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CONCEPT OF AN INTEGRATION OF OPEN DATA FOR SOCIO-ECONOMIC MAPPING IN UZBEKISTAN

ABSTRACT

The purpose of the study is the development of a method for integrating non-spatial and geospatial data from different sources for the online dynamic mapping of Uzbekistan at different spatial scales. From the perspective of using open resources in socio-economic cartography, the challenges and perspectives of using online open non-spatial statistical data through the government portal of the Republic of Uzbekistan are considered for web mapping. The method is suggested for building a web-based spatial visualization tool and getting geographic information. In the case when open geospatial data is not available, it is suggested to integrate non-spatial statistical data of open sources into the environment of web mapping. For using new opportunities and tools of geospatial technologies a methodology of using open resources including open datasets, open source software and cloud computing are widely used on all stages of map development. It has been confirmed that this approach represents one of the valuable opportunities for geospatial modelling in developing countries. The benefits of integrating government open non-spatial statistics have been verified through an interactive mapping population at the national, regional, district, and city levels to be effective in addressing policy and governance issues for decision-makers and practitioners.

KEYWORDS: open resources, non-spatial data, geospatial information, social-economic cartography, Uzbekistan

INTRODUCTION

As the new geospatial technologies are developing, the searching, analyzing and merging large amounts of data becomes crucial task for decision-makers, researchers and broad audience of ordinary users. Today, dealing with products of the geospatial industry including virtual maps, various imagery is a common practice for pathfinding, choosing directions, risk management and other activities. In its report United Nations Committee of Experts on Global Geospatial Information Management (UNGGIM) predicts the “important role the geospatial industry plays in providing data-driven analysis to support decision-making” [*Walter,* 2020, p. 7] in the nearest future.

Modern geospatial data becomes the necessary resource both for research and for decision-making. The volume and the complexity of this data create great opportunity for use in social and economic cartography. Today, the spatial dimension of statistical data becomes the valuable source of research and plays important role in better understanding and modelling the current state and predicting further development. The high demand for geospatially enabled statistics is the reason for the development of the Global Statistical Geospatial Framework (GSGF) by UNGGIM in August 2019. According to its mission, the “GSGF enables a range of data to be integrated from both statistical and geospatial communities and, through the application of its five Principles and supporting key elements, permits the production of harmonized and standardized geospatially enabled statistical data” [*Walter*, 2020, p. 33]. It is the evidence of the growing demand for geospatial information retrieved from online non-spatial statisti-

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cal data. This also addresses the "moving of the Spatial Data Infrastructures towards Spatial Knowledge Infrastructures" [*Walter*, 2020, p. 59].

Researches [*Arnold* et al, 2021; *Chen*, 2000; *Dangermond, Goodchild*, 2020*; Duckham* et al, 2017; *Golubev* et al, 2016; *Hermes, Poulsen*, 2012] stress the importance and value of geospatial information for generating geospatial knowledge as new achievements in geospatial technologies, and they pay more attention to the techniques and methods of geospatial data generation. For this purpose, a source of geospatial data is considered in a case when "this data includes location tag" [*Golubev* et al., 2016, p. 218].

Advanced approaches such as synthetic data generation consider the geospatial information for achieving this goal when dealing with already existing census data. But there is an opinion [*Hermes, Poulsen,* 2012, p. 291], that "many potential applications for synthetic spatial microdata remain to be developed". [*Golubev* et al, 2016, p. 217] suggests open source tools for generating and pre-processing geospatial data, and also points to "the lack of initial geospatial data (such as origin/destination points) that thwarts the progress of artificial intelligence approaches and their implementation in built-in libraries and components". Chen Yan [*Chen,* 2000] notes the sources of the spatial database are the topographic maps.

Open data and tools for mapping through "combining free and open software, open data, as well as open standards" [*Mobasheri* et al.*,* 2020, p. 1] presents new reality in cartography and geography. It is notable that open geospatial data and tools are considered an "increasingly important paradigm to promote many social and economic opportunities" [*Mobasheri* et al.*,* 2020, p. 2]. But other open sources like non-spatial statistical data is beyond of consideration. By combining all possible options for spatial knowledge generation, it is possible to expand the usage of open non-spatial statistical data as well.

By definition, socioeconomic mapping is a process of compiling "a map that shows social phenomena" comprising different issues of economy and society. An accurate and timely statistical data is a core element for mapping of social and economic events and processes. Using open non-spatial statistical data helps compiling interactive maps on any items according to data at the Open data portal of the Republic of Uzbekistan.

Social and economic cartography is one of the branches of cartography which faces challenges in a rapidly developing technological environment [*Shupeng,* 1994; *Tsou*, 2015]. In addition to the traditional data, [*Fatehkia* et al, 2020] shows the ways for using the anonymous, publicly accessible advertising data from Facebook in mapping socioeconomic development in low- and middle-income countries.

