Promoting Open Data services to decision-makers: Providing interactive data through Web Maps and Web Applications for Oradea city and Bihor county

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Abstract. Maps are known since antiquity, the oldest examples are from the 6th to 5th centuries BC. From the Babylonian world map, known as the Imago Mundi, maps evolved continuously. In the present day, maps allow us to visualize data in new and informative ways and to present it in an interactive manner. In recent years, web mapping technology has become a necessity for urban planning, and not only, by helping the population to take better and informed decisions. When communicating with decision-makers or only to take the best decision we need first to assess the answers to all the following questions “What and Why and When and How and Where and Who” and what better way to do this than by using Open Data? The governmental and administrative institutions have data in the form of historical maps, topographic maps, digital terrain models, statistical analysis, and other types of data. Our goal was to make these data available for the public in an easy and interactive way, by creating web maps, applications, and a website that gathers all these data.

1. Introduction

In all domains, geospatial data is important. The main benefits of using geospatial are reducing costs by improving public sector efficiency, improving citizen well-being, health, and security, and adapting to climate change. When communicating with decision-makers we have to keep in mind Rudyard Kipling’s words “I keep six honest serving-men. They taught me all I knew. Their names are What and Why and When and How and Where and Who”. So, if we deliver the answers to all of these questions, we can communicate briefly and compellingly our proposition to the decision-makers.

Maps allow us to visualize data in new and informative ways and to present it effectively.

Our goals are to present, what is possible as state-of-the-art when talking about open data, to decision-makers and to finally, give these services open to the public. For public users, data are essential to decision making, for example a decision related to building a house, a road or to open a new business. Open data have the capabilities to provide to the community the authoritative data they need to make better decisions and achieve their goals [1].

Our case study consists of creating web maps, web applications, story maps, and an open data website in ArcGIS Online, for the city of Oradea and for Bihor County. We have gathered different kinds of data, starting with data available at a national scale, like feature classes from the reference map of Romania (TopRO5) and orthophoto maps, digital terrain model and surface model and going to old maps at different scales available online. For Bihor county, we have used the feature class with the administrative-territorial units from TopRO5. Additional, we have included statistical data from the National Institute of Statistics [2].

Web maps are online mapping platforms allowing geographical data to be overlaid onto digital maps. These maps are embedded into webpages and offer interactive functions, like zoom, pan,
selection, etc. Online maps are now capable of offering multiple features and services by bringing many traditional GIS functionalities through the Internet. Based on the feature class attributes we are able to create web applications that enables a better understanding of the data.

In this article, we will present Open Data for the city of Oradea and Bihor County. This data helps to determine the actual situation in these areas from the point of view of precise positioning data, buildings functionalities, population and others.

2. Web mapping

2.1. Definitions and historical eras

A well-known definition of Web mapping is “the process of designing, implementing, generating, and delivering maps on the World Wide Web” [3].

The terms Web mapping and Web GIS are used as having the same meaning, but this is not completely true. Web GIS emphasizes the analysis and processing of geospatial data projects. Web mapping deals with the creation of maps and their distribution on the Web.

In [4], these terms are explained and put in correspondence with the era we are talking about, due to the evolution of technology in the last 20 years.

| Release year | Event | Details |
|--------------|-------|---------|
| 1993         | First web-based map | Xerox PARC Map Viewer was one of the earliest static web mapping sites. |
| 1994         | MapServer | Was initially UNIX/Linux based. T.E. Downs maps the Internet in 1994 [5]. |
| 1994         | First Online Atlas | Was the original version of Canada’s National Atlas on the Internet [6]. |
| 1995         | TIGER Web Map server | The first national street-level web map, and the first major web map from the U.S. government [7]. |
| 1996         | Internet based GIS | Released by ESRI, Autodesk, etc. |
| 2001         | GeoServer release | The Open Planning Project was a non-profit technology incubator, which created a suite of tools to enable open democracy and helped make government more transparent [8]. |
| 2004         | OpenStreetMap | S. Coast founded OpenStreetMap and focused on mapping the United Kingdom. |
| 2007         | Google StreetView | The inception was in 2001, with the Stanford CityBlock Project [9]. In 2007, Google StreetView was available for several cities in the United States. |
| 2012         | ArcGIS Online | Details are presented in the following. |

Nine web mapping eras were identified by Veenendaal in [10]. The web mapping history starts in 1990 with the static era. After 2010, the web mapping eras are the following: mobile, cloud, and intelligent.

