Journal of Scientific & Industrial Research
Vol. 82, July 2023, pp. 711-720
DOI: 10.56042/jsir.v82i07.472

Utilization of Open Government Data for Environmental Protection

Žaklina Spalević[1], Petar Milić[2]*, Nataša Veljković[3], Violeta Milićević[4] & Srđan Milosavljević[5]

[1]Singidunum University, Danijelova 32, 11000 Belgrade, Serbia

[2]University of Pristina – Kosovska Mitrovica, Faculty of Technical Sciences, Knjaza Miloša 7, 38220 Kosovska Mitrovica, Serbia

[3]University of Niš, Faculty of Electronic Engineering, Aleksandra Medvedeva 14, 18000 Niš, Serbia

[4]Toplica Academy of Applied Studies, Ćirila i Metodija, 18400 Prokuplje, Serbia

[5]University of Pristina – Kosovska Mitrovica, Faculty of Economics, Kolašinska, 38220 Kosovska Mitrovica, Serbia

Received 11 April 2023; revised 10 June 2023; accepted 16 June 2023

Successful exploitation of Open Government Data (OGD) in domain of environment and environmental protection requires development of the regulations and methods for assessment of quality of OGD with the aim to promote innovation in the public sector and pave the way towards the achievement of smarter government services. OGD have huge potential in this regard. This paper focuses on the assessment of how quality aspect of OGD influences their utilization for obtaining useful information needed for enhancing environmental protection. Our evaluation considers factors such as dataset quality, information value, smartness, and legislative compliance. Research findings suggest that open government datasets pertaining to environmental protection require further refinement to improve their information gain. Furthermore, we discuss legal aspect of open data provision as a valuable factor which can contribute to the successful adoption of open data for environmental protection.

Keywords: Environmental data, Dataset quality, Legislation, Open government data, Quality assessment

Introduction

Open government data (OGD) offers effective dissemination of wealth of data to variety of stakeholders such as citizens, business or researchers. Existence of these free data contributes to the achievement of openness and transparency of governments, stimulation of innovation, as well as creation of value-added services. The successful adoption of OGD includes proactive participation of all stakeholders establishing thus resilient data consumption chains and creating sustainable value. Furthermore, areas such as environmental protection, agriculture, transportation and others can be equipped with OGD with aim of production of promising smart solutions.[1] They are not solely about being obtainable, but also oriented towards easy accessibility, well-known and open to everyone. Data publishing is only the first step. What comes after is the supply of data towards creation of opportunities for users to go beyond passive recipients.[1]

However, we must be aware of impediments regarding OGD use. According to Chokki *et al.*[2], among impediments that limit the proper adoption of OGD, unawareness of citizens' of the usefulness of OGD is the most common. This impediment is closely coupled with motivational, social or social factors (e.g., low interest of citizens in getting involved with OGD) or technical factors (e.g., few platforms demonstrate to citizens the usefulness of OGD). In order to overcome technical factors of OGD usage and adoption, identification of requirements for the design of a usable tool that can facilitate OGD exploitation must be carried on.

Proper addressing of usefulness deficiencies of OGD should be carried through compliance with open data principles regarding data discoverability, accessibility and reusability from users' perspective. Through mix of two approaches, on one side from OGD quality and data quality management on another which consider the actual quality of the data, valuable insights and recommendations how to achieve higher OGD quality can be obtained by their stakeholders. They can emphasize which OGD barriers of technical, institutional and legal level for unrestricted access and reusability of OGD should be improved. Not checking whether they are of adequate level of quality and assuming that they are checked by data suppliers[3], it

*Author for Correspondence
E-mail: petar.milic@pr.ac.rs

becomes clear why it is important for OGD to be of high quality and trustable before consumption.

