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GEOINFORMATION ANALYSIS OF HISTORICAL MAPS OVER POLOTSK REGION

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The article presents the results of application of geoinformation technologies for analysis of historical and modern maps over the territory of Polotsk, Novopolotsk and surrounding area to study dynamics of socio-topographic factors from 18th century up to now.

Introduction. Historical maps are an important and quite objective source of information about the area, the living conditions of people of a certain historical period. Analysis of series of historical maps let us evaluate the historical aspects of the dynamics of the natural and built environment, land use planning, land development and their consequences, look into the past of modern settlements, assess the pace of their development.

A number of historical cartographic data over the territory of Polotsk including surrounding area are known. Among them are two plans of Polotsk from 1579, plan of Polotsk from 1707, plan-reconstruction of the 16-17th centuries, plan of 1779, recovery plan of the city of 1778, two plans of the 18th century, a number of plans and maps of the 19 – 20th centuries, as well as the frescoes in the Vilna church of St. Francis and Bernardine depicting Polotsk in the middle of the 16th century. The study of these data is done by a number of scientists [1-3].

Over the last twenty years along with other methods of historical analysis geographic information systems (GIS) have been applied to conjugate analysis of multitemporal spatial data. Despite the undeniable advantages of GIS applications for the analysis of spatial data, the use of GIS in historiography is still quite limited.

Methods. In current work GIS is used for analysis of the historical and modern maps from 1790 up to now to study the historical and topographical conditions of the territory of Polotsk region (appr. 20 x 25 km^2) including Polotsk, Novopolotsk and the surrounding area. Maps of 1790, 1861, 1939 and 1989 are downloaded from Internet [4-6]. The scale range of the maps of the 18 – 20th centuries is 1: 84 000 – 1: 200 000. Data from OpenStreetMap [7], public land information map of the Republic of Belarus [8], public cadastral map of the Republic of Belarus [9] are used as sources of modern cartographic data. The list of settlements of Vitebsk province [10] issued by Vitebsk Regional Committee in 1906 is also used in order to obtain information about the population of settlements of study area.

Among the main components of the natural and built environment analyzed in current study are the territorial changes of settlements, population distribution. Changes of lakes, rivers, forest areas as well as road network are also analysed for mentioned years.

Current study involves the following steps:

– georegistration and transforming of data into WGS 84,

– digitizing of boundaries of settlements and other objects of interest and forming groups of thematic layers for each historical map (year) of study,

– joint analysis of multi layers, qualitative and quantitative data analysis.

Data analysis is performed using QGIS software – a free cross-platform GIS.

Georegistration and transformation is quite time-consuming and laborious process. In order to identify changes in objects between two dates presented by corresponding maps one needs to have maps in common projection and coordinate system. The base cartographic data to which all maps are bound is OpenStreetMap data in the WGS-84 coordinate system. If the original projection and coordinate system of a map are known, map has coordinate grid, than georegistration is as follows: the definition of projection and the parameters of the original map, determining of map in its theoretical coordinate system, than transforming of the original map into the coordinate system of the base map. However, for a number of historical maps it is quite difficult. Georegistration of the General land survey map of 1790 is the most trouble due to lack of information about the projection and coordinate system. Also significant changes of the territory have taken place for more than two hundred years. In this case it is necessary to perform transformation (binding) using ground control points (GCP). It is necessary to find such facilities on the old map, which have not changed their position up to now. It may be junctions, engineering objects etc. Using GIS software these objects are assigned coordinates. The maximum possible number of points are used for more accurate georegistration considering also unknown quality of scanning of the original paper copies of historical map. One must also consider specific features of mapping for a specified time period including systems of cartographic symbols, possible changes in the position of objects. In 1790 railroads did not exist. Some objects located on historical maps have not changed their position for a certain period of time. Definitely it is difficult to say by visual analysis of map whether the object has remained at the same place or not. For example, the road leading to Trosnitsa village located a few meters to

the north from current location. In some cases shift of an object may be probably within the accuracy of the map. For a more accurate transformation of maps one needs still to know the projections and coordinate system. Nearest neighbor method is used for resampling.

Digitizing of maps means the process of translating the original (analog) map into digital form. Digitizing is performed here during manual vectorization. Digitizing is carried out for 4 key dates represented by corresponding historical maps. Each map layer finally contains polygons of three categories: settlements, forest, hydrography. Linear layers are created for the road network (divided into types).

On historical maps the boundary of settlements are considered as city line or boundary of built-up area.

Results. In this paper the analysis of 4 main historical maps as well as contemporary historical maps over Polotsk region is conducted. The paper analyzes the historical and topographical conditions presented for main years: 1790, 1861, 1939, 1989 and 2015 by categories: settlements, forest, hydrography, the road network. As a result of work maps of the dynamics of the territory of Polotsk on 5 major time slices during the last 225 years is done.

Polotsk and Novopolotsk have been developed rapidly and expanded to the surrounding areas including rural settlements. Rapid growth of Polotsk was in the second half of the 19th century and the first half of the 20th century. This is due to the technological revolution, industrialization, the construction of railroads etc. With the growth of Polotsk rural settlements were included in the city limits (e.g. Боровая, Лазовка, Синицы, Пристеницы, Спас, Тогарщина, Селюнцы, Козьи Горки, Гозбузянщина, Присмироки, Борисовский etc).

On the territory of modern Novopolotsk (found in 1958) in 1905 the population was 1557 people and in 1938 it was 4060 people (villages Новый Бор, Хамлы, Подкастельцы, Василевцы, Плаксы etc). For comparison, the current population of Novopolotsk (in 2015) is 108,2 thousand people.

For 225 years analyzed in current study the names of some settlements of Polotsk region were lost. The reason is either complete disappearance of the resident population, or a change of name. Among the extinct settlements are Жабино, Вечгровы, Старонивье, Сеферовщина, Способы, Яськово, Анкудово, Рафиловка, Яциново, Середники. Some settlements were enlarged by annexing of nearest villages.

By the end of the 18th century settlements occupied only approximately 2.5% of the study area, but the number of settlements was much higher than now. The percentage of forest area was about 60%.

By the mid-19th century there were the first railroads. Production and trade prompted the city of Polotsk to rapid growth. Together with the industrialization there was a need in the fuel, which led to a reduction of more than a third of the areas occupied by forest by 1938. Settlements occupied approximately 5 % of study area. By 1989 settlements occupied already almost 14.5% of study area.

Discussion and conclusion. Geographic Information System is a powerful tool for analyzing historical topographical conditions using historical maps.

On the one hand historical maps let us study living condition of the past. On the other hand, multi-temporal analysis of historic and modern maps allows more detailed examination of the principles of mapping of a certain time period.

One should not forget that maps are not absolutely objective data. It should be noted that maps pass through the head and hands of a cartographer and therefore have a certain degree of subjectivity.

The results of using of GIS for analysis of historical maps over Polotsk region as well as quantitative assessing may help to expand the methodological basis of studying the historical topographical conditions of the territory of Polotsk and its surroundings. However, fairly wide range of scales of maps (the scale of historical maps of 1790 – 1989 is within 1: 84 000 - 1:200 000), the difference in survey methods, generalization, georegistration of maps, the mathematical basics of maps should be considered when using the results.

Work continues towards the formation of a historical GIS of Polotsk, refinement of the preliminary results, attracting additional maps and reference materials as well as satellite data.

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