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Integration of geospatial and statistical data

Use of Geographic Information Systems Technologies as a Strategic Concept for the Development of Belarusian Statistics

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Summary

The use of Geographic Information Systems (GIS) technologies is a promising direction of development of modern statistics. It is a powerful tool for improving the accuracy, efficiency and simplicity of perception of official statistical information, as well as its accessibility for a wide range of users.

Integration of geo-information technologies into statistical processes allows for carrying out in-depth analysis of data, visualizing spatial patterns and trends, and informed decision-making.

Belstat actively uses GIS technologies in statistical activities: for census zoning, calculation of Sustainable Development Goals (SDG) indicators, implementation of geo-information modules in the statistical business register, dissemination of official statistical information.

Through the use of such technologies the statistical capacity of Belarus is strengthened: the system of statistical indicators available for visualization is expanded; the methodology of calculation of SDG indicators with geospatial reference is improved; cooperation is developed to improve the management and use of geospatial information in different sectors of national economy.

I. Introduction

1. The integration of geospatial and statistical data is becoming increasingly crucial as the demand for understanding various social phenomena and processes in their spatial context grows. Over the past several years, the National Statistical Committee of the Republic of Belarus (Belstat) has actively implemented the use of spatial data in statistical practice.

2. In line with modern technologies, classifications, and technological needs for censuses and surveys, Belstat has carried out work on creating spatial identification of objects based on georeferencing (coordinates x, y) technologies and geographic information systems (GIS). This work has demonstrated the significance of statistical agencies in integrating geospatial and statistical data.

II. Geographic information system “Population Census”

3. In 2010, the geographical information system “Population Census” (hereinafter, GIS “Population Census”) was created to disseminate the results of the 2009 Population Census of the Republic of Belarus.

4. The objectives of creating the GIS “Population Census” were:

- To develop a spatial-attribute data base of the GIS “Population Census” in the format of the ArcGIS GIS geodata base
- To establish an informational link between the results of the 2009 Population Census of the Republic of Belarus and the corresponding geographic objects of the base map
- To automate spatial analysis and prepare thematic cartographic and graphic (using business graphics) representations of the census results using standard ArcGIS tools
- To provide users with information in cartographic and graphic form, including digital form, suitable for distribution over the Internet.

5. The development of the GIS “Population Census” was continued by Belstat in preparation for the 2020 round of the Population Census of the Republic of Belarus.

6. In 2016, Belstat developed a technology for automated generation of a plan of registry, census and enumeration areas based on data from administrative sources – the population register and the address register.

7. The cartographic material was created using the GIS “Population Census” and represented an electronic map showing the boundaries of registry, census and enumeration areas, as well as houses located within the boundaries of these plots.

8. Registry areas were formed for each city, urban-type settlements, and large rural settlements (with a population of 3,000 people or more), census areas were formed for all settlements, and enumeration areas were formed taking into account the population density in settlements.

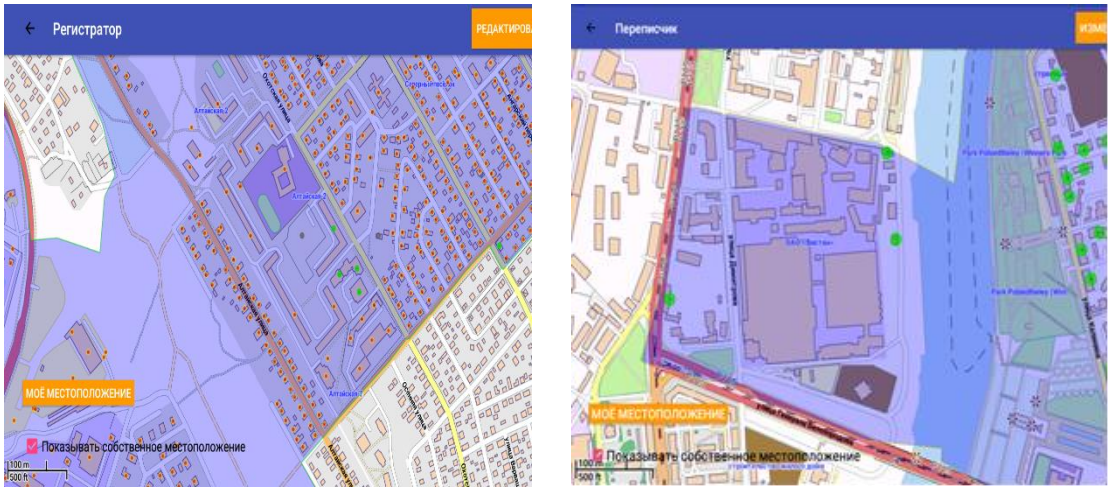
9. The division of the territory of Belarus was carried out taking into account the average workload standards for temporary census personnel: 700 houses for a registrar, 14,500 people for the head of a census area and his assistant, and 750 people for an enumerator.