The OGD behaves like catalyst of open innovation in the public sector.[4] Catalyzation of this innovation mostly goes through web-based open government data platforms which facilitates third-party access to public data collected via sensors, IoT, real-time and open data. OGD must be accompanied by appropriate legislation[5]. Legislation related with open government data refers to the legal aspects of citizens and other stakeholders as well, right to access and use government data and data categories which are automatically published. Indeed, legislation deals with ensuring high-value datasets[6] which is not only about availability and comply with open data principles, but also be of value, i.e., of interest for reuse by the end-user. It is worth mentioning that according to the EU Directive 2019/1024 of the European Parliament and of the Council of 20 June 2019, environmental data are considered as of high value. Moreover, in this way effective cooperation between all actors in OGD ecosystem is promoted, including also context, standards of interoperability and an access network available for all in the ecosystem.[7]

Interesting area of application of the OGD is environmental protection. Marques da Silva *et al.*[8] have shown how it can be utilized for this purpose. Of course, OGD should be accompanied with adequate level of quality in order to be able to provide valuable source of information extraction. OGD about environment, collected through different ways, real-time sensor data, IoT (Internet of Things) and statistical data will enable creation of smart services for improvement of citizens' life. For example, availability of these data, can force researchers to reveal possible connection between air pollution with respiratory diseases.[9] Thus, OGD can be seen as an important technological paradigm for achievement and provision of smart services which are more responsive and accessible to citizens.

Related Work

Innovation in the public sectors through adopting and utilization of OGD and IT technologies represents a large arena for innovation and trajectory for achievement of smartness in offering governmental services. Emerging technologies such as IoT can be leveraged in public sector innovation. Research of Velsberg *et al.*[10], showed that IoT can be adequately exploited for creation and delivery of smart winter road maintenance. Data were collected in real-time and stored for the purpose of optimization of driving directions, visualization of the movement of the vehicles, proper maintenance of the roads etc. Hence, these outputs go towards increased protection. Making Open Government Data available on topics such as air quality, waste management, water quality, soil, and other related areas through the utilization of advanced technology devices like sensors and actuators, is crucial in propelling a city towards becoming smart.[11] Therefore, a crucial aspect of citizens' needs is the provision of a smart environment for their daily lives, achieved by developing intelligent services in areas such as ecology, environment, transportation, and more. Fortes *et al.*[12] bring interesting aspect of utilization of 'smart' environment data. Namely, they claim that such a case can be viewed as urban-lab which can attract innovative educational and research activities, which can be key factors to the valid development of the smart-cities of the future. Collection of these data is also performed through sensor networks which are considered as the main driver of OGD platforms.[4] Sensor networks serve as important contributors to OGD platforms, as sensor nodes communicate with each other to detect and monitor various environmental conditions. Similarly, Hrustek *et al.*[7] reveal that proper data governance in the field of agriculture can reinforce the usability of this data for solving relevant sectoral problems. Sebestyen *et al.*[13] contribute to this topic by proposing methodology for data-driven decision support tool for the preparation and monitoring of long-term environmental policies by utilization of World Bank open data. The incorporation of OGD in conjunction with expert knowledge guarantees the achievement of sustainable development goals. This involves assessing the effectiveness of smart solutions and evaluating their impact and contribution towards broader objectives such as environmental, economic, and social sustainability.[14]

Simply relating concept of smartness with OGD accuracy is not enough to deem essentially good data as high-quality data. Qualitative specification of OGD by using Likert scale to collect respondents' attitudes and opinions, not only identify gaps, but also for ranking purposes (i.e. degrees of goodness or badness) in the light of feedback and requests, can help in definition of OGD as proposed by Nikiforova.[15] Bridging these gaps will have positive impact in consumption of OGD which is a prerequisite for establishing an active open data

ecosystem in smart environment. Keeping this in mind, it is important to have adequate information about OGD which is responsibility of the publisher. This is in line with research of Veljković *et al.*[16] who claim that OGD understandability go toward clarity of data, which is the principle that users should grasp the information contained. Without proper OGD quality management, data may contain anomalies which can throttle its exploitation and lead to misinterpretation.[3]

If the published data are oriented toward machine-readable format, they are consequently considered as OGD, and represent an effective method for their utilization. This facilitates the processing of large volumes of data, particularly in web-based environments, and provides extensive opportunities for customized and interactive visualization.[17] Nowadays, environmental datasets continue to grow, increasing at the same time the demand for data science. Data science is capable to add and extract more value from environmental data[18], even in case they contain noisy or lower quality data.[19] Not to forget the work of Demuzere *et al.*[20] who reveals the possibilities of application of machine learning approach on best ways for acquiring, evaluation, and deployment of urban data in support of climate science. In comparison against independent global and open-source databases reflecting urban forms and functions, they found correlation between OGD and local climate zones. Special attention should be paid to the power of the Artificial Intelligence (AI) in processing OGD for environmental protection which lies in predictive modeling and pattern recognition. AI algorithms can analyze historical and real-time data to identify trends, correlations, and anomalies that might not be immediately apparent to human observers.[21] For instance, AI can process OGD on air pollution levels, meteorological conditions, and geographical factors to predict areas at high risk of experiencing poor air quality. Such predictive models can help environmental agencies in implementing targeted measures, such as adjusting traffic flow or implementing emission control policies, to mitigate environmental hazards. By combining the strengths of AI and open government data, a more sustainable services can be built, where environmental decision-making is driven by data-driven insights, informed policies, and proactive conservation efforts.

