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OPEN DATA FOR WEB-MAPPING THE DYNAMIC OF POPULATION OF UZBEKISTAN

ABSTRACT

This paper covers issues related to using Open Data for web mapping of the dynamic of population of Uzbekistan. Several ways are suggested for performing an analysis of patterns of dynamic of population. The web mapping is recommended as the preferable way for study the spatial distribution of the population and its change. The methods are described from the perspective of their relevance to the technical and conceptual development of interactive dynamic maps. The Open sources that are maintained by state agencies, committees, private companies and other institutions are used for web mapping. The peculiarities of development of Open Data in this country are analyzed with the purpose of applying geoinformation technologies for capturing geospatial information (GI). The model has been developed for using web mapping tools for combining ICT, GIS, interactive cartography and socio-economic data for retrieving GI from existing open resources. Some tools are suggested to bring together Open Data of different official sources by means of Geographical Information Systems. The model of web service is used for uploading map data to a cloud account, while cloud service handles all server-side. ArcGIS Online and other open software are applied for interactive mapping. The interaction with datasets for online mapping and spatial analysis is performed with the help of the cloud service of ArcGIS Online.

KEY WORDS: open data, web mapping, population, dynamics, Uzbekistan.

INTRODUCTION

Using of Open data is generating growing interest as a result of move toward more transparent and innovative governance mechanisms [*Davies et al.,* 2019]; [*Verhulst, Young,* 2017]. From the global perspective, the importance of Open Data is growing as this is noted in the Secretary-General's Roadmap for Digital Cooperation, launched in 2020. This report proposes a series of steps and mechanisms to pave the way towards "more effective global digital cooperation" including calls for: 1) universal global connectivity by 2030, with a special emphasis on emergency situations; (2) the creation of digital public goods, such as open source software, open data, open AI models, and open standards.

This initiative stresses the strong dependence of the efficiency of the spatial technologies on underlying data sets, including open ones. In the geospatial technologies this is motivated by proliferation of voluntary geographic information [*Goodchild,* 2007; *Googdchild, Li,* 2012; *Quarati et al.,* 2021]. The phenomenon of big data [*Goodchild, Li,* 2021], the possibilities of free access to online information resources [*António, Scopeliti,* 2017], and the growing power of mobile applications are driving the studies on open geospatial data. These innovations create more opportunities for the development and exchange of geospatial data, information and knowledge.

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Today, rapidly developing Information and Communication Technologies (ICT) support development of Open sources that are maintained by state agencies, committees, private companies and other institutions. Since 2009, when the United States launched the data.gov portal there is the systematic opening of government data around the world, including Uzbekistan. In this country, the National Open data catalogues include the government portal site https://www.data.gov.uz/en[1]. These online services for citizens and businesses provide access, give an opportunity for using them as data sources, and for public control. The public datasets can legally be shared and republished. This State information resource on the Internet consists of a set of software and hardware and is designed to accommodate a public government information and provides with interactive services. As in other countries this portal along with providing online resources helps in 'generating "added value both economic and social" [*Viscusi et al.,* 2014; *Charalabidis et al.,* 2014].

However, in Uzbekistan, a service for collecting geospatial information has not been yet properly developed. According to the Law of the Republic of Uzbekistan "About Spatial Data"[2] that was signed on July 24, 2021, the Development of the National Spatial Data Infrastructure is at the beginning of its formation with the goal to provide steps to increase the availability of spatial data and metadata.

Meanwhile, Open Data is a valuable source for mapping population in countries like Uzbekistan when such challenges exist:

1. The last time the Census Data were collected in 1989 and an updated data is not available.
2. The National Spatial Data Infrastructure and the Critical Infrastructure are not yet well developed.
3. The Policy of web-services with the use of Open Resources for web – mapping has not been developed.
4. The methodology of using Open Resources for web - mapping the dynamic of population in Uzbekistan is at the beginning of its development.

The main question discussed in this paper is how to capture geospatial information[3] (GI) from Open data of the state agencies in Uzbekistan. Government data is analyzed in terms of increasing the efficiency of use, expanding the exchange of information and assessing the possibilities of obtaining GI. Issues related to the ways of performing an analysis of patterns of population dynamics for decision-making and regional development are discussed with the purpose:

1) to define ways for integrating government Open Data and data of the different sources to each other for capturing and extracting the GI;
2) to develop a simple tool for the broad audience of various actors as well as decision-makers and ordinary citizens with different demand and requirements to the GI;
3) to analyze government open data and the opportunities of its using for web mapping the dynamics of human population;
4) with the consideration of the content of data on different hierarchical levels of collecting, storing, updating and distributing to find out the ways of retrieving GI about population change;
5) to develop a simple on-line tool for visualizing and analysis the dynamics of human population.

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[1] Portal of Open Government of the Republic of Uzbekistan. 2021. Retrieved on February 20, 2021 from https://www.gov.uz/en/pages/open_government.

[2] Law " About Spatial Data" (In Russian Закон Республики Узбекистан о пространственных данных. №ЗРУ-702 23.07.2021) Retrieved on July, 28 2021 from https://lex.uz/ru/docs/5522844.

[3] In this paper, Geospatial information is different location-related datasets combined into layers that show information about demography.

It is suggested that the retrieving GI in a form of interactive maps provides more opportunities for development an analytical tool for research on population. Because of the strong control of the government the administrative data is developing according to standardized rules which provide uniform availability to open sources of different agencies and institutions over the country. This also helps matching of datasets with geospatial geometry data, principally administrative zone boundaries, which is crucial requirement of the mapping of socio-economic open data. It helps avoiding challenges of the "considerable varying in regard to the availability and legal status of administrative spatial data" [*Smith*, 2016, p. 108] and difficulties to conduct year-to-year comparisons because of "spatial extents of census units change with time" [*Dmowska*, 2019, p. 16] for the online socio-economic mapping.

