Open Geospatial Data and Tools for Sustainable Cities – Advantages and Disadvantages

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Key words: open geospatial data; GIS; standards; crowdsourcing; EO Data; Copernicus; Sentinel 2

SUMMARY

There is currently a wealth of geospatial data that can be used through services, which can be downloaded in some cases. This article analyzes the main features of open geospatial data and correlates them with existing standards in the field. The essential advantages that these ways of working offer us are identified, such as cloud processing, the use of real-time data services, the rapid integration in the GIS environment. It is shown that there is also open geospatial data of trust, provided by various institutions, for example in the context of the European directive INSPIRE. The disadvantages of data that are not endorsed by the authorities are also shown, such as errors - spatial and attribute - that may exist in the data sets, incompleteness of the data, etc. The correlation between open geospatial data and crowdsourcing is addressed. Accessible tools for carrying out various analyzes are highlighted, which, in certain work environments, can be run in the cloud. Relevant conclusions are drawn based on the considered examples.

REZUMAT

În prezent există o multitudine de date geospaţiale care pot fi utilizate prin intermediul serviciilor, iar în anumite cazuri pot fi descărcate. În acest articol se analizează principalele caracteristici ale datelor geospaţiale deschise şi se corelează acestea cu standardele existente în domeniu. Sunt identificate avantajele esenţiale pe care aceste moduri de lucru ni le oferă, precum procesarea în cloud, utilizarea serviciilor de date în timp real, integrarea rapidă în mediul GIS. Este arătat faptul că există şi date geospatiale deschise de încredere, furnizate de diferite instituţii, de exemplu în contextul directivei europene INSPIRE. Sunt arătate şi dezavantajele existente în cazul datelor care nu sunt girate de autorităţi, precum erorile – spaţiale şi atribut - care pot exista în seturile de date, incompletitudinea datelor etc. Este abordată corelarea dintre open geospatial data şi crowdsourcing. Sunt evidenţiate instrumente accesibile pentru realizarea diferitelor analize care, în anumite medii de lucru, se pot face în cloud. Sunt extrase concluzii pertinente pe baza exemplelor considerate.

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1. INTRODUCTION

Currently, people access, use and permanently produce a series of open geospatial data through geoportals, smartphones, navigation systems, digital maps, images, virtual globes etc.
When we talk about open geospatial data, the first conceptual difference to be realized is the one between the open geospatial data provided by the public authorities and the open geospatial data obtained through crowdsourcing (VGI – volunteered geoinformation). In turn, the open data provided by the authorities or through different projects can be derived from several various acquisition sources (e.g., LiDAR, satellite images) (figure 1)

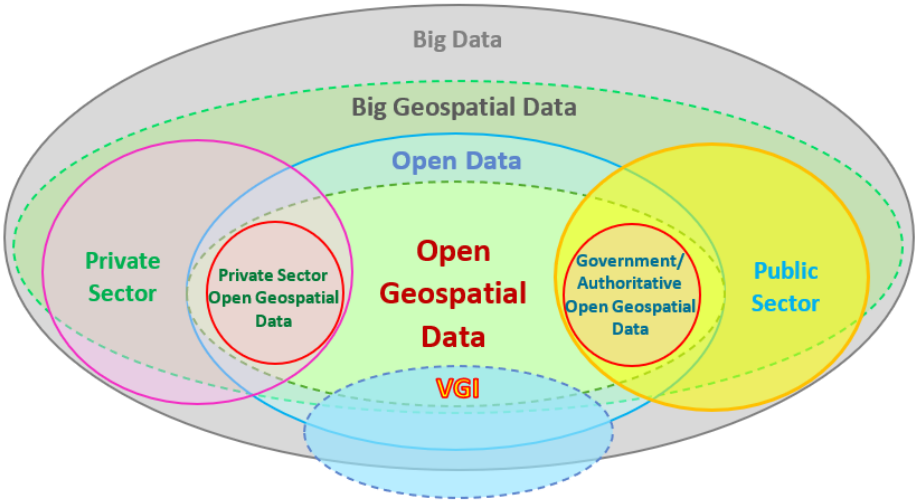


Figure 1 – Open Data Paradigm

If in the first case of open authoritative data, the quality problems are assumed by the organization that made them available to the users and should have documented them with metadata correctly, in the second case of VGI things are more complicated and diverse. Data quality issues are of utmost importance, therefore, when we want to approach the subject of open geospatial data.
As a general principle, a viewer that allows data to be viewed, but one that does not allow it to be downloaded or analyzed in the cloud, and also downloading the results is not considered to be a case of open data.
This type of data is usually created and published by a government authority, such as the national mapping/cadastre agency, regional administration or city administration, and could contain 2D spatial data on buildings (e.g. fingerprints) and non-residential datasets (e.g. spreadsheets or aggregated statistics) and point-based datasets (e.g. geocoded addresses). [24]
In a 2019 publication, "New Trends in Geospatial Information: The Land Surveyors Role in the Era of Crowdsourcing and VGI, Current State and Practices Within the Land Surveying,

Mapping and Geo-Science Communities" [24], prepared by the 3rd Commission - International Federation of Surveyors, it is stated that "The relatively new term Volunteered Geographic Information (VGI), defines the idea of using the internet to create, share, visualize, and analyze user generated geographic information and knowledge, envisioned via the use of numerous computing devices and platforms. This neo-geography revolution has fundamentally transformed how geospatial data are acquired, maintained, analyzed, visualized, and consequently – used." A main observation is that the update process of geospatial data and Spatial Data Infrastructures (SDIs) could now shift to be event-based instead a cyclical-time-based, as in authoritative data.

There is a particular interest in involving volunteers for crowdsourced information in developed countries and it is being analyzed the identification of possibilities to integrate VGI data into authoritative databases because traditional surveying methods for updating old maps are costly and require time. In developing countries, initiatives such as OpenStreetMap (OSM) and Wikimapia [24], used for creating and revising basic topographic maps, but crowdsourcing and VGI should not be seen being in competition with authoritative efforts, are successful, OSM being in fact a crowdsourced map.

The surveyors are in the midst of a wave of geo-information and face the challenge of providing reliable, adequate and accessible geospatial information, tools and services in a timely manner to support all 17 Sustainable Development Goals (SDGs) and the 169 of Agenda 2030 targets.