Successful and appropriate exploitation of OGD and e-government services in area of environment protection must be followed by adequate regulations. According to the work of Sharifbaevich, the use of digital technologies in the environmental sector leads to the generation of vast amounts of data, which creates new opportunities for legislation to be developed.[22] Moreover, its evaluation against FAIR[23] principles could be exploited in order to reveal readiness for immediate exploitation. Aligning to FAIR governance can help for trustworthy, broadly representative, appropriately scoped and sustainable open environmental data.

There is an increasing number of initiatives that promote the opening of environmental data, where, in Serbia, for example, Green Agenda for the Western Balkans program[24], funded by the European Union, encourages the exchange of environmental data in the region and promotes their opening to the public. Also, in the Republic of Croatia there is a national Open Data Program[25] that promotes open data in various sectors, including environmental protection. There are number of initiatives and projects that deal with open data in this area, such as the "Eco-Network" project created by the Government of the Republic of Croatia[26], which is aimed at raising awareness about environmental protection in Croatia, defining, labeling and preserving the natural features of those areas. The European Union has large number of laws and initiatives that regulate open data in the field of environmental protection. Among the most important laws is the General Data Protection Regulation (GDPR - General Data Protection Regulation)[27], which protects the privacy of individuals in the European Union and establishes conditions for the collection, processing and publication of data. The European Commission's Open Data Strategy 2020–2025, addresses open data issues in various sectors, including environmental protection. This strategy promotes the opening of data from the public sector, public companies and the private sector, as well as the exchange of data between member states and EU institutions.[28] When it comes to legal regulations, the European Union also has a Directive on access to information on the environment[29], which establishes the obligation of authorities to provide the public with information on the environment, as well as a directive on greenhouse gas emissions that requires member states to collect and publish data on greenhouse gas emissions, as well as systematize them in hierarchically organized databases. Based on the Freedom of Information Act – FOIA[30] adopted in the USA which provides access to information collected by federal agencies, including environmental data, data on the state of the environment is collected and

stored in databases that represent documents from of public importance. The Act itself (FOIA) mandates that federal agencies release information that is in the public interest, and environmental data has in most cases been considered as information in the public interest. However, there are a few exceptions that federal agencies can use to deny a request for information, particularly in areas where facilities of national security importance are located.

Keeping in mind all previously stated, it can be noticed that there is a research gap that almost none of the studies deals with the readiness towards use of OGD in relation with environmental protection. This triggered us to conduct a study, with aim to try to assess the quality of OGD provided in the area of environmental protection with aim to check whether published OGD are valuable for further reuse. Furthermore, we attempted to describe how quality aspect of OGD influences their utilization for obtaining useful information about environment and how they impact its usability. Here we must mention that high quality OGD will better reflect real-world phenomena and contribute to the optimal decision making. Data-based decision making nowadays is key enabler for increasing the quality of public decisions. Also, we consider the legal aspect of open data provision as a valuable factor which can contribute to the successful adoption of open data for environmental protection. These aspect of provision of the OGD that we found in literature, doesn't deal with quality features for which we are convinced that can shape OGD in right direction.

Materials and Methods

An Approach to Accessing OGD Support for Environmental Protection via OGD Platforms

The objective of this approach is to determine whether OGD can effectively support environmental protection. We researched the readiness towards use of OGD in creation of smart environmental protection services and applications. Additionally, we aim to investigate the impact of OGD on the adoption of modern solutions in this field, as well as determine whether OGD platforms are fully utilized to provide the necessary conditions for proper utilization of OGD in researched domain. The approach is comprised of several building blocks, which will be elaborated in detail in the subsequent paragraphs.

As depicted in Fig. 1, the first step in proposed approach is selection of OGD from various open data portals. For this purpose, we have developed a software tool which takes ODP's API endpoints and performs selection and sampling of datasets. Taking the full scope was expensive and unnecessary operation, therefore we decided to use statistical approach[1,31] that can ensure a reliable method for sample size calculation with given constraints.