However, the spatial value of an open non-spatial statistical data, its value and characteristics are not well examined from the perspective of using for social and economic mapping. Meanwhile, using all opportunities of open non-spatial statistical data for web mapping creates additional opportunities for retrieving geospatial information. In developing economies with limited access to free official geospatial data the challenges for online mapping are greater. They are greater when geospatial and statistical data is not integrated.

This paper consists of 4 sections, each of them contributes to the main idea of open data integration for population mapping in Uzbekistan. The first section describes the materials and methods used for online dynamic mapping. They are used for retrieving geospatial information from open non-spatial statistical data at several spatial scales. For this purpose, methods of using open datasets, open source software and cloud computing were implemented for spatial and non-spatial data integration. The results of testing some options to check the reliability of methodology with the consideration of the technical conditions in Uzbekistan are presented in the Section 3. The dynamic maps of population at the national, regional and local levels were developed using the open government statistical data and ArcGIS Online tools. In the Section 4 it was argued that the development of new approaches to retrieve geospatial information from non-spatial data is based on the experience of using open sources like OpenStreetMap datasets and ArcGIS Online services [*Dangermond, Goodchild,* 2020] on building geospatial infrastructure and theories to form spatial-temporal database [*Frank,* 2007]. This approach helps in more efficient usage of the Open Government Data and contributes to the idea of development of the

Global Statistical Geospatial Framework (GSGF) being an essential part of the movement to generating geospatial knowledge. An interactive capturing, processing and analysis of Government open non-spatial statistical data by means of Web mapping is a plus for mapping changes over time and comparison of data from different time sections.

MATERIALS AND METHODS

This paper discusses the issues related to the options of using open non-spatial statistical data through the government portal for mapping the social and economic events and processes.

For using new opportunities and geospatial technologies tools a methodology is suggested for an integration the geospatial data of open sources into the environment of web mapping by means of developing a tool for retrieving the geospatial information. For this purpose, the open resources were used including open datasets, open source software and cloud computing. The government administrative open non-spatial statistical data was not linked to each other. This distribution over different organizations causes in efficiency in the use of the data. Meanwhile, this data has peculiar property of uniform availability and standardized rules for their development and updating. This statistical data may be considered as part of Big Data with its three major characteristics: large volume, large variety, and high velocity [*White*, 2012] and may be used to develop new products such as geospatial information.

For developing the methodology for integration of governmental non-spatial open statistical data into Web GIS environment it is necessary to:

1. Identify advantages of using open data and open source software.

2. Determine how to use it with the consideration of technical conditions of Information and Communication Technologies (ICT) development in Uzbekistan.

Several online maps are developed for testing this methodology and to capture and communicate geospatial information. With the consideration of current trends in the development of the geospatial technology, the main goal of this study is to retrieve geographical information from open non-spatial statistical data through interactive dynamic mapping.

Based on definition that “Web mapping is the process of designing, implementing, generating, and delivering maps on the World Wide Web” [*Neuman*, 2012, p. 237] it is assumed that the best advantage of this process is the Internet interactivity. Web mapping is similar to the process of all activities related to traditional mapping and, moreover, it includes delivering maps on the World Wide Web.

The theoretical statement about the nature of “spatial data as any type of data that directly or indirectly references to geographical area or location” is fundamental in dealing with non-spatial data as well. This is complemented by a hypothesis that combining open resources like spatial data datasets, online services and cloud computing tools ensures the achievement of the online mapping goals. Traditional social and economic mapping procedures are enriched by new options of Cloud-based software ArcGIS Online to create and share interactive web maps. This web-based mapping software gives an opportunity to interact with data.

This paper discusses the issues related to the options of using open non-spatial statistical data through the government portal of the Republic of Uzbekistan. The purpose is to find out the ways of the development of the method for integrating data in machine readable forms from different sources for the social and economic events and processes online mapping.

Several goals are envisaged to get sufficient results:

1) examine the opportunities of using non-spatial statistical data for mapping on the different administrative levels;

2) evaluate the non-spatial statistical official data from the perspective of using it instead of the address system data;

3) build a framework for geospatial and statistical integration;

4) transform non-spatial statistical data into geoinformation by means of online dynamic mapping and visualization tools;

5) develop the ways for regular updating the geoinformation derived from the non-spatial official statistical data;

6) provide the platform to facilitate statistical and geospatial integration.

The method is suggested for building a web-based spatial visualization tool and getting geographic information "as composed of fundamental atomic tuples <x,z> where x is a location in space – time, and z is one or more properties of that location" [*Goodchild,* et al., 2007, p. 243].

The main source for mapping is Open Data of the State Agency on Statistics of the Republic of Uzbekistan as part of the Open data portal of the Republic of Uzbekistan. This source includes statistical data on various social, economic, and environmental issues. The advantage of using an open online statistical data is its assignment to administrative units. This indirect geographical information gives an opportunity to learn information about given location. This data is collected by regions and sub regions (districts) on an annual and quarterly basis and timely updated.