The spatial distribution of the population is a complex phenomenon in a Human Geography. Its change is influenced by many factors of different origins. In Uzbekistan, change of uneven spatial distribution of population is highly dependent on access to water and land resources. In the eastern part of this country, rich fertile soils and water resources historically attract people for settling. Today, this is the most populous and developed part of this country.

The rapidly growing population is the subject of monitoring in rural and urban areas of this country. The policy of the Government to eliminate the poverty rate requires the accurate and timely up-to-date relevant spatial data on population. The scheme of social and economic development is dependent on analysis of the demographic characteristic of population, including the growth of population.

In such countries like Uzbekistan, the web mapping is the preferable way for study the spatial distribution of the population and its change. This also helps to maintain large quantities of open data. Kerski [2020] points that "the open data movement places an array of rich, varied demographic datasets – in scales ranging from the local to global".

As for Uzbekistan, this is a "blind spot" in many global population datasets. Several of them provide only general (Fig. 1) or no sufficient data (Fig. 2).

Fig. 1. ESRI "Ecoregions, Population Density, Imagery," an interactive map in ArcGIS Online[1]

This paper discusses how to use the government open data of this country to develop online maps of the dynamic of population. It is expected that by integrating data from different sources, you can create more opportunities to use open data for better analysis.

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[1]   ESRI "Ecoregions, Population Density, Imagery," an interactive map in ArcGIS Online. Retrieved on April 15, 2021 from https://www.arcgis.com/home/webmap/viewer.html?webmap=8b6d6ce07c4244bc8b3a9f7c-1c274e48.
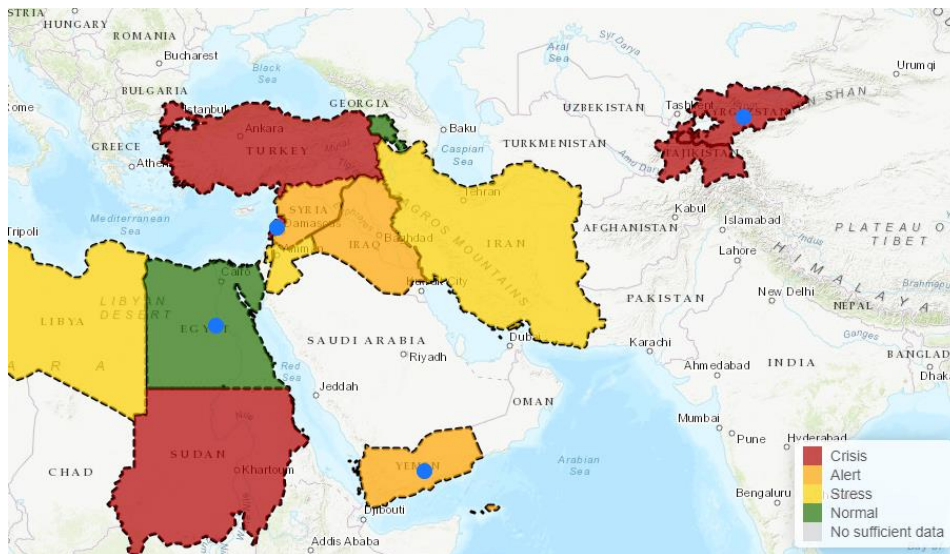
Fig. 2. The World Food Programme's (WFP) Safety Nets Alert Platform (SNAP). Dashboard. Early Warning on Local Food Prices[1]

MATERIALS AND METHODS

Further development of the Digital Earth for addressing the most fundamental problems of concern to all mankind [*Baturin et al.,* 2020] and using it as a platform for comparative analysis of different geospatial products [*Eremchenko et al.,* 2015] requires using of advanced cartographic tools for decision making and efficient use of limited resources.

In this study, the subject of scientific interest is the opportunity and challenges of using web mapping tools for combining ICT, GIS, interactive cartography and socio-economic data for retrieving GI from existing open resources. Advantages of using of web mapping tools are an integration of socio-economic data into national platforms to be substantial in terms of facilitating research and allowing the public to compare and contrast locations across the country using a range of indicators. Based on the definition of an interactive mapping by Roth [2013] as "a cartography where users can change aspects of the map representation" this study is aiming to establish a two-way friendly-use relationship between the map and the map user.

In Uzbekistan, the Government portal at the URL: https://www. data.gov.uz provides with Open Data on the national and regional levels while on community levels an additional tool is required for integration data. These resources are expanding as the result of state policy on increasing transparency and providing an access to official data.

The State Agency on Statistics of the Republic of Uzbekistan provides with data on a wide range of issues related to economy, demography, and environment. This data is updated at least once a quarter and posted at the URL: https: www.stat.gov.uz.

In an absence of geospatial data at the National Spatial Data Infrastructure of Uzbekistan, the geospatial geometry data at all spatial levels is available from different open sources, including geospatial dataset Open Street Map (OSM), Google Map. OSM is considered the most successful example of VGI and a proxy for other VGI projects [*Davies et al.,* 2019]. Comparisons with other sources of spatial data shows sufficient level of data quality and its updating, as well as its role as a tool to support the mission of creating free, editable maps [*Mo-*

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[1] The World Food Programme's (WFP) Safety Nets Alert Platform (SNAP). Dashboard. Early Warning on Local Food Prices. Retrieved on April 12, 2021 from https://snap.vam.wfp.org/index1.php.

oney, Minghini, 2017]. This study follows the frequently used application of OSM data, that is a visualization owing to the flexibility of access and tools for processing directly or from a spatial database. This nature of OSM data is one of main factors for choosing this dataset in this study.