The next step is selection of tags and formats of datasets for analysis. Tags are crucial component of our approach as according to them we examine belonging of datasets to desired group. Tags such as *'environment', 'environmental protection', 'air quality', 'air pollution', 'waste', 'waste management', 'water quality', 'sensor data', 'soil quality', 'geology', 'life-environment', 'life environment', 'exploatation-fields', 'investigation-fields', 'landfills', 'wild-landfills', 'landfill-register', 'pollution-source-register', 'municipal-waste', 'waste-transportation-routes', 'environment-protection', 'clean-water-and-sanitary-conditions', 'trash-cans'* are widely used across portals to mark the data related with environment and its protection as well. In the reminder of this paper, we will refer to them as environmental protection tags (ENVP). Keeping in mind that there are many OGD platforms

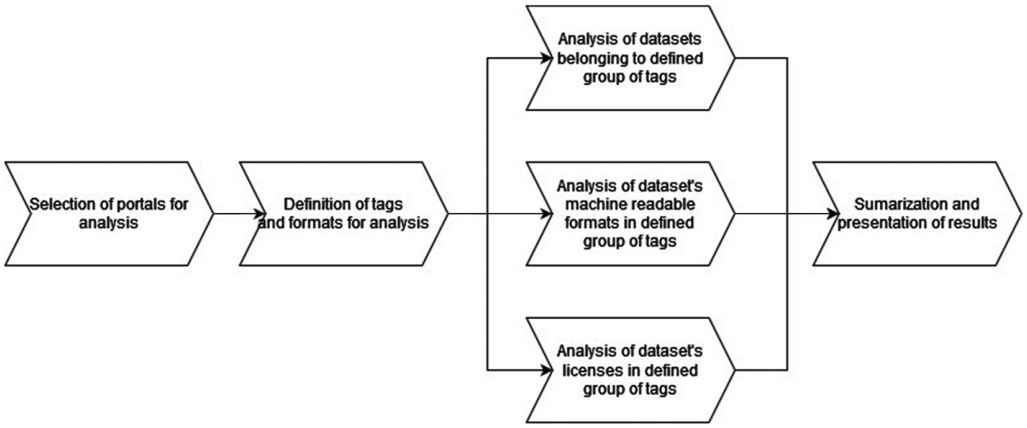

Fig. 1 — Steps in analysis of OGD support for environmental protection on OGD platforms

which publishes OGD either on English or their own natural languages, for each OGD portal used in assessment these tags are additionally translated to their languages by using publicly available dictionaries. At the same time, examination of dataset formats is conducted. More precisely, in our analysis we consider only machine-readable formats – only those are compliant with the definition and principles of OGD.

Machine readable formats are independent of the OGD portal used in analysis, and for this purpose we have identified following formats: *csv, xml, json, tsv, rdf, kml, rdfa, turtle, n-triples*. It is worth mentioning that assessment whether dataset contains machine readable formats is conducted only on datasets that belong to at least one tag from the environmental tags list. The next step in the proposed approach is to verify the proper licensing of the analyzed datasets. This involves reviewing whether the OGD is genuinely open or only available on request. Typically, OGD is free from licensing and available without any constraints. As we can conclude from the third step, it executes in parallel each of previously described tasks, belonging of datasets to defined categories, determination of representation of machine-processable dataset formats, as well as analysis of applied licenses over OGD. The final step involves summarizing and presenting the results, through best practices of information presentation that allows capturing the information quickly and correctly.

Results and Discussion

Based on their popularity and widespread usage for publishing OGD we have selected the following platforms: uData (https://github.com/opendatateam/udata), CKAN (https://ckan.org), DKAN (https://getdkan.org), SOCRATA (https://dev.socrata.com) and OpenDataSoft (https://www.opendatasoft.com). In the following step, we opted for up to 15 portals for each platform, except for the uData platform, which is relatively new and only has four portals. Portals were reviewed to select only those that represent OGD portals, as previously mentioned platforms serves also for publishing open data which are not OGD. We used a predetermined list of environmental tags to analyze the datasets on the selected OGD portals, and we also verified the dataset formats using a predetermined list of machine-readable formats. To save time and streamline the analysis of OGD, we employed statistical sampling of the datasets. Time period in which we conducted this analysis was in March 2023. In the Table 1, the list of selected OGD portals per platform is shown, while Table 2 shows our findings on datasets with ENVP tags.

