has different attributes, using them required standardization. The important is the role of the researcher, which must decide how to interpret received data, for example, identify different the same objects on different maps. The archival cartographic sources consist often of mistakes, sometimes intentionally used by the authors. That is why in building a database the high importance is given to cross-checking the information – between cartographic documents but also with other sources (pictography, written, etc.).

Table 1 The characteristics and challenges of HGIS

The features	The characteristic	The challenges
The sources	Cartographic documents, Statistical information, Raster and vector graphic.	Data completeness, Data accuracy, Data details.
The functions	Digitalize analog data, Work on vector/raster data, Combine / join / merge data, Transform and create new data, Share the information.	Need for standardization of different sources, Concentration on the quantitative sources and methods, Interdisciplinary requires know-how from Geography and History.
The outcome	Reconstruction of the former stages, Estimate and fill up the blank spots, Spatial analyzes and meta-analyzes, Tempo-spatial models, Visualization.	Limited application in qualitative analyzes, Potential information overload Potential limitation just to visualization without analysis.

The prepared database can be used for analyzes. The features of GIS software allow conducting multiple and comprehensive statistical analyzes. Yet the visualized data can also show additional information without the need for statistical measurements, like the concentration of the objects in some areas. The spatial dispersion of the studied phenomena is well visible on the maps and can

quickly point the researcher to a specific interpretation. On the other hand, like in all statistical analyzes, there is a possibility of detecting a false correlation, when independent phenomena accidentally show spatial or statistical correlation. Therefore, to overcome the limitation of quantitative sources, HGIS should be used as one of the analytical tools, creating a context for other analyzes.