The importance of sustainable cities comes from the fact that cities can be seen as "epicenters of sustainability efforts." [25] In figure 2 is depicted the workflow proposed in [41], for taking the right decisions and actions with impact for a sustainable city.

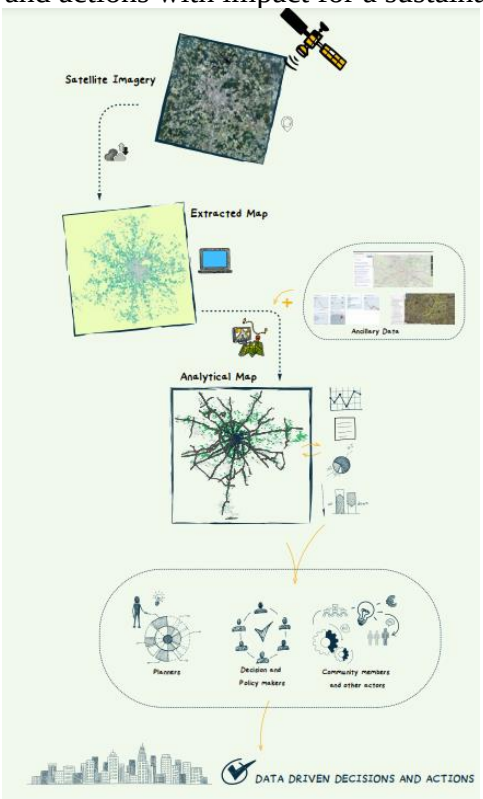


Figure 2 – Obtaining Data Driven Decisions and Actions for a Sustainable City [41] and Relevant Sustainability Impacting Indicators of Cities [25]

For example, geospatial data and technologies in SDG 11 are needed to distinguish urban and non-urban areas, extract data specific to indicators, disaggregate population data, view data, and find variations in trends by location. In this regard, UN-Habitat has developed the guide on the creation of an urban observatory geoportal [41]

2. DATA QUALITY

The reliability of big data quality depends on the properties of the input data. Defining properties of geospatial data and data processing in a transparent way is a main approach. It exists a formal standardization process as a top down approach and non-formal processes of standardization, as a bottom up approach, referred to as crowdsourcing and Volunteered Geographic Information.
In the first stage, an analysis can be made starting from the concept of data quality, as highlighted in INSPIRE. There are OGC/ISO/W3C standards that help define a common framework for geospatial data, leading to the creation of a common platform of information exchange and the generation of added value.
The concept of data quality is based on standards is correlated with the idea of open geospatial data. The quality of geospatial data from an ISO perspective involves ISO 19157 and EN ISO 19101 standards. [14] From the perspective of the first standard, quality is the degree to which a set of inherent characteristics fulfils requirements, and from the perspective of the second, quality is totality of characteristics of a product that bear on its ability to satisfy stated and implied needs, in accordance with EN ISO 19101.
In [1] there are emphasized several ways to classify the quality assessment methods but the following categories are commonly mentioned in literature with different titles: a comparison between open data and authoritative geospatial data; ML rules and patterns for checking the entries; gatekeeping and weighting users' entries.
Metadata for evaluation and use provides a posteriori statements about data quality based on direct measurements, calculations, specific aggregation rules, and other knowledge, expressed as non-quantitative information. [9] There is emphasized very well the value of open geodata in [32], a conclusion being that new studies that look into the economic benefits of Open Data at macroeconomic level need to be conducted at the EU level.

3. OPEN GEOSPATIAL DATA AND TOOLS

Currently, there are many open geospatial data sources that can be the basis for the development of sustainable cities, for example NASA provides open data and tools such as ready-to-use resources, that could be applied in policy areas important to resilient and sustainable cities, like sustainable urban planning, adequate housing, access to public transport, and access to public spaces. Earth Observation (EO) data provide significant cost and time savings in urban monitoring and indicator measurement, particularly over large areas or areas where little data is available. [25] There are included national and city experiences in using spatial data and analysis for monitoring progress towards the Sustainable Development Goals [40] and the New Urban Agenda, and enabling successful, evidence-based decision making.

UN-Habitat has developed a toolkit based on which open data are accessible for analysis and downloading, thus integrating available resources in several geoportals (e.g. Copernicus, EROS) [43]
Figure 3 highlights an analysis of impervious surfaces in Bucharest (Copernicus Open Data), overlapped on OpenStreetMap.
According with [43], the Copernicus Land Monitoring Service (CLMS) is providing geospatial information on land use land cover (LULC) and its changes, vegetation state, water cycle and earth surface energy variables in Europe and in the whole world. There are developed four thematic High-Resolution Layers (HRL) on land cover characteristics for 39 countries of Europe at 10m spatial resolution. These information were creted using High-Resolution (HR) to Very-High-Resolution (VHR) satellite imagery, including ESA's Sentinel-1 and Sentinel-2 satellites.
Earth Observation (EO) gave opportunities for mayors at the local level, by using high-resolution (or images that capture smaller objects on the ground) satellite imagery at low cost, and thus generating mapping, topographic mapping, and other useful information for cities. [30]
The European Space Agency's Copernicus program is working on providing similar built-up area maps for all cities worldwide with at least biannual updates starting in the year 2021. The city mayors can analyzes the information on land use change, spatial growth rates and expansion direction and can take administrative decisions, as to regulate construction and avoid encroachments on public land, to find resources to create supporting infrastructure, to estimate areas with demand for services, and to conserve the identified areas as being ecologically sensitive.