The mobile web mapping era is characterized by the development and the broad-usage of personal digital assistants, tablets, and smartphones [11]. These devices allow and facilitate access to web maps and the geographic location of the devices. In the same period of time were developed mobile mapping...
devices, such as mobile LiDAR scanning systems, where 2D and 3D data are captured from a moving vehicle. The first mobile LiDAR system developed was the Vehicle-borne Laser Mapping System (VLMS) of the Centre for Spatial Information Science of the University of Tokyo [12].

The Cloud web mapping era started from the need of handling large amounts of information. Cloud technology provides resource pooling, virtualized applications, and a shared platform [4]. The most known cloud platforms are Amazon, Microsoft Azure, and ESRI ArcGIS Online. An important aspect of cloud web mapping is the Internet of Things (IoT): “millions to billions of sensors directly or indirectly connected to the Internet” [13].

The intelligent web mapping era deals with semantic technologies and smart environments. Semantics and context must be represented to better understand the data. This era is currently underway.

In the past, the digital geographic information was stored on desktop PCs and required specialized software for viewing. This aspect made data hard to share. Now, due to web mapping, geographical information can be shared, visualized, and edited in the browser. So, the most important advantages of web mapping are the accessibility and simple user interaction with the map.

2.2. Moving from GIS to intelligent web maps in ArcGIS Online

To share the data inside the organization or on the Internet, an option is to publish it as web services. A web service is any service that is available over the Internet or private networks and uses a standardized XML messaging system [14].

ArcGIS Online is a software-as-a-service that enables complete mapping and analysis solutions [15]. In order to create intelligent web maps, the following types of data must be considered [16]:

- basemaps are reference maps that helps in creating a new map. Examples of basemaps include topographic maps, street maps, relief maps, and many others;
- operational layers are focused maps or image services that include access to additional information through a Pop-up. Examples of operational layers include analytical results, reports, routes, field observations;
- foundational layers are web map services that complement operational layers relative to the basemap. Examples of foundational layers include boundaries;
- data behind the map are the feature layers that can be created in a GIS environment and used in a web map;
- labels represent the attributes of the data displayed on the map. Labels are very important for the user because they provide additional information about the data.

2.3. Web Apps

The options available in ArcGIS Online to create a web application based on a web map are the following Configurable Apps, Web App Builder, Story Maps, Dashboards, Sites, or Experience Builder. Some of the widgets available in Web App Builder are displayed in figure 1.

![Widgets used in a web app](image-url)
On the Internet are a lot of web maps and web apps. But not all of them display real and precise data. As Monmonier [18] states: “if not harnessed by someone who is knowledgeable and with honest intent, the power of maps can get out of control”.

The COVID-19 pandemic topic was also debated through web apps, like on gisanddata.maps.arcgis.com [19] or coronavirus-esriro.hub.arcgis.com [20], displayed in figure 2.

3. Open Data

3.1. Overview

Open Data is information available to everyone to use, process, and share without restrictions from copyright, patents, or other mechanisms of control [21]. Since 2015, with the launch of the European Data Portal [22] and national data portals, there are more open data than before. These data are provided by local government agencies, public, and private institutions. Open Data is non-personal data and can be used to identify and predict large-scale trends and behaviors. T. Berners-Lee [23] suggests a five star approach on how to publish the data (figure 3). This is the opposite of the closed data concept that is restricted to internal use within an organization. Anyone, anywhere, and at any time can combine Open Data with their data to generate and even share the new dataset [24].