From the Table 2 it can be revealed that presented results for uData platform are expected. uData is relatively new OGD platform and therefore this is somewhat expected result. Open Data Soft OGD platform has high ratio of failure in publishing ENVP datasets. Interesting finding is that there are only four OGD portals with more than 10% of published datasets related with environmental protection issues: Canada's national OGD portal, Ireland's national OGD portal, NovaScotia OGD portal in Canada and Bristol OGD portal in the UK. Ratio of ENVP datasets against total number of datasets per platform is depicted in Fig. 2. Best results achieved uData platform followed by CKAN, while DKAN has the lowest score. The uData platform, which is relatively new, addresses certain limitations of existing open-source and commercial OGD platforms. These include performance issues, a user-friendly interface, and superior API support. Info on which platform provides publication of machine-readable ENVP datasets is given in Fig. 3.

The platforms that stand out in terms of average number of machine-readable formats per ENVP dataset are SOCRATA and OpenDataSoft. This is due to the fact that they have dedicated API for accessing published data. Moreover, their orientation towards publishing data in tabular format and allowing users to export the data in different machine-readable formats such as CSV, JSON, XML, and RDF, clearly explains obtained results. In cases where the ratio of ENVP datasets to the total number of datasets is zero, the results for machine-readable formats assessments and licensed datasets are also zero. Nonetheless, some portals display results lower than 100%, indicating that not all ENVP datasets have machine-readable formats. These limitations may slow down the full exploitation of OGD potential in the defined area. A similar trend is observed for the ratio of licensed ENVP datasets, suggesting that not all datasets are entirely open.

Theoretical Considerations

Legal Aspects of Provision of Open Government Data for Environmental Protection

Open data in the field of environmental protection represents an important aspect of transparency and responsibility of authorities and can be of great benefit

Table 1 — List of examined OGD portals

platform	No.	portal
uData	1	https://data.gov.rs/api/1/datasets
	2	https://dados.gov.pt/api/1/datasets
	3	https://data.public.lu/api/1/datasets/
	4	https://www.data.gouv.fr/api/1/datasets/
CKAN	5	https://ckan.publishing.service.gov.uk/api/3/action/package_list
	6	https://open.canada.ca/data/api/3/action/package_list
	7	https://ckan.opendata.swiss/api/3/action/package_list
	8	https://datos.gob.mx/busca/api/3/action/package_list
	9	https://data.go.th/api/action/package_list
	10	https://data.gov.au/api/3/action/package_list
	11	https://www.govdata.de/ckan/api/3/action/package_list
	12	https://open.africa/api/3/action/package_list
	13	https://data.gov.ie/api/3/action/package_list
	14	https://data.humdata.org/api/3/action/package_list
	15	https://data.gov.ro/api/3/action/package_list
	16	https://data.gov.sk/api/3/action/package_list
	17	https://dados.gov.br/api/3/action/package_list
	18	https://data.buenosaires.gob.ar/api/3/action/package_list
	19	http://opendata.hu/api/3/action/package_list
DKAN	20	https://data.gov.gh/api/3/action/package_list
	21	https://data.city.kyoto.lg.jp/api/3/action/package_list
	22	https://data.gov.jm/api/3/action/package_list
	23	https://dadesobertes.diba.cat/api/3/action/package_list
	24	https://opendata.by/api/3/action/package_list
	25	http://data.mmr.cz/api/3/action/package_list
	26	https://dati.gov.it/opendata/api/3/action/package_list
	27	https://data.cambridgeshireinsight.org.uk/api/3/action/package_list
	28	https://opendata.transport.nsw.gov.au/api/3/action/package_list
	29	https://datosabiertos.rosario.gob.ar/api/3/action/package_list
	30	https://data.nicva.org/api/3/action/package_list
	31	https://opendata.bonn.de/api/3/action/package_list
	32	https://dati.comune.genova.it/api/3/action/package_list
	33	https://data.louisvilleky.gov/api/3/action/package_list
	34	https://data.gov.sa/Data/en/api/3/action/package_list
SOCRATA	35	https://data.edmonton.ca/api/catalog/v1
	36	https://data.cityofnewyork.us/api/catalog/v1
	37	https://www.dati.lombardia.it/api/catalog/v1
	38	https://data.texas.gov/api/catalog/v1
	39	https://data.honolulu.gov/api/catalog/v1
	40	https://cohesiondata.ec.europa.eu/api/catalog/v1
	41	http://www.datos.gov.co/api/catalog/v1
	42	https://healthdata.gov/api/catalog/v1
	43	http://www.pivcide.pr/api/catalog/v1
	44	http://data.usaid.gov/api/catalog/v1
	45	http://data.sfgov.org/api/catalog/v1
	46	http://citydata.mesaaz.gov/api/catalog/v1
	47	http://data.cincinnati-oh.gov/api/catalog/v1
	48	http://data.novascotia.ca/api/catalog/v1
	49	http://www.data.act.gov.au/api/catalog/v1
OpenDataSoft	50	https://public.opendatasoft.com/api/v2/catalog/datasets
	51	https://data.explore.star.fr/api/v2/catalog/datasets
	52	https://data.laregion.fr/api/v2/catalog/datasets
	53	https://www.data.corsica/api/v2/catalog/datasets
	54	https://opendata.vancouver.ca/api/v2/catalog/datasets
	55	https://ressources.data.sncf.com/api/v2/catalog/datasets
	56	https://opendata.wuerzburg.de/api/v2/catalog/datasets
	57	https://opendata.comune.bologna.it/api/v2/catalog/datasets