The quality of the data in OSM is assessed visually following the common practice of comparison of OSM map layers with other popular mapping systems (Google, Bing, HERE, ESRI) and digital maps compiled by the Cadastral Agency under the State Tax Committee of the Republic of Uzbekistan. The assessment has been carried out to check up the state and an accuracy of administrative spatial data: location of the centers of regions and main cities, length of boundaries, distance between major cities. A socioeconomic statistic on population is mapped on top of administrative boundaries.

It is suggested that the government Open Data of the Republic of Uzbekistan is a valuable source for web mapping of social and economic events and processes. Its hierarchy is represented in Fig. 3.

Interactive mapping is a tool not only for visualizing demography but for conducting geospatial analysis and making decisions [*Gulyamova,* 2018]. The cloud-service model is the most suitable option in a rapidly changing environment of socio-economic datasets. Zastrow [*Zastrow,* 2015] points to such its advantages as reducing the technical skill demands and need for server access.
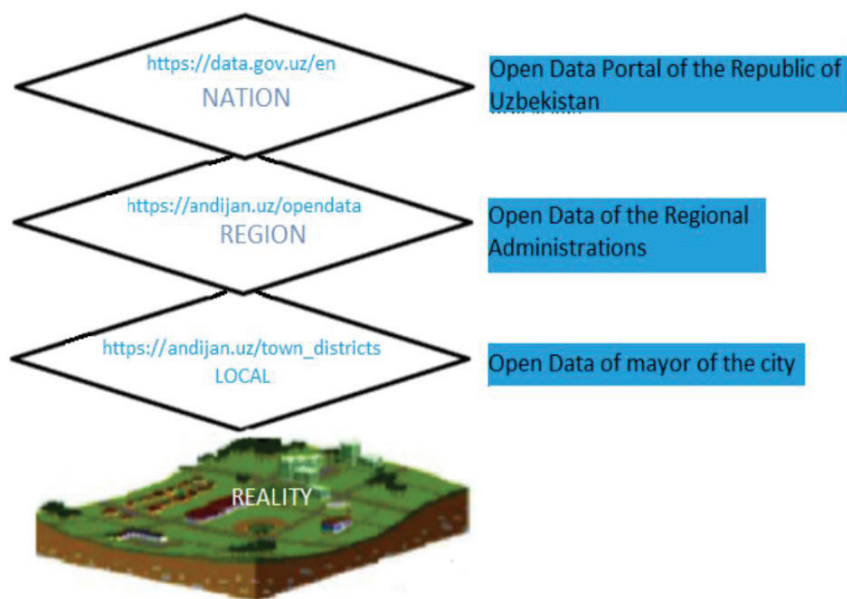

Fig. 3. The hierarchy of Open Data in Uzbekistan

In this study, the model of web service is used for uploading map data to a cloud account, while cloud service handles all server-side. Using this model gives more options for interactive web mapping and enlarging the audience of on-line users and developers. Interactive mapping is one part in a chain of web service (Fig. 4).
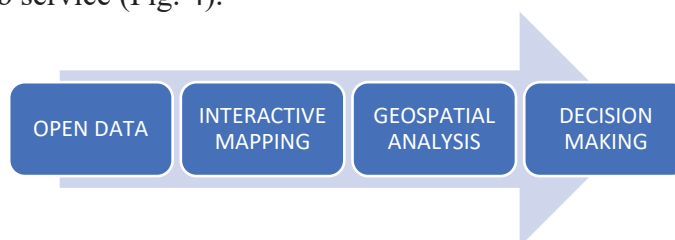

Fig. 4. Interactive mapping is a part of a chain of Web service Online mapping software