Open data must fulfill the following criteria [23]:

- **Availability and access:** the data must be public and available with no cost, preferably by downloading over the Internet. The data format must allow any system to access and read it.
• **Usage, process, and distribution:** the data must be provided under terms that permit re-usage and redistribution.

• **Universal participation:** anyone must be able to use, process, and share the data. There should be no discrimination against fields of endeavour or against persons or groups. For example, ‘non-commercial’ restrictions that would prevent ‘commercial’ use, or restrictions of use for certain purposes (e.g. only in education), are not allowed [25].

The purposes of Open Data are similar to those of other "open sources" such as open-source software, hardware, open educational resources, open government, open knowledge, open access, open science, and open web. The increase in Open Data usage is accompanied by a rise in intellectual property rights. [26]. The main benefits of Open Data are found in the administrative, social, economic and performance environment and are displayed in figure 4 [27].

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Nowadays, more and more governmental institutions are turning to open data with precise locations in order to optimize current services, while preparing more sustainable solutions in the light of urban growth, climate change, and increased population [28]. Open Data are mostly organized into thematic groups (eg. transportation, security, education), by public institutions (eg. Police Department, Public Works Department), or by other organizations [29].

There are different platforms for developing websites, composed of several individual server/web/mobile applications, search engines, metadata catalogues, and more. The architecture of such platforms has to allow building, implementing, and managing Open Data.

Governments need Open Data services to provide public access to information and support applications. The architecture of Open Data closely matches the one of GIS infrastructure. Both have four levels of the application: data storage, metadata, search, and public access [30].

In [22] are given three examples of Open Data: eHealth Ireland, TheyWorkForYou, and Waze (figure 5). These applications are developed in order to inform citizens and to improve their decision-making capacity.

![Figure 4. The benefits of open data.](image)

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![Figure 5. Most known open data applications.](image)
3.2. Open data in ArcGIS Online

In 2014, ESRI launched ArcGIS Open Data, a platform in the ESRI community that explicitly aims to facilitate government and public institutions to create and distribute authorized Open Data. ArcGIS Open Data is a web application that uses the cloud catalogues with links to local or cloud-hosted data and gives a self-styling interface to launch one or more open data websites [30]. In conclusion, Open Data not only enables citizens to make better-informed decisions, but more importantly, allows them to contribute to the creation of datasets.

4. Study case

We have chosen two study cases the city of Oradea, situated in Bihor County, Romania and Bihor county (figure 6).

The dataset for Oradea City consists of:
- feature classes for roads, rivers, lakes, buildings, administrative boundary, points of interest, etc;
- orthophotomaps, digital terrain model, and digital surface model;
- auxiliary data: old maps at different scales and from different years (1598 - 2020).

For Bihor county, we used the feature class with the boundaries of the administrative-territorial units (U.A.T.).

TopRO5 is Romania's reference topographic map in digital format, corresponding to the scale 1:5,000 and contains graphic and semantic information, organized in a spatial database. The feature classes used in this article are obtained through generalization at 1:10,000 scale of the data in TopRO5, but also included updates and new geospatial collected data, in the project Maps for the major cities in Romania, which is performed at the National Center of Cartography. The decision to initiate this project came from the need for an up-to-date map for the major cities in Romania, which can be used by the local administration as a decisional support for the management and application of various planning programs, but also by public users.

The workflow used to obtain the final map product consist of the following:
- designing the cartographic database (structure, attributes, rules, etc.);
- updating some of the geospatial information from TopRo5 and collecting new geospatial data.
  In this step, we collected attributes for the classification of road segments considering the number of lanes and we have updated the points of interest;
- generalization of the data by collapsing the divided roads for obtaining a single road line where the distance between lanes was smaller than 20 meters, selection/elimination of the building smaller than the minimum set size and geometry simplification of building polygon;
- adding symbology and labelling;

Figure 6. City of Oradea and Bihor county
cartographic generalization process included displacement operations due to the graphic conflicts between the object symbols and the refinement of text placement;

- preparing the map template by placing the additional elements, such as legend, logos, contact details, and others;

- preparing the ready to print map.