In the traditional way of map-making, collecting data, processing, grouping and analysis usually takes time. When using online statistical data these tasks are available in real time. These procedures become easier and faster within Web GIS environment after linking open data to the location data, and crowd-sourced geographic information from OpenStreetMap (OSM). It is accepted that "OSM is often the most complete and accurate source of base mapping" [*Dangermond, Goodchild,* 2020, p. 5].

The option of using open resources for Web mapping is examined from the perspective of the development of interactive dynamic social and economic maps. These maps visualize the spatial dimension of non-spatial statistical data. At the same time, they are a good source for generating the geospatial knowledge. Interactive dynamic mapping is the best way for the integration of open data and data from different sources. This approach may fill the gap in countries with limited access to geospatial data. Dynamic interactive mapping becomes a rapidly growing branch of web mapping [*Gulyamova*, 2018; *Rakhmonov, Gulyamova,* 2021] because of the possibility to support open data.

The following resources are considered key for mapping:

1) Open Street Map datasets as the geometry source on local, regional and national levels of mapping;

2) Environmental Systems Research Institute's (ESRI's) cloud-based mapping platform;

3) Government online open data as the non-spatial option for linking with location data.

The purpose is to create interactive web maps and test the methods of retrieving geospatial information from Government online non-spatial statistical open data. The overall scheme of Web socioeconomic mapping, including 5 phases is represented in the Fig. 1.

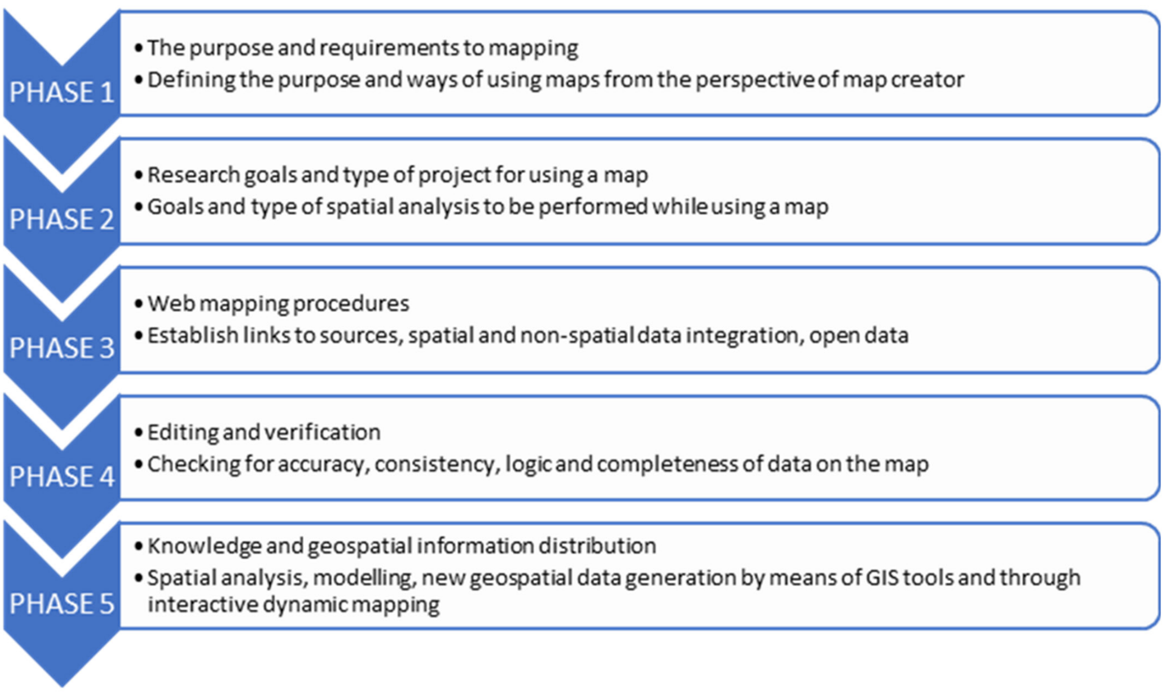

Fig. 1. The overall scheme of Web socioeconomic mapping consists of 5 phases.
Source: (Compiled by authors).

In the beginning, it is crucial to define the purposes and uses of the maps, as this determines the content and area to be covered on the map.

Phase 2 is the step to define the research goals and project type for using the map. E.g., if required: the high precision of measurements of distances and area size, goals and type of spatial analysis through overlaying, comparison, extracting features and other tasks.

Phase 3 is a web mapping procedure to provide links to sources, to perform spatial and non-spatial data integration using ArcGIS Online, Open Street Map (OSM), based on standard web services and protocols.

Phase 4 is for editing and verification, checking for accuracy, consistency, logic and completeness of data on the map.