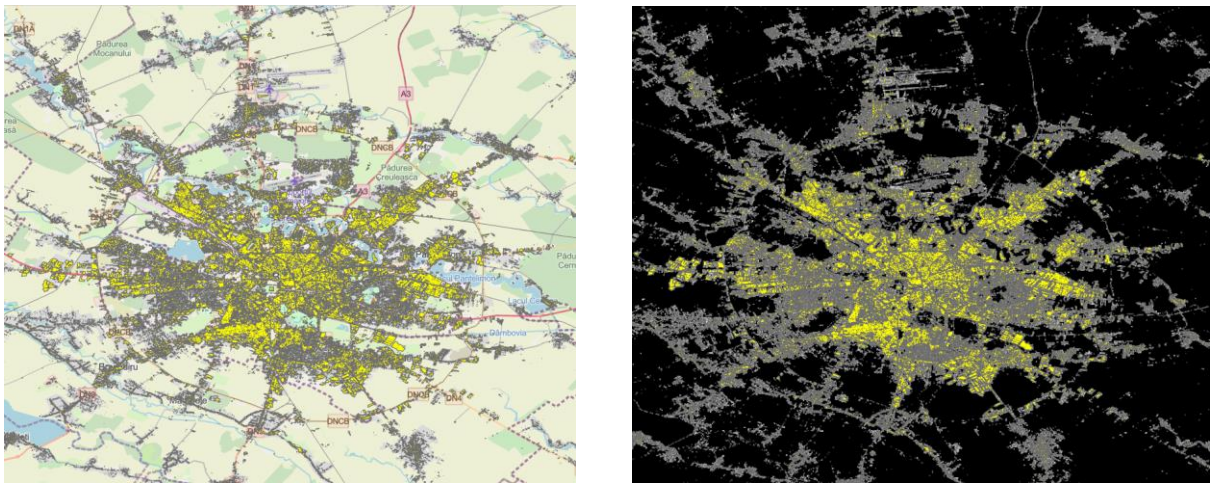


Figure 3 - Impervious Built-up 2018 in Bucharest in ArcGIS Pro, based on Copernicus Data – Basemap: OpenStreetMap (left side) - Overlapped on information layer on probability of built-up area presence as derived from a Sentinel-2 image mosaic (right side)

Another data source with impact in the built environment is GHS-BUILT-S2 R2020A, a built-up grid derived from Sentinel-2 global image composite for reference year 2018 using Convolutional Neural Networks (GHS-S2Net - GHS stands for Global Human Settlements, S2 refers to the Sentinel-2 satellite), being a global map of built-up areas expressed in terms of a probability grid at 10 m spatial resolution, using a new Deep Learning framework for pixel-

wise large-scale classification of built-up areas. [12] The GHSL datasets that are available for open and free download: the data can be downloaded for each product in a single file or split by tiles. The produced built-up map is delivered at 2 m pixel resolution (level 1 layer) while the residential/non-residential layer (level 2) is delivered at 10 m spatial resolution. [12]
The European Settlement Map is a spatial raster dataset that is mapping human settlements in Europe based on Copernicus Very High Resolution optical coverage (2m) for year 2015 for 39 European countries. [44] These data were uploaded in ArcGIS Pro (figure 4) to explore together with imagery basemap.

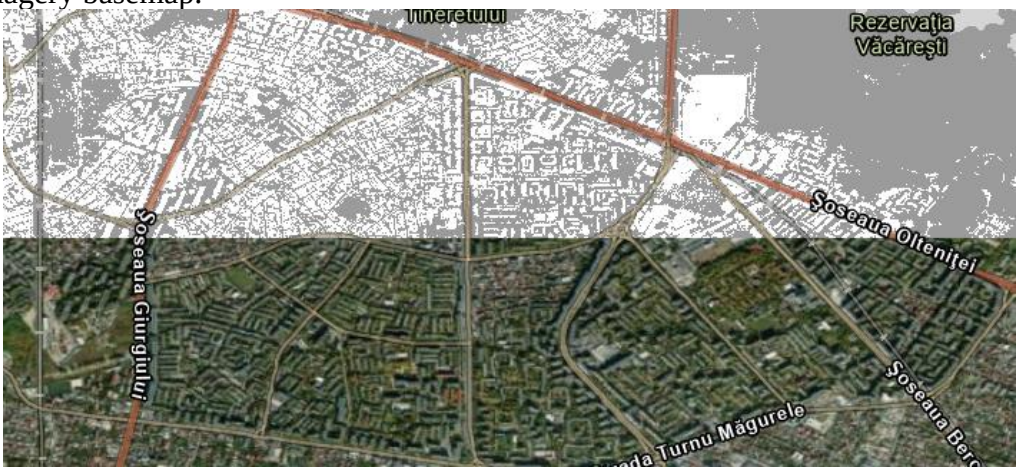


Figure 4 – Exploring the European Settlement Map Data in ArcGIS Pro (South Area of Bucharest)

In figure 5 is emphasized an information layer on probability of built-up area presence as derived from a Sentinel-2 image mosaic that can be used to analyse urbanisation, map population or analyse exposure to natural hazards.

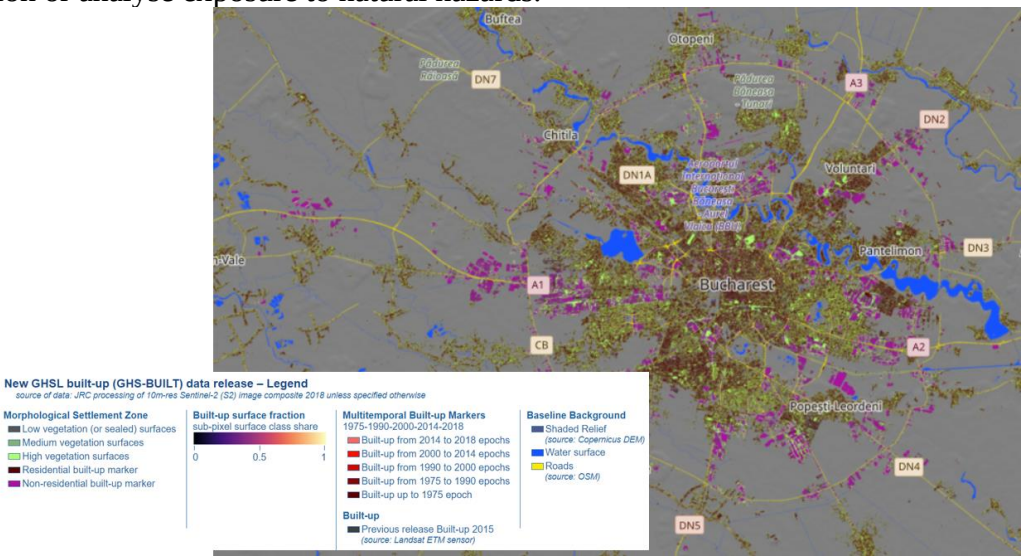


Figure 5 - Global built-up areas (Bucharest) relies on novel classification methods applied for joint assessment of Sentinel Multi Spectral Instrument (MSI), Landsat Enhanced Thematic Mapper (ETM), Thematic Mapper (TM), and Multi Spectral System (MSS) remotely sensed imagery data organized in five collections: 2018, 2014, 2000, 1990, and 1975 [44]

The Degree of Urbanisation is a new approach, related to the 2030 Agenda for Sustainable Development, which classifies the entire territory of a country into three classes: cities, towns and semi-dense areas, rural areas. [44] The reasons for these calls for the collection of harmonised indicators for cities and urban and rural areas are to support consistent international comparisons across countries. Data are organized under two extensions, the first ones including cities, towns, suburban or peri-urban areas, villages, dispersed rural areas and mostly uninhabited areas and the second ones including a zone around each city to create a functional urban area or metropolitan area.
This method has several advantages, as following:

- is based on a population grid.
- the distortions created by the variable size of statistical and administrative units are reduced.
- captures the spatial concentration of people directly, improving global comparability.
- is monitoring access to services and infrastructure in areas with different population sizes and densities.