10. When forming registry areas, the housing patterns and the location of residential blocks and residential areas were taken into account. Census areas were formed while preserving the integrity of the administrative-territorial division, and enumeration areas were formed taking into account the population density in settlements.

11. Individual cartographic materials were generated for each registrar, census supervisor and enumerator, which were automatically loaded onto the tablet at the first start of the special software. The district map displayed the district boundaries, address points of buildings within the district, the street and road network, and natural barriers (green areas, water bodies, and others).

12. The cartographic material defined the work areas of temporary census personnel and helped them navigate in unfamiliar terrain.

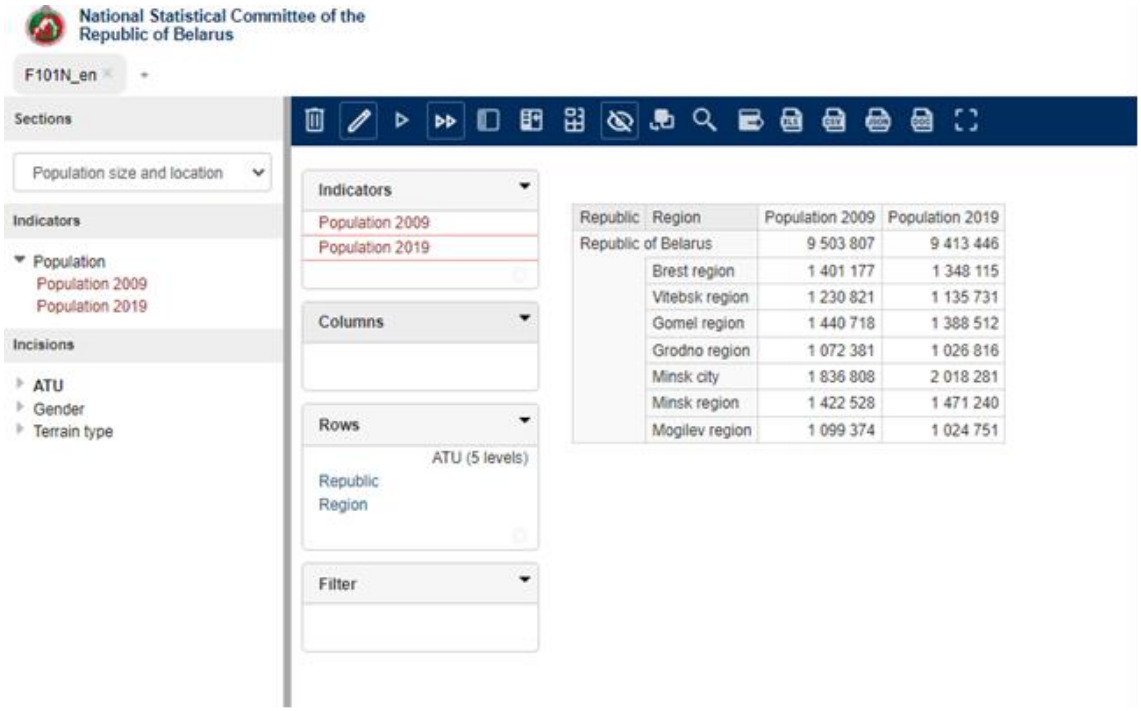
Figure 1
Maps of Registry and Enumeration Areas



13. The GIS "Population Census" was further employed for disseminating of the final data in the information and analytical system "Population Censuses Data of the Republic of Belarus" (IAS PC).