For Bihor county, we added statistical data about the population from the National Institute of Statistics [31]. For each of the 101 U.A.T.s in Bihor county, we attached the following attributes:

- number of inhabitants from the table POP107D, for the years 1992, 1995, 2000, 2005, 2010, 2015, 2020;

- birth rate and death rate from the tables POP201D and POP 204C, for the years 1990, 1995, 2000, 2005, 2010, 2015, 2019.

The auxiliary data used is composed of the historical maps of Oradea city from the years 1598, 1669, and 1692, downloaded from the Internet. The maps display a perspective view of Oradea Fortress and the city around it [32].

The raster data includes the following:

- orthophotomaps generated from images acquired by the governmental institution Ministry of National Defence Romania – the Topographic Military Department, in 2012, with a resolution of 50 cm and a planimetric accuracy of 1 m;

- the Topographic Map of Oradea at the scale 1: 25.0000;

- orthophotomap generated from images acquired in the Project LAKI II (Land Administration Knowledge Improvement), in 2017, property of the National Agency for Cadastre and Land Registration of Romania, with a resolution of 20 cm and a planimetric accuracy of 20 m;

- digital terrain models and surface models obtained in the same project LAKI II, by aerial LiDAR scanning with a density of 16 points/m². The digital models have 1 m resolution and 30 cm vertical accuracy.

4.1. Web maps

Using the instruments available in ArcGIS Online, we have created two web maps. The map named **Web Map of Oradea City** (figure 7) is composed of the feature classes listed above for the city and uses as basemap the Topographic map implemented in the software.

![Figure 7. Web Map of Oradea City.](image)

The map named **Inhabitants Web Map of Bihor County** (figure 8) is made of the feature class U.A.T. for the county and uses as basemap the National Geographic map implemented in the software.
4.2. Web applications

The first web application (figure 9) is based on the data from the **Web Map of Oradea City** and displays dynamic information about the data through the following five widgets:

- **Buildings Summary** displays the number of buildings, the total building area, and the average building area within the view;
- **Road Summary** displays the number of road segments and the total road length within the view;
- **River Summary** displays the number of river polygons and the total river area within the view;
- **Point of Interest Summary** displays the feature counts for churches, museums, post offices, universities, police stations, and hospitals within the view;
- **Attribute Table** displays the table of attributes for the feature classes in the map within the view.
Figure 9. Information about the map content through two widgets 
Building summary and Point of interest summary.

The second web application is based on the data from the Inhabitants Web Map of Bihor County (figure 11) and displays dynamic information about the data through the following five widgets:

- Population Summary displays the number of U.A.T, the population in 2020, the population in 2015, the birth rate, and the death rate in 2015 within the view;
- Population Chart displays by category the U.A.T.s inhabitants in the years 1992, 1995, 2000, 2005, 2010, 2015, 2020;
- Birth Rate versus Death Rate Chart displayed by category the U.A.T.s rates in the year 2019;
- Resume Summary displays the number U.A.T., the total U.A.T. area, the average and total population in 2020 within the view;
- Area Chart (type - pie chart) displays by category the U.A.T. area.

When using chart widgets, the information revealed can be either from the features intersecting the current map area, either from the features intersecting a user-defined area (figure 10).

Figure 10. Options for the user-defined area.
Figure 11. Information about the map content through three widgets
Population chart, Birth rate versus death rate, and Area chart.
4.3. Open Data
We created, with the help of the ArcGIS Story Maps application, a data collection, named The history of Oradea Fortress, based on a group of maps and topographic maps of the city of Oradea, to better present the history of the city seen from cartographic and raster information (figure 12).

The story map begins in 1598, passes through 1669 and 1692 (an image of the Oradea Fortress), continues with the topographic map at scale 1: 25,000 and the official map of Oradea Municipality at scale 1: 10,000 and ends with the Web Map of Oradea City, developed in the frame of this article. We also added the orthophotomaps from the years 2012, 2017, and the digital terrain model and surface model and highlighted Oradea Fortress by using visualization tools (swipe).