(*Contd*.)

Table 1 — List of examined OGD portals (*Contd.*)

58	https://data.gouv.nc/api/v2/catalog/datasets
59	https://transparencia.sns.gov.pt/api/v2/catalog/datasets
60	https://data.education.gouv.fr/api/v2/catalog/datasets
61	https://opendata.bristol.gov.uk/api/v2/catalog/datasets
62	https://data.leicester.gov.uk/api/v2/catalog/datasets
63	https://data.montreuil.fr/api/v2/catalog/datasets
64	https://data.bs.ch/api/v2/catalog/datasets

Table 2 — Results of assessments

Portal No.	Total number of datasets	Ratio of ENV datasets against total number of datasets	Ratio of machine readable formats per ENV dataset	Ratio of licensed ENV datasets
1	2030	4.35%	100%	100%
2	5686	0.65%	50%	100%
3	1740	6.59%	29%	100%
4	45705	3.13%	33%	100%
5	52760	5.21%	50%	100%
6	34038	10.42%	0%	100%
7	7774	1.05%	0%	100%
8	9515	3.16%	100%	100%
9	7912	0%	0%	0%
10	13508	5.26%	46%	100%
11	62812	3.16%	0%	100%
12	6798	2.11%	0%	100%
13	14435	10.53%	23%	100%
14	33558	5.21%	100%	69%
15	3038	1.08%	0%	100%
16	2939	4.30%	62%	100%
17	13685	2.11%	43%	100%
18	430	0%	0%	0%
19	69	2.50%	0%	100%
20	315	0%	0%	0%
21	630	0%	0%	0%
22	32	0%	0%	0%
23	83	3.61%	0%	100%
24	229	0%	0%	0%
25	43	0%	0%	0%
26	56296	7.29%	33%	100%
27	234	1.28%	0%	100%
28	216	1.49%	10%	0%
29	250	0.80%	0%	100%
30	190	1.08%	0%	100%
31	329	1.52%	39%	100%
32	141	0.71%	13%	100%
33	300	2.43%	0%	100%
34	6418	0%	0%	0%
35	2457	2.17%	100%	100%
36	3579	2.13%	100%	100%
37	5635	3.19%	100%	100%
38	5932	3,16%	100%	100%
39	321	0%	0%	0%
40	1171	4.49%	100%	100%
41	10000	1.58%	100%	100%
42	4388	1.06%	100%	100%
43	70	0%	0%	0%
44	1556	3.30%	100%	100%
45	1083	1.14%	100%	100%
46	967	1.15%	100%	100%
47	158	3.33%	100%	100%

(*Contd.*)

Table 2 — Results of assessments (*Contd*.)