14. IAS PC became available to users in late October 2021. It comprises the results of the 2009 and 2019 censuses on population size, age structure and marital status, fertility, educational attainment, ethnic composition, mother tongue and language spoken at home, economic characteristics of the population, migration and temporarily resident persons, household composition, and amenities. This service also features data visualization tools such as graphs, charts and cartograms.

Figure 2
Interface of IAS PC



15. The obtained visualization results can be exported in machine-readable formats, which allows users to work with the information in other systems or databases. IAS PC is available at https://census.belstat.gov.by/.

III. Information and analytical system “Geostatistics”

16. The scope of application of the GIS “Population Census” is no longer limited to the population census.

17. Recently, there has been a growing interest in using geographic information systems as a convenient visual tool for presenting statistical results.

18. The ArcGIS software products used in the GIS “Population Census” make it possible to link any statistical data to a cartographic base and display the distribution of the indicator across the country, region, administrative district and settlement.

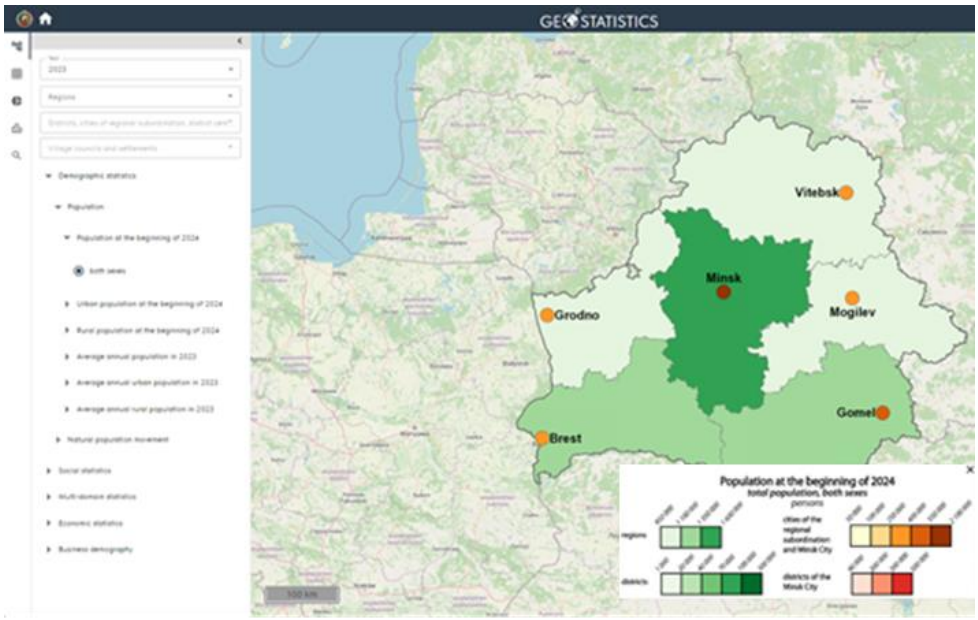
19. The information and analytical system “Geostatistics” (IAS “Geostatistics”) was created on the basis of ArcGIS and became available to users in December 2023.

20. The system is an interactive graphical visualization of all official statistics, since in addition to the data of the 2019 population census, it is also uploaded with information on various statistical domains, including business demography.

21. The system allows for compiling tables based on individual requests, building graphs, charts and cartograms and exporting them in a convenient format. Users have the opportunity to receive information about the country’s area of interest, taking into account its socio-economic and demographic characteristics.

22. The system is available worldwide, including from mobile devices, in Belarusian, Russian and English. IAS “Geostatistics” is constantly being updated with new data. The system is available at https://gis.belstat.gov.by/.