Phase 5 is the final step for sharing geographic information and knowledge by means of interactive dynamic mapping. These maps may be used for performing spatial analysis online and new geospatial data generation. ArcGIS Online tools are good to do this.

This method is suitable both for development of analytical and complex maps on social and economic issues (Fig. 2).

Web mapping using Open sources includes several interrelated tasks. The geodatabase is the heart of the Web mapping. This is a large spatial database and it is hosted on cloud storage of ESRI using Cloud Technology. Open Street Map is a free editable geographic database, and its dataset is used for geometry verification after the linking objects. The Open Data form the Government portal is downloaded after text editing if necessary. The search and select operations are the chains in this sequence of procedures. ESRI's web-based mapping software ArcGIS Online is used as a cloud-based mapping and analysis solution for interactive web maps based on non-spatial statistical data.

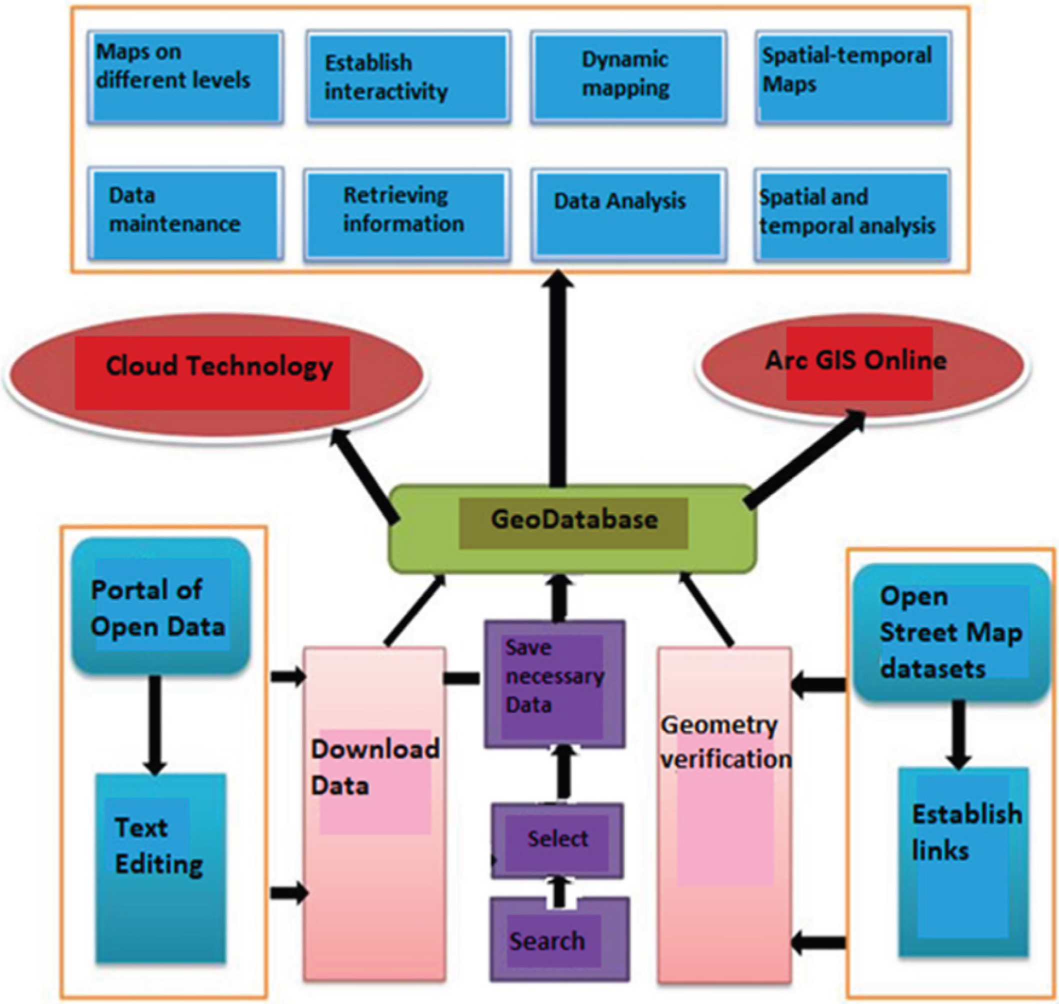

Fig. 2. Procedures of Web mapping using Open sources. (Source: Compiled by authors)

The next level of tasks comprises:

1. Compiling maps with different spatial extent depending on data;
2. Establishing interactivity for retrieving data;
3. Dynamic mapping with options to update data;
4. Developing spatial-temporal maps;
5. Data maintenance;
6. Retrieving information for comparison, modeling and forecasting;
7. Data analysis using analytical tools of ArcGIS Online;
8. Spatial and temporal analysis of selected maps series.