The interaction with datasets for online mapping and spatial analysis is performed with the help of the cloud service of ArcGIS Online. The advantages of this software are JavaScript API and many spatial analytical functions. The street-level spatial database and editing functionality of OSM serves as the additional tool including all necessary features for mapping of population. OSM maps are used to integrate datasets on demography with geospatial geometry data. In addition, the ability to apply attributes from datasets on demography is an advantage of using OSM. The process of the interactive dynamic mapping includes several procedures including search, select, integration, retrieving information from open data, spatial-temporal analytical functions (Fig. 5).
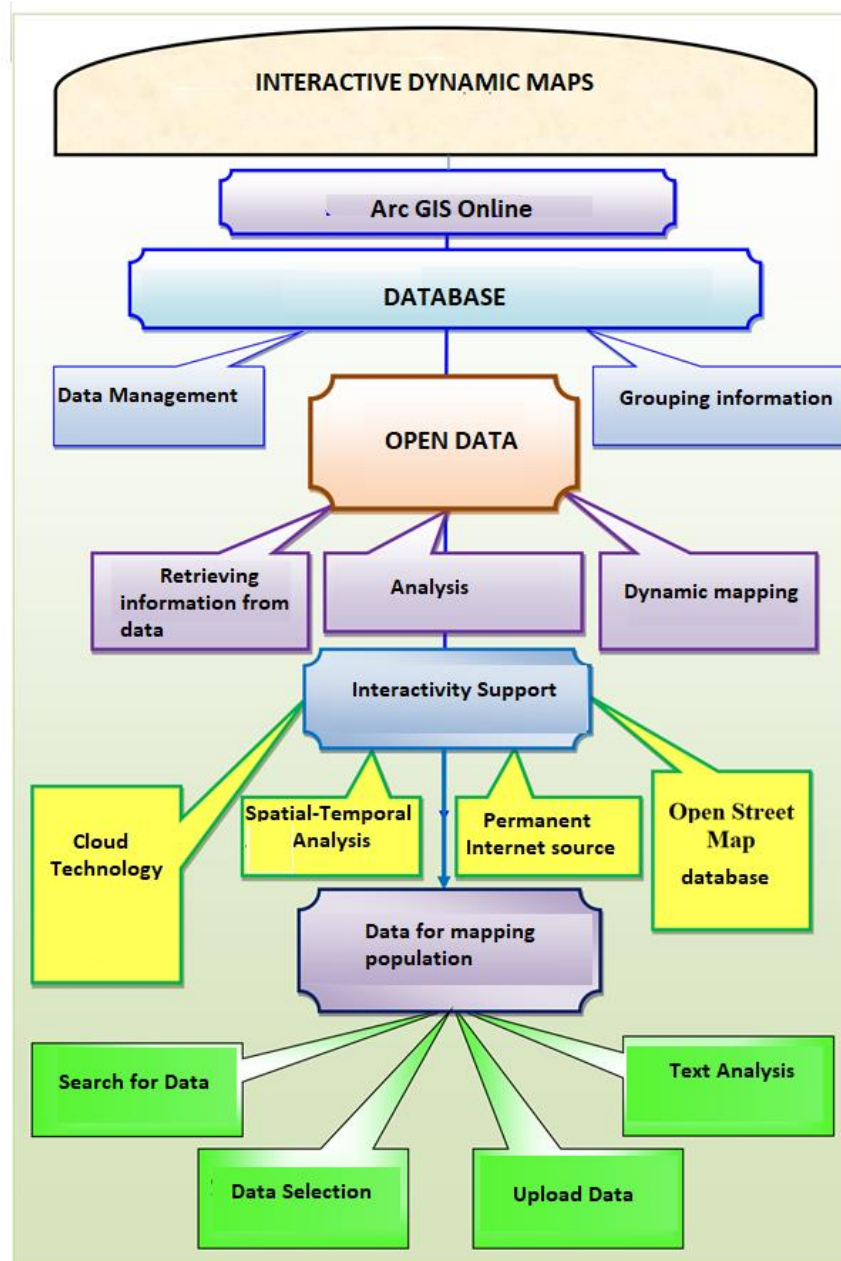
Fig. 5. The scheme of an integration of different operations for interactive dynamic mapping

The model is used for providing open services based on integration of open software, open database, data and knowledge generation (Fig. 6).

393
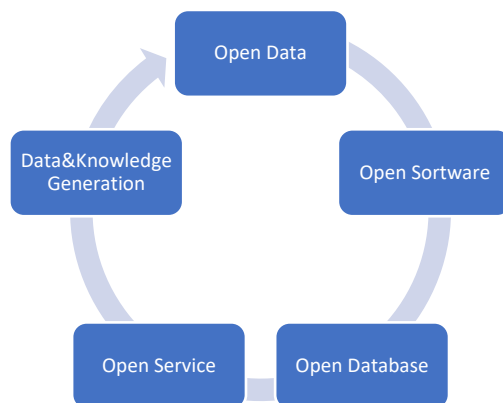
Fig. 6. The model of open database and software integration

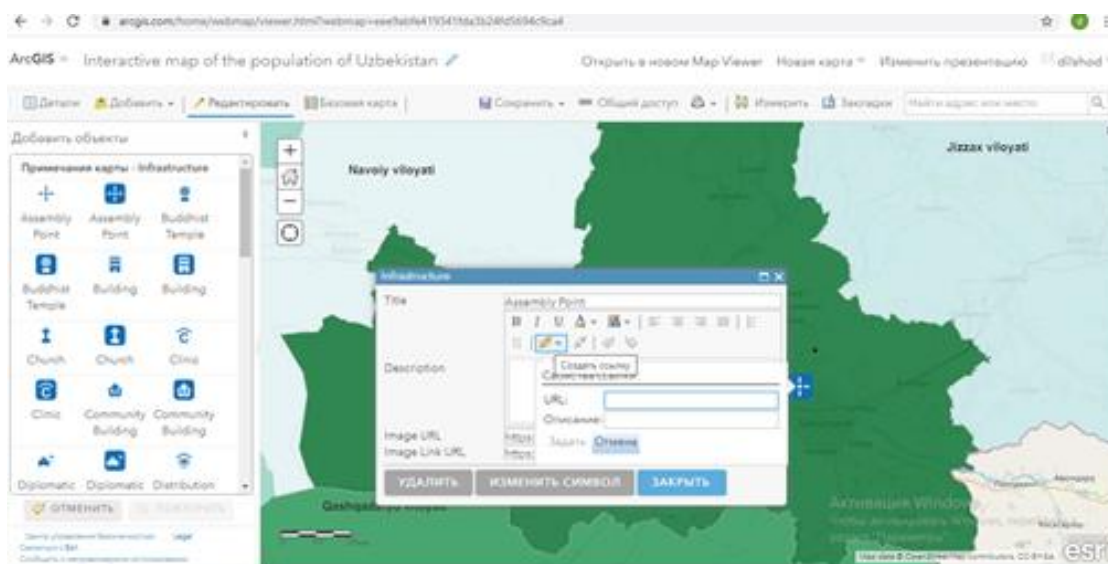Fig. 7 represents this process in ArcGIS Online.