Figure 12. The History of Oradea through maps and raster data.

Using the input data, the apps detailed in Section 4.3, and the Web Map of Oradea City detailed in Section 4.2 we have created an Open Data Hub for the city of Oradea. We used ArcGIS Open Data platform to create this website. This application offered the possibility to create and launch the website for the entire city of Oradea in only a few hours. The most time-consuming step was the design of the
website structure and interface so that the result can be interesting and easy to use. The tools to create the website are the following:

- configure the URL and getting the web address https://oradea-city-datasets-oradea.hub.arcgis.com/
- define the name of the website: Oradea city datasets
- configure the datasets: import the data from the contents of the organization.

To customize the graphic interface of the website the edit mode tool must be used. We added links with the most important maps and apps developed and also with the story map of Oradea, to allow users to visualize and analyze the data (figure 13).

Using ortophotomaps and the digital surface model as background, we created the theme of the website. The spatial analysis for the total number of building, universities, and hospitals in the city of Oradea were added to the graphic interface of our website. To highlight the spatial analyzes and to bring forward more information about Oradea city, we also included the applications developed above.

As a final step, we created the connection between the official map of Oradea at scale 1: 10.000 from the website and the website of the project started by the National Cartography Center.
The website created in ArcGIS Hub was added to our organization's account on the ArcGIS Online platform, as an application and it could be shared with the general public, both for users of this platform and for non-users. This website contains the most important geospatial data about Oradea city. This fact makes it Open Data. The Open Data site for Oradea city tries to help the user to visualize, analyse, and process this type of geospatial data and to create a better connection between public institutions and private users.

5. Conclusions
Maps are used from antiquity, by specialists, but also by common users. The appearance of web maps made this cartographic product even more used than in the past. Nowadays, web mapping offers the advantages of accessibility and simple user interaction with the data. Sharing the data is possible by publishing it inside the organization or on the web. ArcGIS Online enables complete mapping, analysis solutions, and publishing on the Internet through your own website. When using this environment for creating new geospatial datasets it is important to use or create accurate and current data.

Geospatial data presented in a simple and concise manner is what decision-makers, like CEO’s or heads of governmental or administrative institutions, need. So, web applications or dashboards made from precise and complete maps are the best way to communicate the proposal or problem. Open Data in Romania is a sensitive subject, but by showing to decision-makers the power and importance of these services represents a step forward to provide these services open to the public users.

The Web Map of Oradea City provides useful information both for citizens and institutions and represents the support for the application developed in the frame of this article. The widgets used offer information within the view-area about buildings (number of buildings, the total building area, and the average building area), roads (number of road segments and the total road length), rivers (number of river polygons and the total river area), point of interest (feature counts for churches, museums, post offices, universities, police stations, and hospitals), and all the attributes of the feature classes included in the map.

The application based on the Inhabitants Web Map of Bihor County presents the most important statistical analysis of the population in this county, like summaries about the total and average population in 2020, the birth and death rate in 2015 for the U.A.T.s in the view. Another widget used is the chart. The information provided in the chart manner are the inhabitants in the years 1992, 1995, 2000, 2005, 2010, 2015, 2020 or the Birth versus Death Rate in 2019 in the U.A.T.s selected in the view.

The website Oradea city datasets is available at the address https://oradea-city-datasets-oradea.hub.arcgis.com/ and contains the Story Maps application, called The history of Oradea Fortress, all the web maps and apps created previously, and other statistics about the data. The story map is composed of orthophotomaps of the Ministry of National Defence Romania – the Topographic Military Department, in 2012, the Topographic Map of Oradea at the scale 1: 25.0000, orthophotomaps generated in the Project LAKI II, property of the National Agency for Cadastre and Land Registration of Romania, digital terrain and surface models from Project LAKI II, and historical maps available on the Internet. This website is available only in our organization due to the property rights for the data.

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