Figure 3
Interface of IAS “Geostatistics”



23. The existing address layer makes it possible to use cartographic material for the preparation and conducting of sample surveys.

IV. Geographic information systems for Sustainable Development Goals

24. The use of space technologies and geographic information systems is being considered as an innovative means of data collection for assessing progress towards achieving sustainable development at the global level. To implement these technologies in Belarus, a special working group was created at the initiative of Belstat with the support of the National Coordinator for the Sustainable Development Goals (SDGs).

25. In the course of work of this working group, partnerships were established between Belstat and the State Committee on Property of the Republic of Belarus, which owns space and GIS technologies, as well as with the Unitary Enterprise "Geoinformation Systems" of the National Academy of Sciences of Belarus, responsible for the national space system of remote sensing of the Earth. In addition, cooperation was established with several line ministries and organizations to adapt the international methodology for the compilation of SDG indicators using GIS in the context of national conditions.

26. Taking into account the existing potential, at present, calculations are carried out using GIS technologies for 10 indicators of the national SDG indicator list.

27. For the calculation of indicator 6.6.1 "Change in the extent of water-related ecosystems over time", experts from the State Committee on Property use data from the Land Information System of the Republic of Belarus (LIS). LIS is a complex of software and technical tools that automates the accumulation, processing, storage and presentation of information on the state, distribution, and use of the country's land resources in electronic form.

28. The area of land under swamps and water bodies represents the arithmetic mean value over a five-year period. The moving average method is used to smooth out seasonal and climatic fluctuations in the extent of water-related ecosystems.

29. For the calculation of indicator 9.1.1 "Proportion of rural population living within 2 km of an all-season road", specialists in geographic information systems from an organization subordinate to the Ministry of Transport and Communications of the Republic of Belarus use specialized QGIS software.

30. This indicator is produced using data from the "GIS of the Road Cadastre", as well as based on data on:

- Length of public motor roads
- Population in rural settlements
- Boundaries of settlements
- Number, name and category of settlements.

31. The road network for this indicator is formed using the geodetic basis and is updated on the basis of high-resolution satellite imagery. The boundaries of settlements are updated from open cartographic sources and resources: "Public Cadastral Map of the Republic of Belarus", "Public Land Information Map of Belarus", "Yandex", "Google", "OpenStreetMap" and others.

32. To calculate the indicator, a 2-kilometer buffer zone of public roads is formed in the GIS. Using spatial analysis tools, settlements that do not fall within the buffer zone are selected. Based on data on the population living in rural settlements, the proportion of the rural population living within 2 km of an all-year road is determined.

33. Indicators 15.1.1 "Forest area as a percentage of total land area" and 15.2.1.1 "Forest cover" are calculated by specialists of the Ministry of Forestry of the Republic of Belarus on the basis of:

- Forest management materials (including aerial and/or space imagery of the forest management object)

- Information obtained as a result of various types of surveys of forest fund plots (soil surveys, forest pathology surveys, field surveys of changes that have occurred in the forest fund as a result of forest damage by fires, pests and diseases).

34. Processing of data obtained from aerospace imagery and expeditionary field surveys of forests is carried out using specialized software complexes (used for creating orthophotoplans, using stereoimages) and geographic information systems (GIS “FORMOD” is used for preparing and processing cartographic information).

35. To determine the area of land covered by forest, processed cartographic and attribute data are linked in a single information database of forest resources of the Republic of Belarus.

36. In addition to the above mentioned indicators, space technologies and GIS are also used to calculate the following indicators:

6.5.2 Proportion of the area of transboundary water basins covered by transboundary cooperation mechanisms. The indicator is produced using GIS shp-files that contain spatial information about the catchment area of the basins of the main rivers (Dnieper, Pripyat, Western Dvina, Western Bug, Neman) within the country;

9.c.1 Proportion of the population covered by mobile networks, disaggregated by technology. The indicator is produced using cartographic materials of republican unitary enterprise Belgeodezia that contain information about the boundaries of the settlements of the country and the population of each of them;