Fig. 7. Data integration functions in Arc GIS Online. Source on internet:
https://www.arcgis.com/apps/View/index.html?appid=ea5d5997ff6f4bfcb7b14d237052cfc7

RESULTS AND DISCUSSION

In this study, Open Data of the Government Uzbekistan is used on the national and regional levels while on community levels an additional tool is applied for integration data. The geospatial geometry data at all spatial levels is derived from different open sources, including OSM, Google Map. Researchers[1] point out that "the origins of open data are not always disclosed, which can lead to incomplete, erroneous or overlapping data sets". In this study, the main attention has been paid to testing of coincidence of the geometry of OSM data and data of digital maps. Results of this testing reveal sufficient accuracy (MSE[2] – 0. 6) of lines, points and

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[1] United Nations Office for the Coordination of Humanitarian Affairs. From Digital Promise to Frontline Practice: New and Emerging Technologies in Humanitarian Action. Policy paper. 2021, p. 14 https://www.unocha.org/sites/unocha/files/OCHA%20Technology%20Report.pdf (accessed 2021, April 15).

[2] mean squared error is calculated according to

$$\text{VSE} = \frac{1}{n} \sum_{i=1}^{n} (Yi - \hat{Yi})^2.$$

polygons of administrative units and suitable for population mapping. OSM maps are well suited to integrate datasets on demography with geospatial geometry data on national, regional, and local levels of interactive mapping.

More options exist for retrieving the GI from the Portal of Open Data of the State Committee of the Republic of Uzbekistan on Statistics which publishes quarterly and annually data about population at URL: https://stat.uz/en/official-statistics/demography (Fig.8). They are in formats that suitable for integration. It includes data that gives an opportunity for efficiently retrieving GI by means of interactive mapping. This source of information is valuable for development of various social-economic maps. The mapping of the dynamic of population growth is the only example to get the picture of change of the spatial distribution of population. The series of interactive maps of population are compiled with the ArcGIS Online and with the help of established links to Portal https://stat.uz/en/official-statistics/demography. Maps are interactively compiled according to data as of any date that exists in a dataset (Fig. 8).

Fig. 8. The open data on demography at the URL: https://stat.uz/en/official-statistics/demography
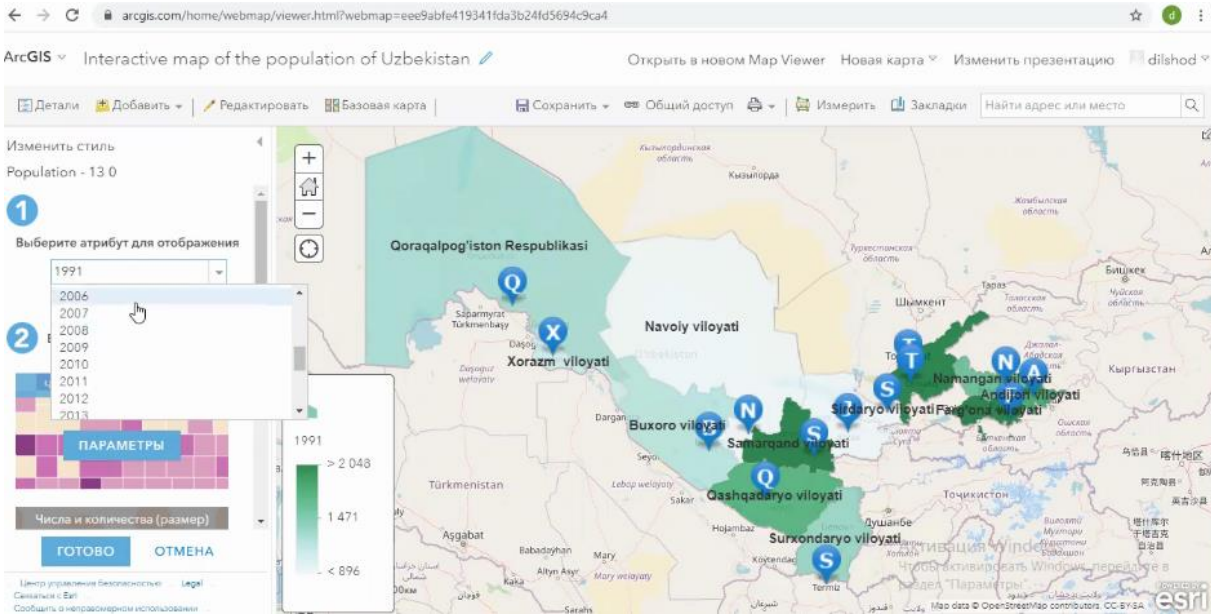
The main demographic indicators in machine-readable forms and shapefiles are imported to the ArcGIS Online server. Fig. 9 represents the standard procedure of export-import of shape file to ArcGIS Online.
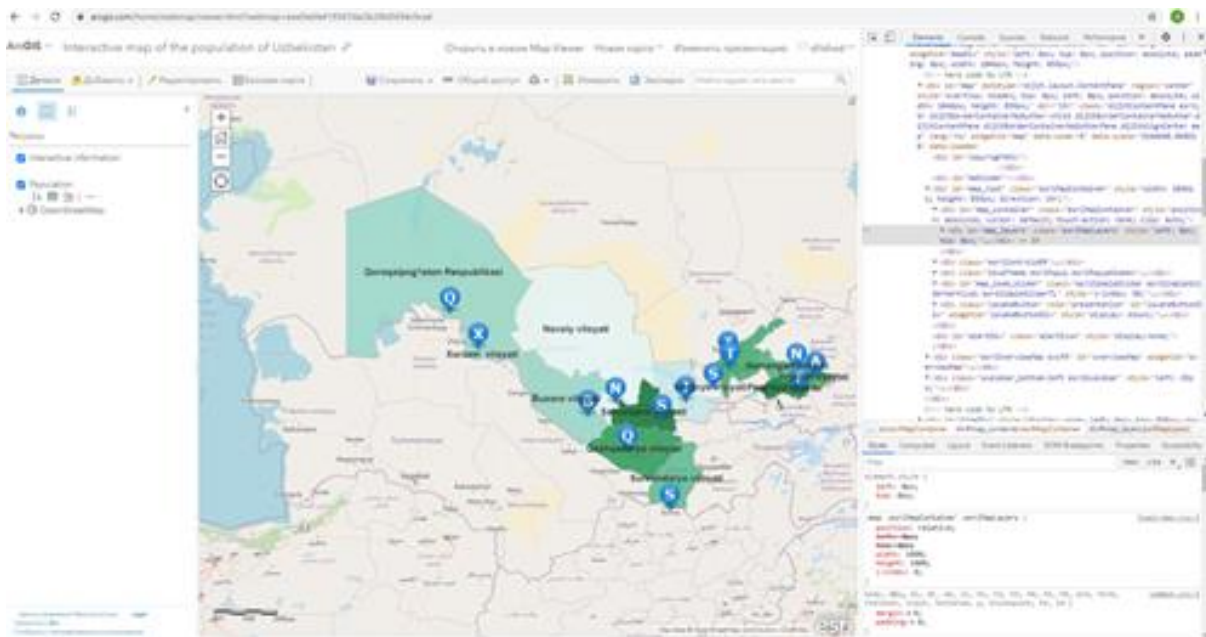