However, some constraints exist for mapping on the lower level of spatial hierarchy. The reason is limited access to non-spatial data of municipalities since no database exists.

In Uzbekistan, no census data has been created after 1991. The procedure of calculating, acquiring and recording information about population is performed within the administrative units. This is not yet a part of a larger system of different surveys and collecting national demographic data.

RESULTS AND DISCUSSION

Several mapping options exist, depending on type of the map to be compiled:

1) Analytical static maps to depict the state of an event or process.

2) Dynamic mapping to depict dynamic spatial phenomena or to present spatial information in a dynamic way by means of incorporating the time dimension into a map.

3) Composite maps as the result of combining several mapping themes together by means of overlay operation and combining the geometry and attributes of the input data sets.

4) Forecast maps based on modelling of further development.

This hypothesis was tested by developing the maps of the population of Uzbekistan [*Gulyamova, Rakhmonov*, 2021; *Rakhmonov* et al, 2020]. In this study, some of the options were tested to check the reliability of methodology and its relevance to the technical conditions in Uzbekistan. Samples like the dynamic map of population were developed (Fig. 3). For dynamic mapping we used the open government statistical data on population by regions imported to ArcGIS Online.

The base map is geometry data from Open Street Map dataset. As Goodchild notes “no geographic data can be perfect, since it is based on measurements and observations and subject to innumerable sources of uncertainty” [*Goodchild*, 2008, p. 8], this data is uncertain by nature, ideally time-stamped and often incomplete [*Frank*, 2007, pp. 406-420]. As for OpenStreetMap, “it has proven that crowd sourced data can compete with official sources” [*Li* et al, 2016, p. 16].

According to well established practice, data quality is measured by “spatial, temporal and thematic accuracy, resolution, consistency and completeness” [*Veregin, 2005*, pp. 177–189]. According to research [*Maron, Channell,* 2015; *Veregin*, 2005], some countries have 100 % coverage of major roads when comparing CIA World Factbook data on road length in a country with OpenStreetMap data. Study shows that “the approximately 15 m shift between the high-resolution imagery and the Google base that the Google base is most substantially misregistered” [*Goodchild*, 2008, p. 8].

From this perspective, data from OpenStreetMap dataset is checked for accuracy of positioning major cities as point features, major rivers and administrative boundaries as linear features. The data of the digital base map of Uzbekistan and data of Open Street Map is used for comparison by means of overlaying features. The point and linear features of the base map have been obtained from 1:200,000 topographic mapping with a published accuracy of 100 m. The misfits between data of Open Street Map and the base map occur in 10 % of observed cases. In this study, this 20 m shift is considered acceptable. All points of interest are checked by their location and the 20–30 m shift is accepted for mapping.

In ArcGIS Online, content items, search results, groups, and non-spatial statistical open data can be accessed directly by a URL This and other more options may be developed for online mapping (Fig. 4 – Fig. 5).

Function <establish link> in ArcGIS Online provides linking to non-spatial statistical open data, and more options may be developed for online mapping (Fig. 4 – Fig. 5).

Fig. 3. Dynamic map of population of the regions in the Republic of Uzbekistan (2018). Source: (compiled by authors and posted at ESRI ArcGIS Online[1])

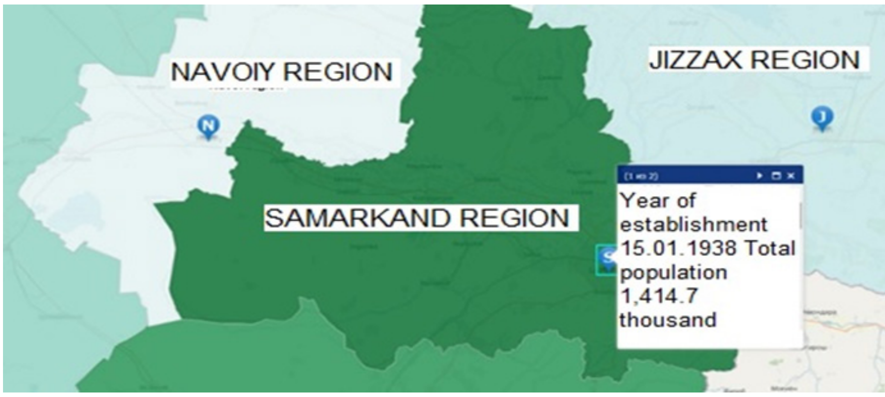

Fig. 4. Access is established to the local government non-spatial statistical open data of Samarkand region. Map is interactively compiled in accordance with selected non-spatial data. Source: (Compiled by the authors and posted at ESRI ArcGIS Online[2])