4. LEGISLATIVE INITIATIVES IN ROMANIA

In order to make things work, a first step is the legislative harmonization that makes it possible to implement open data initiatives, by clearly establishing the categories of data to which there should be open access. (figure 6)

Geospatial domain:	data on coordinate reference systems;
	data on national and local georeferenced maps: administrative limits, delimitation of electoral districts, cadastral, topographical, marine plots, vectorized representations of roads (boulevards, streets, entrances, etc.), geospatial localization of addresses;
	data on administrative-territorial units;
	address data, location of properties, based on address identifiers, street name, administrative number and postal code;
	data on the geospatial location of the buildings, as well as their destination (e.g. city hall, high school, general school, etc.);
	data on the map of industrial and logistic objectives, production capacities with specification of the industrial category, warehouses with destination specification;
	data on the building permits map and demolition permits map, as well as their number at the level of administrative-territorial unit;
	data on road, naval, rail, aeronautical, electricity, gas, oil, primary, secondary, tertiary networks, charging stations for electric cars, coverage rate per locality, fiber optic communications, GSM, etc., water supply and sewerage, public lighting, traffic cameras and fixed radars;
	data on public emergency services, firefighters, ambulance, police;
	data on units for the dissemination or use of statistical information.
LOCALITIES	data on the administrative organization at county level, administrative-territorial units - municipalities, cities, communes;
	data on urbanism and spatial planning documentations approved at the level of territorial administrative unit and at county level.

Figure 6 – Extract from data related to geospatial domain and localities, with impact for the creation of sustainable urban areas (adapted from [22])

It is currently approved by the Romanian Government the "Law on open data and re-use of public sector information" [22], which aims to organize the way of working on open data, the public entities having the obligation to make available the data held, mentioned in [22]figure 7

and to ensure the conditions for easy access to the documents available for re-use, such as by publishing data inventory lists, together with relevant metadata, accessible, online and in machine-readable formats, as well as to facilitate access to portal sites with links to resource lists.

EARTH OBSERVATION FIELD AND ENVIRONMENT	land use data, a territory characterised by the current or future planned functional size or socio-economic, residential, industrial, commercial, agricultural, forestry, recreational purpose;
	satellite and in-situ data, weather and quality monitoring of the earth, water and air - nitrogen dioxide, PM2.5, PM10, seismicity, energy consumption, energy performance of buildings;
	data on public utility and public service services, public utility facilities such as sewage systems, waste management, electricity and water supply, and public administrative and social services such as civil protection shelters, schools and hospitals;
	data on land cover, physical and biological coverage of the earth's surface, including artificial areas, agricultural areas, forests, (semi-)natural areas, wetlands and bodies of water;
	data on the areas of administration, restriction, regulation and reporting units (landfills, restricted areas near drinking water sources, nitrate vulnerable zones, regulated fairways at sea or in major inland waters, areas intended for the unloading of waste, areas where noise limits have been introduced, areas covered by a prospection and mining permit, river basin districts, corresponding reporting units and coastal management areas);
	soil and subsoil data, characterised by depth, texture, structure and content of particles and organic material, skeleton, erosion, medium inclination and anticipated water storage capacity, where relevant;
	data on the geographical distribution of dominant pathologies (allergies, cancers, respiratory diseases, etc.) as well as information indicating the effect on health, biological indicators, decreased fertility, epidemics or on human well-being (fatigue, stress, etc.), directly related (air pollution, chemicals, thinning of the ozone layer, noise, etc.) or indirectly (food, genetically modified organisms, etc.) to the quality of the environment;
	data on natural risk areas, vulnerable areas characterised by natural phenomena of atmospheric, hydrological, seismic, volcanic nature, fires, floods, landslides and subsidences, avalanches, forest fires, earthquakes and volcanic eruptions;
	data on digital elevation/elevation patterns of terrestrial, ice or oceanic surfaces, altimetry, bathymetry and coastline;
	data on energy resources, hydrocarbons, hydraulic energy, bioenergy, solar energy, wind energy, accompanied by information on the depth and height of the resource;
	data on mineral resources, metal ores, industrial ores, accompanied by information on the depth/height at which they are located, where appropriate;
	data on the location and operation of environmental monitoring facilities, the observation and measurement of emissions, the state of the environment and other ecosystem parameters, biodiversity, ecological conditions of vegetation, etc., by or on behalf of public authorities;
	data on production and industrial plants, industrial production parks, including integrated pollution prevention and control facilities, as well as water abstraction, mining and storage facilities;
	structured data underlying monthly reports on waste charging and recycling, value, responsibility, source, tonnage;
	structured data that are the basis of the annual statistical reports on the coverage with electricity or alternative energy by county / locality.

Figure 7 – Extract from data related to the areas of Earth observation and environment, with impact for the creation of sustainable urban areas (adapted from [22])

This initiative transposes into national law the provisions of Directive 2019/1024/EU of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information, published in the Official Journal of the European Union L series, no. 172/56 from 26.06.2019. Thus, Directive 2003/98/EC of the European Parliament and of the Council transposed into national law by Law no. 109/2007 on the re-use of information from public institutions, with subsequent amendments and completions.
Specific, high-value open datasets must be machine-readable, made available through APIs, made available by mass download, if applicable, and where available, including information allowing spatialisation, such as geographical coordinates, SIRUTA code, addresses, etc. will also be made available.
An aspect of interest with an impact on open data is also that, among the objectives of the revision of the principles of property tax, there are, among other things, the automatic assessment of properties subject to local tax for tax purposes. [36] This regulation is mentioned in the National Recovery and Resilience Plan. This measure is implemented with the support of a consultancy service by creating an IT system to automate the valuation of real estate for the purpose of determining the taxable amount on the basis of information available in the systems of other institutions (e.g. The Agency for Cadastre and Land Registry, local authorities), as well as public information (e.g. real estate announcements, catalogues used by evaluation agencies, statistical data).