Fig. 9. Export-import of shape file to ArcGIS Online

Interactive maps of population of Uzbekistan are interactively compiled according to the attributes and the OSM datasets. Fig. 10 - Fig.11 represent the using of function of selection data and processing in ArcGIS Online. Major urban centers are marked with symbols. Each of them is linked to the relevant Open Data source at the https://data.gov.uz. The dataset is developed and posted on cloud at URL: https://www.arcgis.com/apps/View/index.html?appid=ea5d5997 ff6f4bfcb7 b14d237052cfc7

Fig. 10. Function of selection data for Interactive dynamic map of population.
https://www.arcgis.com/apps/View/index.html?appid=ea5d5997ff6f4bfcb7b14d237052cfc7

Fig. 11. The interactive Map of population of Uzbekistan in 2018. Source:
https://www.arcgis.com/apps/View/index.html?appid=ea5d5997ff6f4bfcb7b14d237052cfc7

These interactive maps are a valuable tool for comparing of the spatial changes of population on multiple levels. Along with national maps to study the general population growth trends, the regional maps are easily developed using official national, regional and local open data, open datasets of Open Street Maps, cloud services of ESRI and Arc GIS Online.
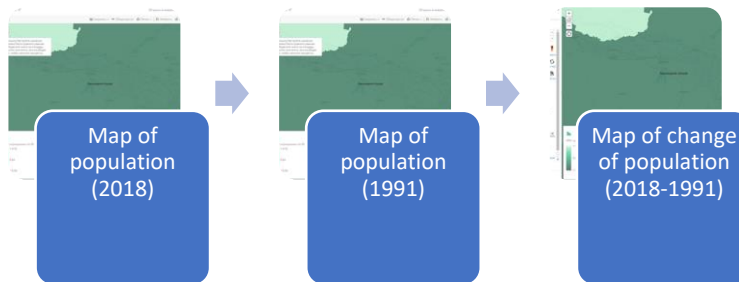
The development and integration of datasets at the regional and local level is carried out by establishing links to the portal of the official open data of the regions. An interactive map of the population change in the Republic of Karakalpakstan is shown in Fig. - 12. Design flexibility gives you more options for mapping. The dataset is developed and posted on cloud at URL:

https://www.arcgis.com/home/webmap/viewer.html?webmap=54b458f0e6c44c90bfdb776abb21b685.
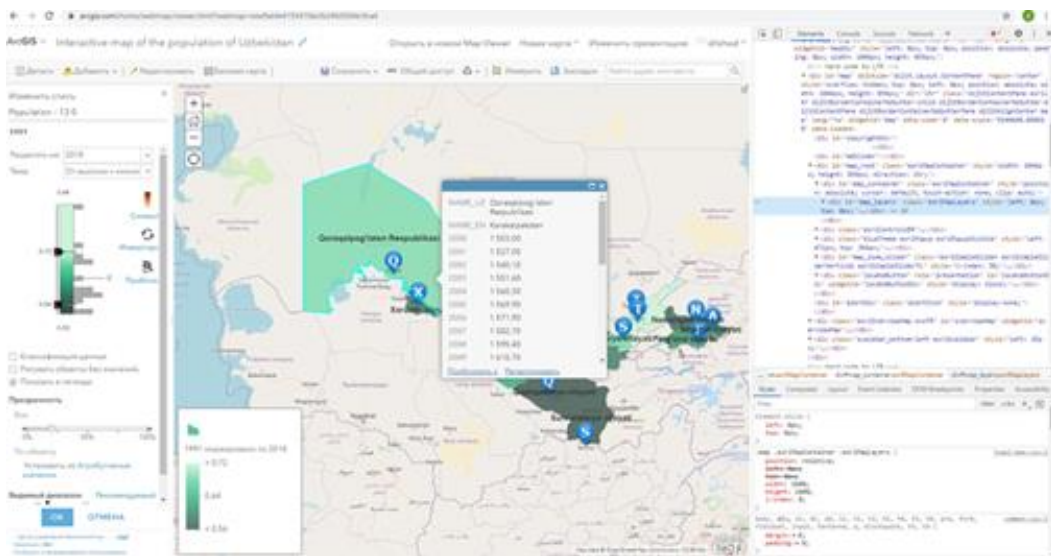
Fig. 12. The interactive map of dynamic of population of the Republic of Karakalpakstan.
Source on internet: URL:
https://www.arcgis.com/home/webmap/viewer.html?webmap=54b458f0e6c44c90bfdb776abb21b685

