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INTERNATIONAL EXPERIENCE OF USING GIS IN POPULATION CENSUS: EXPERIENCE FOR UKRAINE

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Abstract. *The work examines the international experience of using GIS technologies for population censuses. When applying this technology, three main stages are observed: preparatory (in which the database for the census is formed), the main stage – the actual census procedure itself, and the final stage (which includes the processes of data processing, data verification). The use of GIS tools and technologies and their integration with other technical solutions are gaining more and more popularity in Ukraine and can become a significant addition during the population census procedure, including according to international experience: conducting a population census via the Internet, as well as using handheld portable devices-smartphones for filling out census forms during the traditional round of households. The use of GIS technologies makes it possible to cover almost the entire population, regardless of transport accessibility of the respondent's area of residence, employment and other factors.*

Keywords: *population, population census, GIS technologies, geography.*

Introduction.

Geoinformation systems (GIS) are a type of information systems that are characterized by the presence of a set of elements and spatial relationships, which allows for the integration of GIS with other information resources involved in all stages of the population census, in particular with address databases.

The research data of the United Nations Statistics Division show that the use of GIS during the population census procedure and the collection of statistical information is becoming a widespread global practice. In particular, in the last round of population censuses, 71 countries out of 122 applied GIS technologies and tools. Ukraine has long been using GIS to collect statistical indicators in various spheres of public life. In order to effectively establish the use of GIS technologies during the procedure of the population census of Ukraine, it will be advisable to consider the foreign experience of their application.

Results and discussion.

GIS technologies and tools can be used and are effective at all stages of the census: during the preparation of the census, its implementation, and at the stage of dissemination and use of its results.

The full use of GIS in the census (especially at the stages of preparation and conducting the census) is impossible without the availability of complete and reliable



address databases localized in space. The first stage in the preparation for the population census is the creation and updating of address registers of residential buildings, which, as a rule, is initiated by the national statistical service. In some cases, it is directly responsible for its creation, maintenance and updating in the inter-censal period.

To use address databases in GIS, it is necessary to geocode each object from the address register, i.e., assign the corresponding geographic coordinates to it. After that, the data of the address database can be plotted on a map, combined with other spatial objects (contours of residential buildings, street and road network, etc.), used for automatic census zoning, and also used at the stage of the census during the round of households (in the presence of positioning systems).

Geographic coordinates for the objects of the address database can be obtained by direct localization of objects using positioning systems, as well as by using already existing geocoders that allow you to automatically determine the coordinates of objects based on their address descriptions, or from other sources. For example, in Germany or Austria the spatial coordinates of address base objects were mainly obtained as a result of cooperation with state cartographic services. The main source of information for the spatial localization of address database objects in Germany was address data with reference to geographic coordinates (GAB).

In Israel, fieldwork was conducted in 2012 to geocode buildings, which were later matched with data already existing in the registry. In the countries of Northern Europe, the Baltic countries and some countries of Central Europe (Czech Republic, Slovenia, Hungary, Austria), data on residential buildings tied to geographic coordinates were also used in the census process.

In Poland, Spain, Italy, Portugal the process of geocoding of buildings was carried out in the process of preparing for the 2010 round census and partly directly during its conduct. For example, in Italy residential buildings in municipalities with a population of more than 20.000 people (53% of the country's population) were geocoded six months before the critical moment of the census (as part of the "House Number Registration" project). This work was carried out in order to update the data of municipal registers: adding missing buildings, checking and establishing an unambiguous correspondence between the variables "building" and "address", dividing buildings into residential and non-residential, checking and assigning geographic coordinates to all residential buildings. In other Italian municipalities the process of geocoding residential buildings took place during the census [6].

The use of geoinformation systems at the stage of the population census is almost entirely connected with the use of global positioning systems, the main advantage of which is the accurate determination of the enumerator's location in real time.

During the 2010 Hong Kong census it was possible to send requests for a better time to conduct interviews, and a mapping program installed on the enumerator's tablet computer determined the optimal route to visit households, taking into account the requests received.

In Albania the enumerator sent information about the number of surveyed citizens and households to the census headquarters every day, where the received data were accumulated in the GIS database and promptly displayed on the map. This allows you



to monitor the conduct of the census, control the work of enumerators, redistribute the workload, promptly respond to failures, and monitor the coverage of the population by the census on a daily basis.

A good example of the use of GIS at the stage of the population census is the experience of Brazil, when the population survey is carried out with the help of smartphones, which were provided to all enumerators. In addition to filling out all census sheets electronically, the map application in the smartphone allowed the enumerator to navigate the area, geocode missed residential buildings in rural areas.

Turning to GIS at the final stage of dissemination and use of census results is associated with two main possibilities. The first is the provision of population census results in the form of arrays of statistical information related to sets of spatial data of different spatial coverage and detail. A similar principle, for example, is implemented by the US Bureau of Qualifications: the user has the opportunity to download a set of spatial data of the necessary detail (from the level of states to ZIP codes) and the corresponding array of statistical data. At the same time both spatial and statistical data contain a unique field that can be used to combine data for further analysis in a geoinformation environment.

It is obvious that the more detailed the level of spatial analysis, the more difficult it is to perform it in tabular form and the importance of geo-informational and cartographic methods of population study increases.

Another option for the distribution of census results is their presentation in cartographic form. It can be a traditional printed census atlas, a multimedia atlas demographic system, an interactive information system with advanced graphic and functional capabilities. When creating them the question arises about thematic content, spatial coverage and levels of detail.