5. OPEN GEOSPATIAL DATA - ROMANIAN SITUATION

According with the Global Open Data Index (GODI), the annual global benchmark for publication of open government data, run by the Open Knowledge Network [47], Romania is on the 24th place when taking into account the availability of open data made available by the authorities. (figure 8)

Figure 8 - Romania Authoritative Open Data, using Data Categories [47]

In a recent paper [6], it is analyzed to what extent the existence of open geospatial data on buildings constitutes the foundation of sustainable cities, because they can provide valuable information that can be used in analyses that lead to urban sustainability, infrastructure improvement and environmental monitoring, being considered a global comparative study on open geospatial datasets on buildings released by local, regional, and national governments on all continents.
There were analyzed the datasets classified on five key elements: accessibility, richness, data quality, harmonisation, relationship with other actors. These date were also assessed using a set of thirteen quantitative and qualitative features. [6] The area covered in the project [26] does not include countries from Eastern and South Eastern Europe, such as Hungary, Romania,

Croatia, Serbia, Bulgaria, Greece. Figure 9 shows the correlation between open geospatial data on buildings and the utility they have in achieving sustainable cities.

Figure 9 – Importance of Building Data in Urban Sustainability (adapted from [6])

It is also to be appreciated that in recent years, ANCPI (National Agency of Cadastre and Land Registration) has greatly developed the applications in the ANCPI geoportal [20] which offer the visualization of extremely useful elements with impact in sustainable development, some of which allow data to be downloaded.

The initiative was correlated with the implementation of the INSPIRE Directive in Romania. Thus, open datasets are available both on the data.gov.ro portal [7] and on the INSPIRE portal [8].

According with [6], attributes are largely unavailable in the countries buildings datasets (e.g. type 34%, height 21%, age 16%). However, Romania was also mentioned, which appears to have an OpenStreetMap coverage coefficient equal to 0.13 and restricted access. There are mentioned also "The coverage ratio for OpenStreetMap is computed by dividing the number of buildings downloaded on in February 2021 by the number of buildings reported in EUROSTAT. The availability of open government data is based on self-reported information by governments in the INSPIRE geoportal."

Figure 10 - Criteria taken into account for Assessing the Accessibility of Open Data (adapted from [6]

Regarding the large cities, of metropolis type, it is worth mentioning that the big data concept intervenes. For example, in Romania, through the National Agency of Cadastre and Land Registration (ANCPI), the technical-legal cadastral information is integrated within the eTerra national database. The complete data are available to the authorized specialists that perform the cadastral works, and the data related to INSPIRE, as a geometry are available as an example of open geospatial data [8], because it mentions some Limitations On Public Access, according to Article 13(1)(e) of the INSPIRE Directive.

It is important that the users have the possibility to search for geospatial information by using a variety of user-generated geospatial and geo-tagged digital information data-sources, established and maintained by the public and private citizens, like Wikipedia entries, Facebook and Twitter postings, OSM features. As an example, it is possible to download, using [8], a set of data related to buildings (Bustuchin commune, Gorj county – where the cadastral works are finalized), in Geodatabase format, which can be used only partially (at the intersection of DJ675C with DC31C) to make an analysis correlated with OpenStreetMap, because in that area the information on OpenStreetMap is not updated. (figure 11), being here the main shortcoming of the open source data.

Figure 11 – OpenStreetMap and the building layer overlapped – dashed outline (left side) and ortophoto base map (right side)

6. GIS AND OPEN GEOSPATIAL DATA

The urban environment in many areas of Bucharest looks as though the General Urbanism Plan (PUG) or the building permit have become over the years documents whose compliance is optional, both by some real estate investors, as well as by the representatives of the municipalities issuing them the documents required to build a construction. The main reasons were the legislation in the field, but also the lack of implementation of the methods and technologies of endorsement using integrated GIS systems, in which the restrictions can be set according to the area. [2] All these processes can be managed based on the creation of processing models. [3]

The main tool used when discussing open geospatial data management is GIS technology, which has evolved extremely rapidly in recent years, as well as the volume of open geospatial

data that can be accessed and used through it. For example, Esri promotes the concept of open data, lately making accessible a series of open datasets.
Sentinel-2 10-Meter Land Use/Land Cover App, provides an annual 10-meter resolution map of Earth's land surface from 2017-2021. (figure 12, 13)

Figure 12 – Urban Expansion (Stefanestii de Jos) – Esri App Data (2017 – left side, 2021- right side)

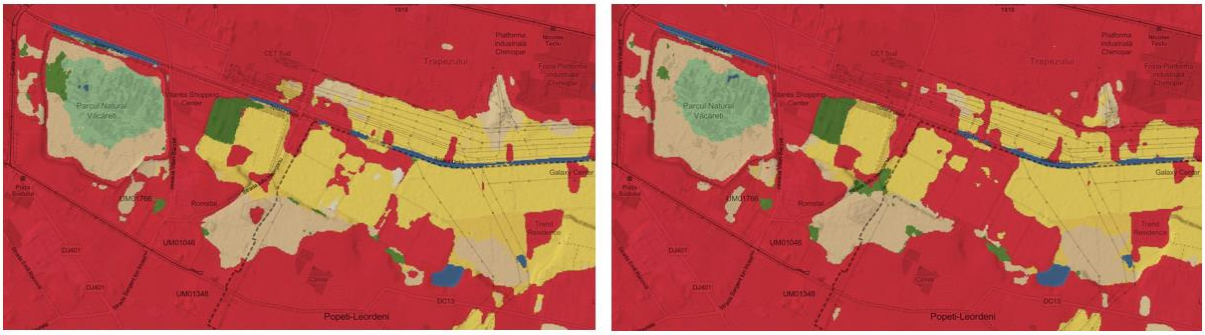


Figure 13 – Urban Expansion (SouthEast Area of Bucharest) - Esri App Data (2017 – left side, 2021- right side)

Trends.Earth is using three sub-indicators for monitoring achievement of Land Degradation Neutrality (LDN, Sustainable Development Goal (SDG) Target 15.3): productivity, land cover, and soil organic carbon. [51] (figure 14)