The maps on numbers of population as of any date and of any administrative unit are compiled interactively and they are used for calculation changes of any demographic indicators. Fig. 13 represents the cycle of mapping change of numbers of population.

Fig. 13. The process of mapping change of population (2018-1991).
Source on internet: URL:
https://www.arcgis.com/home/webmap/viewer.html?webmap=54b458f0e6c44c90bfdb776abb21b685

This method is used for mapping the change of population of the city of Tashkent (Fig. 14). The data on number of populations may be put on screen for further calculation of change.
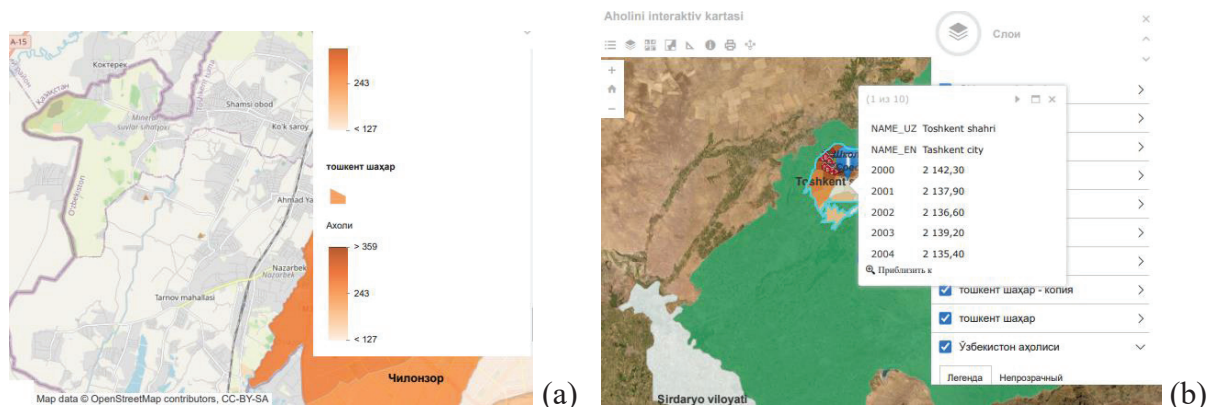
Fig. 14. The interactive maps of population (a) and dynamic of population (b) of the city of Tashkent in 2000-2004. Source on internet: URL: https://www.arcgis.com/home/webmap/viewer.html?webmap=54b458f0e6c44c90bfdb776 abb21b685

The geospatial datasets on the community level may be created from open source data with the help of the developed in this study methodology (Fig. 15).
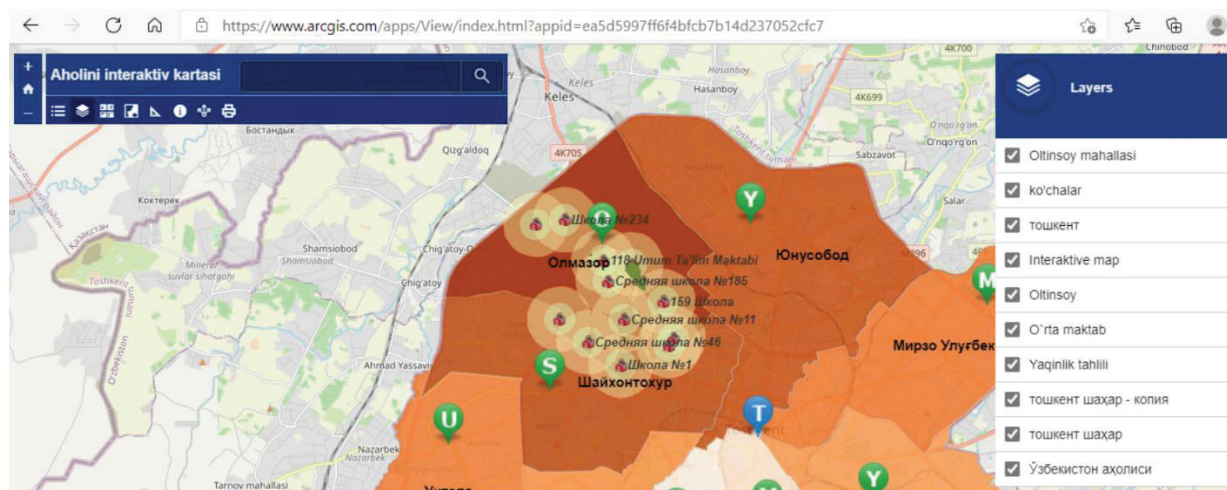

Fig. 15. Example of geospatial datasets created from open source data on community level. Source on internet: URL: https://www.arcgis.com/home/webmap/viewer.html?webmap=54b458f0e6c44c90bfdb776 abb21b685

CONCLUSION

Open resources provide many options for interactive mapping. This study focuses only on some of them and the main goal is to look for proper analytical tool for retrieving GI about population from Open Data Portal of the Government of the Republic of Uzbekistan. Web-based GIS and on-line imagery analysis tools provide a flexible way to access, extract and create spatial information essential for monitoring tasks.