A fairly new form of presentation of census results is the spatial microdata base. For example, in Ireland in order to study pendulum migration in 2002 the places of work (arrival points) of 15% of the population, selected at random, were geocoded. In 2006 and 2011 a similar operation was performed for 100% of the population. Taking into account the results of geocoding, a microdata file was created with geographical characteristics of places of work and residence, as well as socio-demographic characteristics of respondents.

Pendulum migration analysis is possible at the level of electoral and accounting precincts using any socio-demographic indicators that the researcher can obtain on the basis of the microdata base.

The Irish experience confirms that at the current stage to solve scientific and practical tasks population data are needed, presented not only for large administrative-territorial units, but also for small territorial locations.

However, census data are more often published within the framework of administrative-territorial units, different indicators may be published for different types of territorial units. Changing the boundaries and status of any territorial units significantly limits the possibility of accurate analysis of the changes that have occurred.

Thus, in Great Britain between the censuses of 1981-1991 the boundaries of only 32% of the census divisions remained unchanged, they were the units of the lowest



territorial level for the publication of census data. Therefore, the analysis of changes at this territorial level was very problematic, which led to a change in the approach to the formation of census data publication units until 2011. In the United States there is a TIGER system that provides access to census data submitted for different units, political or statistical, on the scale of census blocks.

The latter are the smallest territorial units for which information is collected, but during the period 1990-2000 more than 50% of census tracts changed their configuration.

Since the geography of socio-demographic phenomena is more complex than its reflection within the framework of administrative boundaries, one cannot but say about the growing tendency to present the results of the population census on the basis of a regular grid with a given spatial resolution. Presentation of data in the form of a regular grid, obtained on the basis of primary census data, allows to analyze the geography of phenomena regardless of the area and configuration of objects of administrative-territorial division (ATD), from changes in ATD over time; enables analysis at any scale, limited only by data privacy considerations.

The use of GIS tools and technologies and their integration with other technical solutions are gaining more and more popularity in Ukraine and can become a significant addition during the population census procedure, including according to international experience: conducting a population census via the Internet, as well as using handheld portable devices-smartphones for filling out census forms during the traditional round of households [3].

However, it would be fair to note that Ukraine has long been using GIS to collect statistical indicators in various spheres of public life. In order to effectively establish the use of GIS technologies during the procedure of the population census of Ukraine in the future, it is worth carrying out a number of procedures at the preparatory stage of the census.

At the preparatory stage of the population census it will be necessary to prepare schematic plans for the territory of urban and rural settlements, inner-city districts and districts, as well as schematic maps of territorial communities. Most of the maps are made on the basis of already available “on-the-ground” cartographic materials, popular cartographic web services, which complicates their comparison and further use. The mapping materials are updated in the process of visiting the territories by comparing the maps with the real terrain, after which changes are made manually.

At the same time, the process of updating the address database of residents of settlements will be important at the preparatory stage, which in the post-war period will become an acute problem for statistical services [3].

As a result of the preparatory stage, two separate products should be created: an updated paper cartographic material and a list of current addresses of buildings (address database). The absence of such a system at the preparatory stage significantly complicates and increases the costs of updating materials in the inter-census period and prevents the use of GIS capabilities directly during the census itself.

An important aspect of conducting population censuses using GIS technologies and tools is the responsibility of all participants in the population census procedure, as well as their compliance with the basic norms of the Law of Ukraine “On the All-



Ukrainian Population Census” [4] and the Law of Ukraine “On Amendments to Certain Laws of Ukraine Regarding State Statistical activities” [5], which guarantee the non-disclosure of individual data and also provide for liability for illegal actions regarding the illegal use of private statistical information.

An important aspect of conducting a census using these technologies is the availability of good quality navigation devices and uninterrupted Internet coverage. In the period before the start of the war in Ukraine in 2022 our country had the best network coverage among all European countries. As for the issue of navigation devices, it was planned to be resolved for the population census procedure, which was planned for 2022 by purchasing the corresponding devices from the Apple company, on which the relevant agreement was signed by the President of Ukraine. However, these and other technical issues will be resolved after the end of the war.

Conclusions.

The conducted research gives reason to conclude that the use of GIS technologies during the population census procedure will have significant advantages for our country, as it makes it possible to cover almost the entire population, despite the transport accessibility of the respondent’s area of residence, employment and other factors.

Complex use of geoinformation technologies, including the creation of an address spatial database, the use of positioning systems and smart devices, the development of cartographic web services can both improve the quality of the census procedure itself and significantly expand the possibilities of analyzing the data collected during the census. International experience clearly demonstrates the advantages of using GIS at various stages of the population census. At the same time, one cannot fail to note the laboriousness of the application of geoinformation systems, which affects organizational, human and financial resources. In order to identify the problems of conducting a census with the use of GIS, it is necessary to conduct a micro-census of the population for a small area beforehand.

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Анотація. В роботі розглядається міжнародний досвід використання ГІС-технологій для проведення переписів населення. При застосуванні даної технології дотримуються трьох основних етапів: підготовчого (на якому формується база даних для перепису), основного – власне сама процедура перепису та заключного (який включає процеси опрацювання даних, перевірку даних). Використання інструментів та технологій ГІС та їх інтеграція з іншими технічними рішеннями набувають дедалі більшої популярності в Україні і можуть стати суттєвим доповненням під час процедури переписів населення, у тому числі відповідно до міжнародного досвіду: проведення перепису населення через Інтернет, а також з використанням кишенькових портативних пристроїв-смартфонів для заповнення переписних листів у ході традиційного обходу домогосподарств. Застосування ГІС-технологій дає можливість охопити практично все населення, незважаючи на транспортну доступність території проживання респондента, зайнятість та інші фактори.

Ключові слова: населення, перепис населення, ГІС-технології, географія.

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