11.3.1 Ratio of land consumption rate to population growth rate. To obtain data on the area of land under development, the LIS is used (with the exception of data for the city of Minsk). In the process of creating and maintaining (operating, updating) the LIS, data of current high-resolution aerial photography with subsequent processing (cameral interpretation and digitization), cartographic and other materials are used;

11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities. To obtain data on the area of administrative-territorial units, the distribution of land by type (public use land), LIS is used (with the exception of data for the city of Minsk). In the process of creating and maintaining (operating, updating) the LIS, data of current high-resolution aerial photography with subsequent processing (camera interpretation and digitization), cartographic and other materials are used;

15.3.1 Proportion of land that is degraded over total land area. The estimates are produced on the basis of data from global and/or national sources obtained using remote sensing of the Earth and geographic information systems.

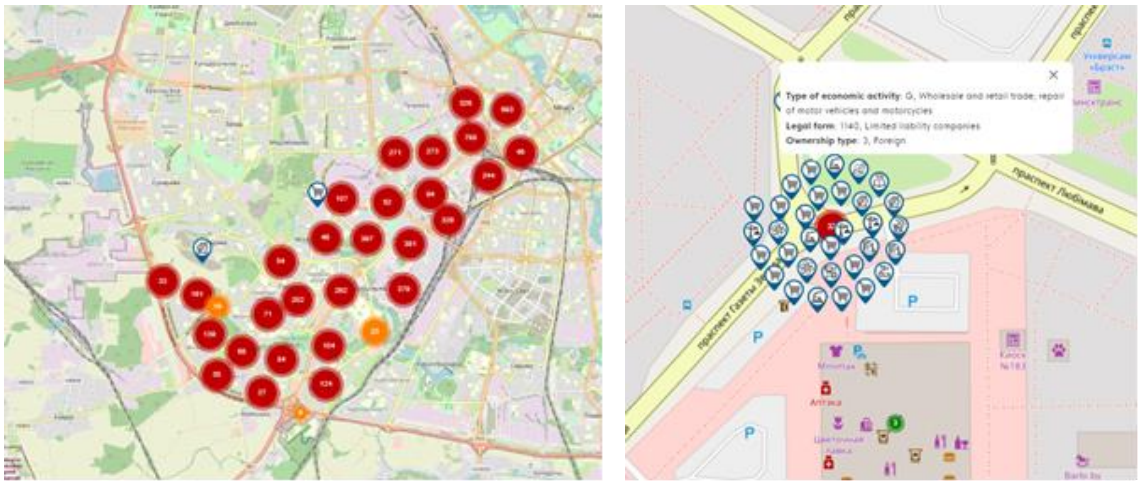
37. In 2024, Belstat specialists carried out an experimental calculation and visualization of SDG indicator 11.2.1 “Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities” using ArcGIS.

Figure 4
Cartographic representation of indicator 11.2.1 for Minsk City

V. Geographic information systems for business statistics

38. In 2023, Belstat carried out work to determine the geographic coordinates for all objects of the statistical business register (SBR). The possibility of adding X, Y coordinates of SBR objects to the output information was implemented, which allows for geospatial visualization of SBR objects in geographic information systems (ArcGIS, QGIS), using various statistical indicators as attributes.

Figure 5
Enterprises by economic activity in the IAS "Geostatistics"



39. A separate section for business statistics indicators is provided in the IAS "Geostatistics". The basis for the cartographic representation is the digitized statistical register, in which geographic coordinates have been implemented for each economic entity and a resource of unique addresses has been created.

VI. National Spatial Data Infrastructure

40. Engagement of Belarus as a member country of the Committee of Experts on Global Geospatial Information Management (UN-GGIM) has contributed to improving the management of geospatial information and its use in various sectors of the national economy.

41. Thus, in January 2024, the National Spatial Data Infrastructure (NSDI) was created in the country. The mandate to organize the creation, functioning and development of NSDI, as well as to analyse its functioning, are vested in the State Committee on Property of the Republic of Belarus.