The main output of this research is the aggregation of multiple datasets for mapping, development ways of using searchable databases, and dissemination of processed open data in a form of interactive maps. This fills the gap in the retrieving GI on Uzbekistan population on global level, too.

An integrated web-based GIS architecture is suggested by combining three levels of GIService: data archive, information display, and spatial analysis.

Multiple interactive map servers and image servers are used to provide web-based mapping functions for the display of population growth.

From the technical point of view with the consideration of current state of ICT and GIS development the interactive mapping is the best way to establish relationship between the map and the map user as well as to develop and update datasets. In some cases, when datasets are not posted on the Government Portal the flexibility of this technology helps to integrate available data with geometry data.

Traditionally, maps are compiled based on an existing one. In this case the common practice is a saving of many features, i.e. general geographic and mathematical basis, structural elements of the legend, the selected system of image and their combinations. The primary preparation includes collection of updated statistical information on the displayed indicators and its comparison with the data tables of the original map (Fig.16). This is a time-consuming process with challenges to assign data to geographical or administrative units. Comparison of data affects decisions to maintain or rescale quantitative parameters, specific symbols and their graphic elements (shapes, colors, etc.). The need to add new settlements, to change the boundaries of administrative units creates a headache for the cartographer and requires additional editing work. At the final stage, the main task is a development of a legend, bringing together and arranging all the elements and final design.
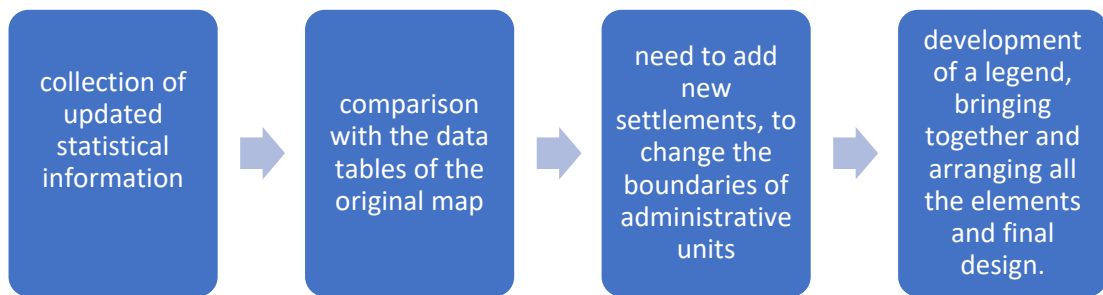
Fig. 16. Creating a new map based on an existing one

When a new map is compiled according to independently selected data, general geographic basis and general geographic basis. At the beginning the main task is a development of a general base map. This multistage process is represented in Fig.17.
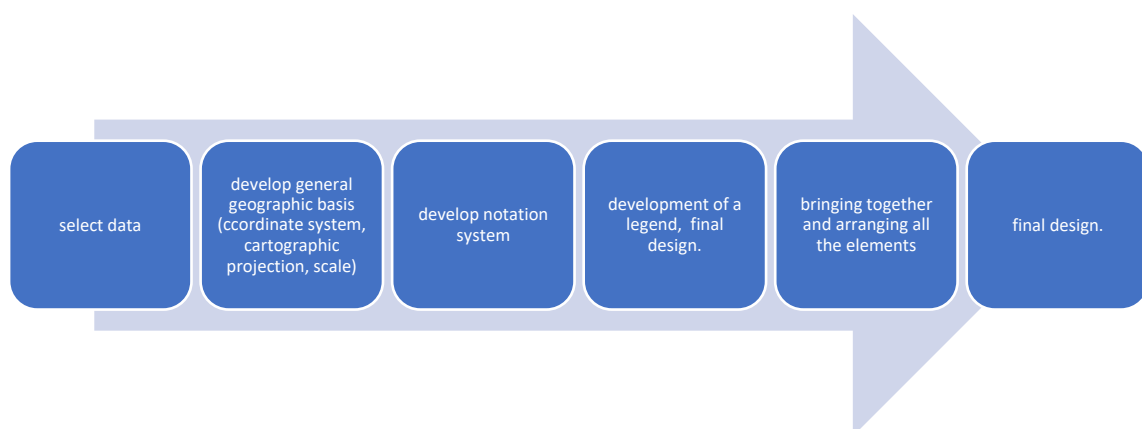
Fig. 17. Creating a new map from the scratch

Comparison of the traditional mapping the dynamic of population and suggested in this study one shows several advantages: 1) All governmental data is assigned within the latest boundaries of administrative units; 2) No need to select geographical bases for each of the maps of different years; 3) The calculating changes over time is easy to perform; 3) The results are visualized immediately; 4) The design may be improved automatically; 5) it helps collecting geospatial data efficiently and economically. The procedure is shown in Fig. 18.
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Fig.18. The process of calculating and visualization of changes

Innovations in the mobile mapping technologies require efficient geospatial data acquisition and new approaches to the interactive mapping.

The future prospects for study are in a field of further integration of existing open sources. Today, many datasets are not connected to each other while they are good source for retrieving GI. This study shows advantages of existing software in a form of open resource for improvement of interactive cartography and interactive mapping of social and economic processes.

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