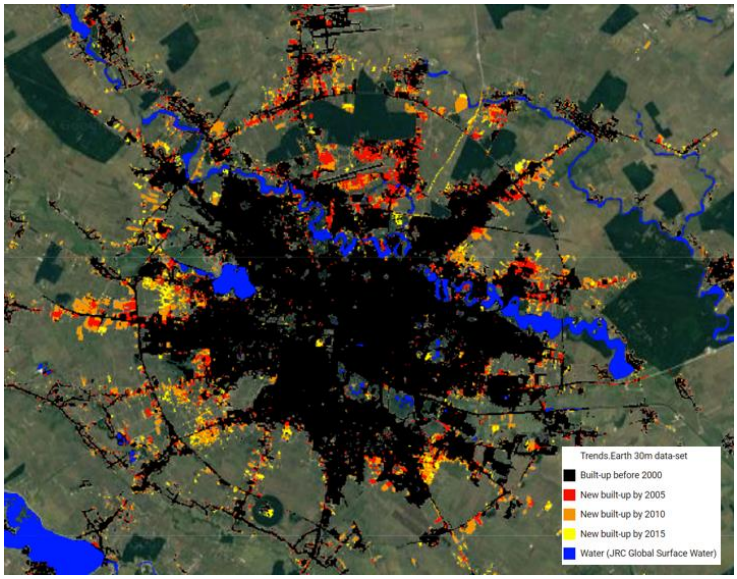
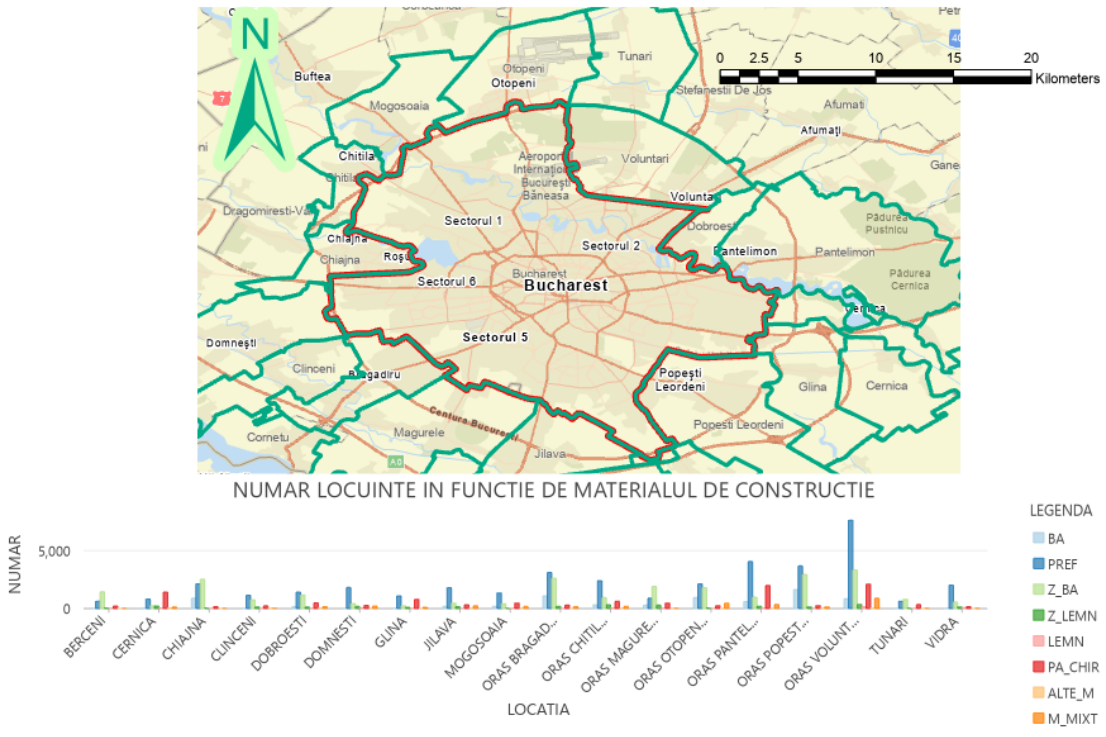


Figure 14 – Urban Expansion (Bucharest) Trends.Earth 30m Dataset

7. THE TERRITORIAL OBSERVATORY

The Territorial Observatory [28] is a geoportal developed through a project of the Ministry of Development, Public Works and Administration (MDLPA) together with Esri Romania. In the interactive computer application, data were integrated for data analysis in territorial profile and quantifications of the territorial impact of public programs in the field of spatial planning, urbanism, housing and regional development, which is exactly what would be needed at present, in the context of PNRR and sustainable urban development. The application offered the possibility to develop its own approaches, using the ArcGIS Online platform, but also by downloading the data, in Esri Gdb or MS Excel xls format. By accessing the dashboard UAT Sheet – Sheet of the administrative-territorial unit, the indicators of interest were quickly highlighted. From this context one could clearly extract the degree of urbanization of an area, and highlights the advantages of the degree of urbanisation. Some updates seem to be made in April 2021, according to the website. The application allowed the analysis of data in territorial profile and quantifications of the territorial impact of public programs in the field of spatial planning, urbanism, housing and regional development, through a geographical information system and a database that includes information and statistical data necessary for the characterization of a territory, highlighting the dynamics of regional and local development throughout Romania. Data integrated in the geoportal are: geographical elements and administrative organization, demography and population, housing, intrastructure and social services, economic development, spatial planning and urban planning. In figure 15 is an analysis based on these data, regarding the building material in the peri-urban areas of Bucharest.