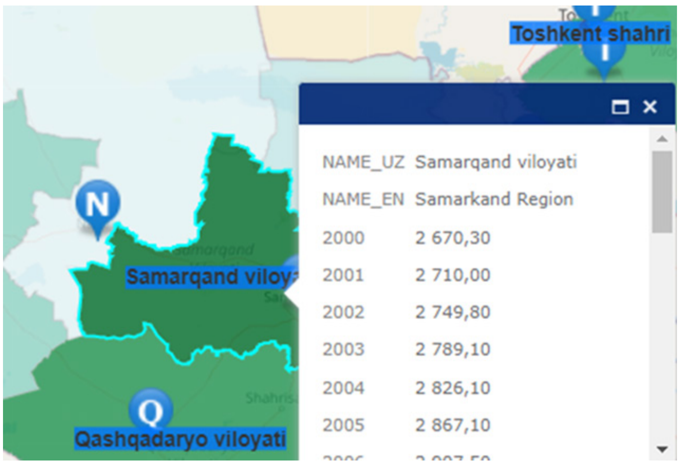

Fig. 5. Link to non-spatial statistical open data of the State Statistical Committee of the Republic of Uzbekistan.

[1] Web resource: https://www.arcgis.com/apps/View/index.html?appid=ea5d5997ff6f4bfcb7b14d237052cfc7
[2] Web resource: https://www.arcgis.com/apps/View/index.html?appid=ea5d5997ff6f4bfcb7b14d237052cfc7

On the districts level, data is also available and easily imported to ArcGIS Online cloud. The interactive dynamic map of the population of the city of Tashkent is compiled according to data of all administrative districts, i.e. total population, of them male and female. Non-spatial open data of local authorities is integrated with data of Open Street Map datasets. The most up-to-date data of Open Street Map is preferable for mapping social and economic events at the city level [*Rakhmonov, Gulyamova*, 2021].

Dynamic interactive mapping at the level of community is a valuable source both for capturing geospatial information and for decision-making, maintenance and management. This map is the result of integrating data from local authorities and data from Open Street Map datasets. The positional accuracy is assessed by comparing with the imagery of 30 m resolution. The 20 m shift is accepted as satisfactory for mapping.

Online dynamic maps were developed with the help of different open resources. Their combination helps to compile maps at several spatial scales ranging from national to community level. The suggested methodology is used for mapping the population of the Republic of Uzbekistan for the period from 1991 to 2020 in accordance with the demographic data available at the Governmental Portal. These maps were compiled interactively through online services of ArcGIS Online (ESRI).

This study used the suggested scheme of the online dynamic mapping for population of Uzbekistan. Meanwhile, any other thematic social and economic maps may be developed with the help of this methodology. The Government Portal provides the wide range of non-spatial statistical data on economy, demography, business, etc. Unfortunately, the use of this data is lower than expected. According to the State Statistical Committee of the Republic of Uzbekistan, in February 2022, the average daily number of visitors was about 3,000.

While implementing the suggested methodology, several issues were solved including establishing access to the non-spatial statistical data and defining the possible ways for retrieving the geospatial information from them. It was discovered that the positional accuracy of the geometry data from Open Street Map dataset meets the requirements for mapping social and economic events at several spatial scales. The functionality of ArcGIS Online and its 'software as a service" (SaaS) nature provides sufficient tools for online mapping.

The traditional sources for mapping population are topographic maps for urban GIS [*Chen*, 2000], census data [*Golubev* et al, 2016; *Hermes, Poulsen*, 2012] for generating synthetic spatial microdata. [*Mobasheri* et al., 2020] lists open source geospatial data including datasets generated by volunteer as one of the solutions for urban/environmental spatial analysis. Few studies cover the issues related to using non-spatial statistical data [*Scott*, 2016]. Meanwhile, the experience of using open sources like OpenStreetMap datasets and ArcGIS Online services [*Dangermond, Goodchild*, 2020] for building geospatial infrastructure and theories to form spatial-temporal database [*Frank*, 2007] are good fundamentals for the development of new approaches to retrieve geospatial information from non-spatial data.

The future of using open data as a tool of governing will continue to grow alongside with the "more usage of open data in machine-readable formats rather than PDFs" [*Davies* et al, 2019, p. 14]. The challenges over seeking the specific datasets still exist when it comes to social and economic cartography. In these circumstances, the proper way for using open non-spatial statistical data with the help of open software tools for mapping, sharing maps, collaboration and analysis plays crucial role in more broad meaning.

The peculiar feature of open government data is its direct or indirect reference to location. [*Davies* et al., 2019, p. 137] notes that this is common to "approximately 80 % of all government data". While mentioning open geospatial data in the form of mapping mash-up by Google Maps, or a platform for the collection and display of mapping data with OpenStreetMap, non-spatial statistical open data are beyond of interest and concern. This is not considered in online mapping. In the case geographic layer itself is not open data, this is challenging to compile a map and in particular, social and economic one. It is true that "many practitioners working with open data consider geography primarily in terms of x and y coordinates, usually expressed as latitude and longitude, respectively" [*Davies* et al., 2019, p. 139]. It is difficult to ignore this case.