42. The National Spatial Data Infrastructure is an interconnected set of organizational structures, technical and software tools, sets of basic spatial data and sets of thematic spatial data, metadata, services, agreements on access, exchange and use of such sets of spatial data, that ensures, through information and communication technologies, access for suppliers and users to distributed information resources of the Republic of Belarus that contain sets of spatial data, as well as dissemination and sharing of sets of spatial data on the Internet.

43. Currently, the development of information resources containing spatial data is carried out by various structures, mainly on a departmental basis. The task of NSDI is to unite line resources in one hub on the National Geoportal. This will provide users with the opportunity to quickly search for the necessary information on the basis of the “one-stop shop” principle, reducing the time costs for its collection, processing and updating.

44. The typical components of the NSDI include:

- sets of basic spatial data
- sets of thematic spatial data
- National Geoportal
- services for sets of spatial data
- metadata about sets of spatial data and services for these sets.

45. The National Geoportal is a state information system that acts as a common access point to the NSDI services, the interface of which provides users with access to information via the Internet to search for sets of spatial data and services for these sets based on their metadata, as well as implements other functions in accordance with the purpose of this information system and its target audience.

46. The National Geoportal contains:

- metadata about sets of spatial data included in the NSDI and services for these sets
- sets of basic spatial data and sets of thematic spatial data included in the NSDI, as specified in the list of mandatory sets of spatial data, their suppliers, the composition of information included in such sets, update schedules
- sets of basic spatial data and sets of thematic spatial data included in the NSDI upon application for inclusion in the NSDI of a set of spatial data in the prescribed form
- services for sets of spatial data included in the NSDI
- other information related to the functioning of the NSDI.

47. The main goal of creating the NSDI and the National Geoportal is to create conditions for sustainable economic development, environmental protection, ensuring security, preventing and eliminating the consequences of emergencies and other spheres of activity.

48. The principles and standards of the United Nations Integrated Geospatial Information Framework (UN-IGIF) have been fully adapted and implemented in the NSDI of Belarus:

- data and metadata standards
- interoperability
- regulatory principles

- data quality standards
- accessibility and openness
- training and development.

49. These principles and standards help to ensure efficient management and use of geospatial information within the NSDI in Belarus.

VII. Conclusions and recommendations

50. Thus, the success of GIS as a separate domain is based on the powerful potential of geospatial information for improving the dissemination of official statistical information and decision-taking. The use of geospatial technologies is an integral part of the changing technologies and methods of the census, primarily for the compilation of detailed geographical data in a sufficiently detailed scale, as well as for obtaining higher quality results and analyses.

51. The GIS "Population Census" of the Republic of Belarus is a significant tool used to collect, analyse and visualize census data. Created in 2010, this system has a number of specific objectives, including the formation of a database, the interlinking of census results with geographical objects, and the automation of analysis and preparation of cartographic representations. Belstat continues to develop the system, integrating it into the preparation for the forthcoming census. The GIS "Population Census" improves the data collection process and ensures a more accurate and reliable population census, which is an important element in planning.

52. The IAS "Geostatistics", based on the GIS "Population Census" and ArcGIS software products, is an important tool for visualizing and analysing statistical data. The system, available since December 2023, combines information on various statistical domains, including the 2019 census results and information on business demography.

53. The integration of GIS technologies into the process of evaluating and monitoring SDGs in Belarus allows for a more accurate and comprehensive analysis of progress towards SDGs, which contributes to more effective management and informed strategic decision-making.

54. As part of the improvement of the dissemination of official statistical information, Belstat continues to work on expanding the list of SDG indicators to be calculated and visualized using GIS, and also plans to modernize the IAS "Geostatistics".

55. The creation of the National Spatial Data Infrastructure in Belarus in January 2024 is a significant step towards improving the management of geospatial information and its use in various sectors of the national economy. The membership of Belarus in UN-GGIM contributes to the successful functioning of the NSDI.

56. The adaptation and implementation of the principles and standards of UN-IGIF in the NSDI of Belarus ensure effective management and use of geospatial information within the system.

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