[28]

Figure 15 – Analysis regarding the type of materials used for constructions in the communes around Bucharest (ArcGIS Pro - Data given from the Territorial Observatory)

There is possible to analyze General Urban Plan existence and expiration date, and also to download it. (figure 16)

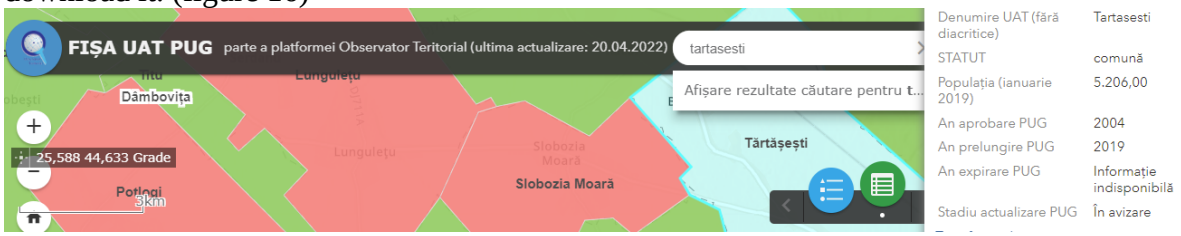


Figure 16 – Availability of General Urban Plan in Territorial Observatory Geoportal

8. DISCUSSION

The right distinction must be made between what means open geospatial data provided by an authority and open geospatial data created including through crowdsourcing, as VGI initiatives. This aspect is important because the first type of data involves assuming the elements of data quality, and the second type of data still remains difficult to evaluate in terms of quality elements, mainly due to heterogeneity and because data is collected by non-professional volunteers working independently, without coordination and following certain standards in terms of data collection, verification, and use.

The advantages of providing specific high-value open datasets are to generate important socio-economic or environmental benefits and innovative services for a large number of users, especially SMEs, to help generate revenue and to be combined with other datasets.

The challenges involved in this approach, however, consist in the pressure on public institutions, which will be generated by the requests for access to this data. Although it is envisaged that public institutions are encouraged to produce and make available documents in accordance with the principle of 'openness by design and by default', public entities must make the dynamic data they hold available to potential users for re-use, immediately after collection, by means of appropriate APIs and where appropriate, by mass unloading. A critical element will be the updating of data, a resource-consuming activity.

A good example of a successful project form Romania, but which has not been funded further, is in this respect the Territorial Observatory. This was an application coordinated by a ministry that coordinates capacity-building assistance and compiles and analyzes urban indicator data to assess national trends and needs. Local urban observatories are also mentioned by UN-Habitat and are comprised of a consortium of local stakeholders coordinated by a municipal government office, university research center, community-based organization or private entity. The main recommendation would be that groups with complementary interests in an urban area to set up one observatory rather than replicate efforts. In fact, in Romania at city hall level there are cities that have developed geospatial data portals, but they only allow searching and not downloading. Another aspect for Romania is the growing need for open geospatial data and the completion of the development of INSPIRE themes, as well as the intensification of the efforts of publishing geospatial data on the datagov.ro portal. This data must be downloadable or used through the services. Gradually, the applications on the ANCPI geoportal will allow more and more the use of data.

Another implication of today's open data paradigm is reflected in training activities, or rather in surveying competence for other disciplines. Thus, the expertise of land surveyors, seen as geospatial experts, should be changed towards statistical issues, data and information analysis and management, knowledge on standards and data quality, accuracy assessment, designing specific informational systems for real estate security, development and management of data using WebApps.

9. CONCLUSIONS

The data regarding the urban footprint and constructions represent only a first step towards the sustainable development of the cities, based on which correlations can be made with the applications that provide environmental attributes of cities. Mayors can use information integrated with land surface temperatures at scale to create policies on target areas within the city that require mitigation measures, such as urban greening. Then they can be further considered and other types of data such as precipitation, soil moisture, surface water quality or quantity, in order to correlate urban development with them.
The applications using Earth Observation Data are valuable tools for decision-makers as city mayors. These possibilities can improve understanding of land use planning, surface water, and resource management planning, as well as the trends in the country's natural capital, which helps define land planning priorities correlated with the the budgetary resources.
In particular, in Romania, along with these possibilities to use this information to substantiate decisions at local level, very good initiatives that have existed over time, such as the Urban Observatory, should also be revitalized. There are legislative initiatives that support open data, therefore, they would need to be found in decisions at the local level.
Initiating legislative changes regarding the availability of open geospatial data is a correct step in this regard, which will lead to sustainable development.

REFERENCES

[1] *Autoritatea pentru Digitalizarea României* - (no date) *Autoritatea Pentru Digitalizarea Romaniei*. Available at: https://www.adr.gov.ro/ (Accessed: 2 April 2022).
[2] Badea, A C, Badea, G (2019). Modern Methods for Spatial Urban Planning, http://revcad.uab.ro/upload/48_737_badea_badea.pdf (last accessed on 25 March 2021)
[3] Badea, A C, Badea, G (2013). The Advantages of Creating Compound GIS Functions for Automated Workflow, 10.5593/SGEM2013/BB2.V1/S11.043
[4] Basiri, A. *et al.* (2019) 'Crowdsourced geospatial data quality: challenges and future directions', *International Journal of Geographical Information Science*, 33(8), pp. 1588–1593. doi:10.1080/13658816.2019.1593422.
[5] Bédard, Y., Wright, E. and Rivest, S. (2015) *A Guide to Geospatial Data Quality*. doi:10.13140/RG.2.1.2819.1763.
[6] Biljecki, F. *et al.* (2021) 'Open government geospatial data on buildings for planning sustainable and resilient cities', *arXiv:2107.04023 [cs]* [Preprint]. Available at: http://arxiv.org/abs/2107.04023 (Accessed: 27 January 2022).
[7] *data.gov.ro* (no date). Available at: https://data.gov.ro/ (Accessed: 27 January 2022).