This study suggests solution for defining geography by means of open data of OpenStreetMap datasets and assigning non-spatial statistical data to administrative units of any spatial scale. This approach supplements the data system hierarchy which does not exist in Uzbekistan and provides producing "coordinate and regional statistics" [*Scott,* 2016].

The web mapping methodology using open data and open GIS software tools provides more efficient usage of the Open Government Data and contributes to the idea of developing the Global Statistical Geospatial Framework (GSGF) being an essential part of the movement to generating geospatial knowledge.

The web mapping methodology based on open sources includes methods for interactive capturing, processing and analysis of Government open non-spatial statistical data for Web mapping. The advantage of this data such as uniform availability to open sources of different agencies and institutions creates good opportunity for assigning data to administrative units. Moreover, data is assigned to the relevant administrative unit with frequently changing boundaries. This way of data representation in the Government Portal is a plus for mapping the changes over time and comparing data of different time sections.

Interactive dynamic maps are developed based on Government open statistical data at several hierarchical levels. The variety of ArcGIS Online functions provides the vast opportunities for linking spatial and non-spatial data, editing and manipulation.

When distribution of Open Government Data should be "a driving force for economic and social growth" there is still "risk that a large part remains unused" [*Quarati, Matrino*, 2019, p. 1]. As this study demonstrates, establishing links within Web GIS environment between different open sources is supportive for generating geospatial information and "could built critical capacity for spatial analysis' [*Veregin,* 2005, p. 151].

CONCLUSION

This study reveals opportunities for retrieving geospatial information from government open non-spatial statistical data. Based on this data an interactive dynamic mapping helps to improve the usage of Open Government Data and serves as an indicator to measure its benefits. The methodology included the overall scheme of Web socioeconomic mapping, consisting of 5 phases, each of them describes the necessary steps for the online dynamic map generation. Particular attention was paid to the purpose and ways of using maps, the research goals and type of project for using map. Web mapping procedure is viewed from the perspective of establishing links to sources, performing spatial and non-spatial data integration using ArcGIS Online, Open Street Map (OSM), based on standard web services and protocols. Using open sources ensures sharing geographic information and knowledge by means of interactive dynamic mapping. These maps may be used for performing spatial analysis online and new geospatial data generation. Further research should be aimed to advance this methodology for developing online interactive complex and prediction maps. Many opportunities exist in using open sources for interactive dynamic maps of society and the economy. At this stage of research limited issues were studied with the purpose to find out the ways for Web mapping based on Open non-spatial statistical Data of Government of the Republic of Uzbekistan.

REFERENCES

1. *Arnold L.M, McMeekin D.A, Ivánová I, Armstrong, K*. Knowledge on-demand: a function of the future spatial knowledge infrastructure. Journal of Spatial Science, 2021. V. 66. Issue 3. P. 365–382. DOI: 10.1080/14498596.2019.1654942.
2. *Chen Yan.* A practical method to collect data for urban GIS. International Archives of Photogrammetry and Remote Sensing, 2000. V. XXXIII (Supplement B7). Web resource: https://www.isprs.org/proceedings/xxxiii/congress/part7/27_xxxiii-part7s.pdf (accessed 03.01.2022).
3. *Dangermond J., Goodchild M.F*. Building geospatial infrastructure. Geo-spatial Information Science, 2020. V. 23. Issue 1. P. 1–9 DOI: 10.1080/10095020.2019.1698274.