[8] Centre, E.C.-J.R. (no date) *INSPIRE Geoportal*. Available at: https://inspire-geoportal.ec.europa.eu/ (Accessed: 28 January 2022).
[9] Cetl, V. *et al.* (2019) *New Trends in Geospatial Information: The Land Surveyors Role in the Era of Crowdsourcing and VGI*.
[10] Cho, G. (2014) 'Some legal concerns with the use of crowd-sourced Geospatial Information', *IOP Conference Series: Earth and Environmental Science*, 20, p. 012040. doi:10.1088/1755-1315/20/1/012040.
[11] Coetzee, S. *et al.* (2020) 'Open Geospatial Software and Data: A Review of the Current State and A Perspective into the Future', *ISPRS International Journal of Geo-Information*, 9(2), p. 90. doi:10.3390/ijgi9020090.
[12] Corbane, C., Syrris, V., Sabo, F. et al. (202) 'Convolutional neural networks for global human settlements mapping from Sentinel-2 satellite imagery' *Neural Comput & Applic* 33, 6697–6720. https://doi.org/10.1007/s00521-020-05449-7
[13] *Crowdsourced Geospatial Data — Federal Geographic Data Committee* (no date). Available at: https://www.fgdc.gov/topics/crowdsourcing (Accessed: 27 January 2022).
[14] *Data Quality: Geospatial Data Quality – Basic concepts* (no date). Available at: https://www.geo-train.eu/mod/page/view.php?id=66 (Accessed: 28 January 2022).
[15] *eterra* (no date). Available at: https://eterra.ancpi.ro/eterra/#/login (Accessed: 28 January 2022).
[16] European Commission. Joint Research Centre. (2021) *Non-commercial Light Detection and Ranging (LiDAR) data in Europe.* LU: Publications Office. Available at: https://data.europa.eu/doi/10.2760/212427 (Accessed: 28 January 2022).
[17] *EuroSDR Workshop Crowdsourcing in National Mapping – Building a VGI Map of Europe 2020 | EuroGeographics* (no date). Available at: https://eurogeographics.org/calendar-event/eurosdr-workshop-crowdsourcing-in-national-mapping-building-a-vgi-map-of-europe-2020/ (Accessed: 27 January 2022).
[18] Fritz, S. *et al.* (2017) 'A global dataset of crowdsourced land cover and land use reference data', *Scientific Data*, 4(1), p. 170075. doi:10.1038/sdata.2017.75.
[19] *Crowdsourced geospatial data quality: challenges and future directions* (no date). Available at: https://www.tandfonline.com/doi/full/10.1080/13658816.2019.1593422 (Accessed: 27 January 2022).
[20] *Geoportal ANCPI* (no date). Available at: https://geoportal.ancpi.ro/portal/home/ (Accessed: 27 January 2022).
[21] Global Facility for Disaster Reduction and Recovery (2018) *Identifying Success Factors in Crowdsourced Geographic Information Use in Government*. World Bank, Washington, DC. doi:10.1596/32195.
[22] 'Guvernul României a aprobat Proiectul de Lege privind datele deschise și reutilizarea informațiilor din sectorul public, inițiat de ADR și MCID' (2022) *Autoritatea Pentru Digitalizarea Romaniei*Available at: https://www.adr.gov.ro/guvernul-romaniei-a-

aprobat-proiectul-de-lege-privind-datele-deschise-si-reutilizarea-informatiilor-din-sectorul-public-initiat-de-adr-si-mcid/ (Accessed: 2 April 2022).
[23] Heipke, C. (2010) 'Crowdsourcing geospatial data', *ISPRS Journal of Photogrammetry and Remote Sensing*, 65(6), pp. 550–557. doi:10.1016/j.isprsjprs.2010.06.005.
[24] International Federation of Surveyors (2019) *The land surveyors role in the Era of crowdsourcing and VGI: new trends in geospatial information : current state and practices within the land surveying, mapping and geo-science communities*. Frederiksberg: The International Federation of Surveyors (FIG).
[25] Kavvada, A., Mwaniki, D., Kemper, T., Tuholske, C., Moreno, S., Mudau, N., Gerasopoulos, E. (2022) *'Earth Observations Toolkit for Sustainable Cities and Human Settlements'*.
[26] Lab, U.A. (2021) *Open Government Building Data, Urban Analytics Lab | Singapore*. Available at: https://ual.sg/project/ogbd/ (Accessed: 28 January 2022).
[27] Minghini, M. *et al.* (2020) 'Geospatial openness: from software to standards & data', *Open Geospatial Data, Software and Standards*, 5(1), p. 1. doi:10.1186/s40965-020-0074-y.
[28] *Observatorul Teritorial | Ministerul Dezvoltării Regionale și Administrației Publice* (no date). Available at: https://ot.mdrap.ro/website/maps/ (Accessed: 27 January 2022).
[29] Östman, A. and Ab, N. (2007) 'Geospatial data quality – Basic concepts', Available at: https://inspire.ec.europa.eu/ (Accessed: 27 January 2022).
[30] Prakash, M., Ramage, S., Kavvada, A., & Goodman, S. (2020). *Open Earth Observations for Sustainable Urban Development*. Remote Sensing, 12(10), 1646. https://doi.org/10.3390/rs12101646 (Accessed: 29 April 2022).
[31] Publications Office of the European Union. (2022) *Open data maturity report 2021*. LU: Publications Office. Available at: https://data.europa.eu/doi/10.2830/394148 (Accessed: 1 April 2022).
[32] Publications Office of the European Union., Capgemini Invent., and European Data Portal. (2020) *The economic benefits of open data*. LU: Publications Office. Available at: https://data.europa.eu/doi/10.2830/081754 (Accessed: 1 April 2022).
[33] *The Home of Location Technology Innovation and Collaboration | OGC* (no date). Available at: https://www.ogc.org/ (Accessed: 27 January 2022).
[34] Vahidnia, M.H. and Vahidi, H. (2021) 'Open Community-Based Crowdsourcing Geoportal for Earth Observation Products: A Model Design and Prototype Implementation', *ISPRS International Journal of Geo-Information*, 10(1), p. 24. doi:10.3390/ijgi10010024.
[35] Walter, C. (no date) 'Future trends in geospatial information management: the five to ten year vision', p. 82.

[36] https://www.adr.gov.ro/wp-content/uploads/2022/03/Planul_National_de_Redresare_si_Rezilienta_PNRR_final.pdf (Accessed: 3 April 2022).
[37] https://www.iso.org/standards.html (Accessed: 4 April 2022).
[38] https://www.ogc.org/docs/is (Accessed: 4 April 2022).
[39] https://www.w3.org/standards/ (Accessed: 4 April 2022).
[40] https://sdgs.un.org/goals (Accessed: 4 April 2022).
[41] https://unhabitat.org/sites/default/files/2020/06/urban_observatory_guide.pdf (Accessed: 4 April 2022).
[42] https://land.copernicus.eu/ (Accessed: 4 April 2022).
[43] https://unhabitat.org/ (Accessed: 4 April 2022).
[44] https://ghsl.jrc.ec.europa.eu/ (Accessed: 4 April 2022).
[45] https://eo4sdg.org/ (Accessed: 4 April 2022).
[46] https://gadm.org/data.html (Accessed: 5 April 2022).
[47] https://index.okfn.org/place/ (Accessed: 5 April 2022)
[48] https://resourcewatch.org/ (Accessed: 10 April 2022)
[49] https://www.diva-gis.org/ (Accessed: 11 April 2022)
[50] https://data.world/ (Accessed: 11 April 2022)
[51] https://trends.earth/ (Accessed: 28 April 2022)

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