4. *Davies T., Walke, S., Rubinstein M., Perin, F.* (Eds.). The State of Open Data: Histories and Horizons. African Minds and International Development Research Centre. Cape Town and Ottawa: African Minds and International Development Research Centre, 2019. Web resource: https://www.idrc.ca/en/book/state-open-data-histories-and-horizons (accessed 02.02.2022).
5. *Duckham M., Arnold L., Armstrong K., McMeekin D., Mottolini D.* Towards a Spatial Knowledge Infrastructure. White Paper. Australia and New Zealand Cooperative Research Centre for Spatial Information (CRCSI), 2017. Web resource: https://www.crcsi.com.au/assets/Program-3/CRCSI-Towards-Spatial-Knowledge-Whitepaper-web-May2017.pdf (accessed 02.12.2021).
6. *Fatehkia M., Tingzon I., Orden A., Sy S., Sekara V., Garcia-Herranz* M., Weber I. Mapping socioeconomic indicators using social media advertising data. EPJ Data Science, 2020. Web resource: https://epjdatascience.springeropen.com/articles/10.1140/epjds/s13688-020-00235-w (accessed 15.12.2021).DOI: 10.1140/epjds/s13688-020-00235-w.
7. *Frank A.U.* Data Quality Ontology: An Ontology for Imperfect Knowledge. Spatial Information Theory: International Conference on Spatial Information Theory, 2007. P 406–420. DOI: 10.1007/978-3-540-74788-8_25.
8. *Golubev A., Chechetkin I., Parygin D., Sokolov A., Shcherbakov M.* Geospatial Data Generation and Preprocessing Tools for Urban Computing. System Development. Procedia Computer Science, 2016. V. 101. P. 217–226. DOI: 10.1016/j.procs.2016.11.026.
9. *Goodchild M.F., Yuan M., Cova T.J.* Towards a general theory of geographic representation in GIS. International Journal of Geographic Information Science, 2007. V. 21. Issue 3. P. 239–260. DOI: 10.1080/13658810600965271.
10. *Goodchild M.F.* Assertion and authority: the science of user generated geographic content. Proceedings of the Colloquium for Andrew U. Frank's 60th Birthday. Geoinfo 39. Department of Geoinformation and Cartography, Vienna University of Technology, 2008. Web resource: https://people.geog.ucsb.edu/~good/papers/454.pdf
11. *Gulyamova L.* Geographical Information Systems and Technologies. Tashkent: University, 2018. 188 p. (in Uzbek).
12. *Gulyamova L.X., Rakhmonov D.N.* Open Data for web-mapping the dynamic of population of Uzbekistan. Proceedings of the International conference "InterCarto. InterGIS". Moscow: MSU, Faculty of Geography, 2021, V. 27. Part 4. P. 388–401. DOI: 10.35595/2414-9179-2021-4-27-388-401.
13. *Hermes K, Poulsen M.* A review of current methods to generate synthetic spatial microdata using reweighting and future directions. Computers, Environment and Urban Systems, 2012. V. 36. Issue 4. P. 281–290. DOI: 10.1016/j.compenvurbsys.2012.03.005.
14. *Li S., Dragicevic S., Castro F.A., Seste, M., Winter S., Colteki, A., Pettit C., Jiang B., Haworth J., Stein A., Cheng T.* Geospatial big data handling theory and methods: A review and research challenges. ISPRS Journal of Photogrammetry and Remote Sensing, 2016. V. 115. P. 119–133. DOI: 10.1016/j.isprsjprs.2015.10.012.
15. *Maron M., Channell T.* How complete Is OpenStreetMap? Mapbox, 2015. Web resource: from https://blog.mapbox.com/how-complete-is-openstreetmap-7c369787af6e (accessed 15.11.2021).
16. *Mobasheri A., Pirotti F., Agugiaro G.* Open-source geospatial tools and technologies for urban and environmental studies. Open Geospatial Data, Software and Standards, 2020. V. 5. DOI: 10.1186/s40965-020-00078-2.
17. *Neuman A.* Web mapping and web cartography. Springer Handbook of Geographic Information, 2012. P. 273–287. DOI: 10.1007/978-3-540-72680-7_14.
18. *Quarati A., Matrino M.* Open government data usage: a brief overview IDEAS'19. IDEAS '19: Proceedings of the 23rd International Database Applications & Engineering Symposium, 2019. No. 28. P. 1–8. DOI: 10.1145/3331076.3331115.
19. *Rakhmonov D., Gulyamova L., Egamberdiev A., Shchukina O., Abdukodirova S.* The issues of the creating an interactive map of Tashkent city population. International Journal of Advanced Science and Technology, 2020. V. 29 No. 05. P. 1346–1352.

20. *Rakhmonov D., Gulyamova L.* Theoretical and Practical Issues of Development the Interactive Dynamic Maps of Population. Tashkent: "Kaleon Press", 2021. 126 p. (in Uzbek).
21. *Scott G.* Integrating Geospatial Information and Statistics. United Nations Institute on Global Geospatial Information Management (UN-GGIM), 2016. Web resource: https://ggim.un.org/knowledgebase/knowledgebasecategory22.aspx
22. *Shupeng Ch.* Challenges and opportunities cartography faces. Acta Geographica Sinica, 1994. V. 49. Issue 1:18-8. (in Chinese) DOI: 10.11821/xb199401002.
23. *Tsou M-H.* Research challenges and opportunities in mapping social media and Big Data. Cartography and Geographic Information Science. 2015, V. 42. Issue sup1. P. 70-74. DOI: 10.1080/15230406.2015.1059251.
24. *Walter Ch.* Future Trends in geospatial information management: the five to ten-year vision. United Nations Committee of Experts on Global Geospatial Information Management. 2020. Web resource: https://ggim.un.org/documents/DRAFT_Future_Trends_report_3rd_edition.pdf
25. *Veregin H.* Data Quality Parameters. Goodchild M.F., Longley P.A., Maguire D.J., Rhind D.W. (Eds.) New Developments in Geographical Information Systems: Principles, Techniques, Management and Applications, 2005. Hoboken NY: Wiley. P. 177–189.
26. *White T.* Hadoop: The Definitive Guide. Sebastopol, CA: O'Reilly Media, Inc2012