Portal No.	Total number of datasets	Ratio of ENV datasets against total number of datasets	Ratio of machine readable formats per ENV dataset	Ratio of licensed ENV datasets
48	1132	16.85%	100%	100%
49	1133	1.12%	100%	100%
50	616	2.38%	100%	100%
51	41	0%	0%	0%
52	1600	0%	0%	0%
53	519	1.23%	100%	95%
54	182	0%	0%	0%
55	215	0%	0%	0%
56	116	0%	0%	0%
57	606	0%	0%	0%
58	143	0%	0%	0%
59	156	0%	0%	0%
60	92	0%	0%	0%
61	237	17.39%	100%	90%
62	213	3.03%	100%	96%
63	156	5.00%	100%	95%
64	179	9.52%	100%	100%

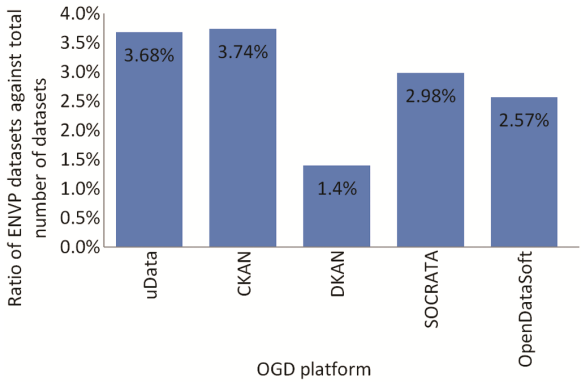

Fig. 2 — Ratio of ENVP datasets against total number of datasets per platform

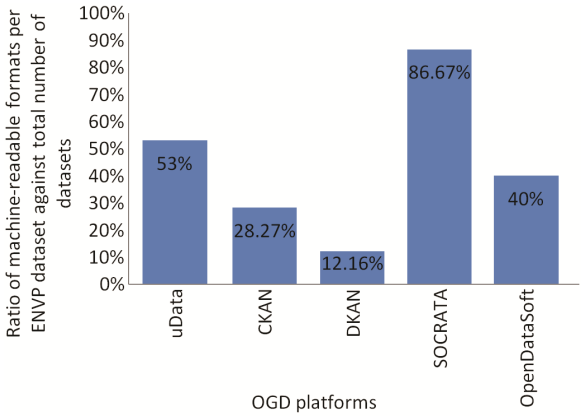

Fig. 3 — Ratio of machine-readable formats per ENVP dataset against total number of datasets per platform

for the preservation and improvement of the environment. The provision of OGD for environmental protection raises several legal issues that must be carefully considered. Firstly, government agencies must ensure that the data they release do not violate any privacy laws or regulations. Personal data, such as information about individuals' health or location, must be protected from public access. Secondly, governments need to ensure that they are not infringing on any intellectual property rights. The datasets must be created either in-house or with proper licenses from third-party data providers. Moreover, governments must adhere to copyright laws and licensing agreements when making data available to the public. Finally, governments must ensure that their release of environmental data complies with any relevant environmental laws and regulations, such as those related to pollution or natural resource management. Therefore, to provide high-quality and legally ENVP data, government agencies must have a clear understanding of their legal obligations and carefully navigate through complex legal issues.

Legal aspects of open data in the field of environmental protection vary depending on the country or region in the world. However, there are several international initiatives and agreements dealing with open data and environmental protection, such as the United Nations Environment Program (UNEP)[32] which is dedicated to promoting sustainable development and environmental protection. UNEP implements a series of programs and projects aimed at collecting and publishing data on the state of the environment, as well as promoting the opening of data in this area.

Another important international agreement is the Aarhus Convention[33] signed by more than 45

countries in Europe, Central Asia and the South Caucasus. The Convention guarantees the public's right to access information about the environment, including the right to access data collected by authorities. The Convention also obliges States to ensure that environmental information is available to the public through various media, including the Internet. Depending on the country or region of the world, there are other laws and initiatives related to the opening of data in the field of environmental protection. In some countries there is an obligation to publish certain data, while in other countries it is not mandatory. However, the trend is that more and more countries are turning to open data in this area, which allows for greater transparency and better management of natural resources.

Conclusions

In this paper, we have revealed that the current level of utilization of OGD in environmental protection falls short of what is possible and necessary. To enable the successful exploitation of OGD in this area, it is essential to develop regulations that promote innovation in the public sector and pave the way towards the achievement of smarter government services. Additionally, we have clearly indicated that it is vital to further improve the publication of environmental data in machine-processable formats, which will make them easier to process and visualize in web environments.

Future research efforts should focus on developing methodologies for in-depth quality checks of OGD datasets published in relation to environmental issues. These efforts will enable more accurate and precise information about the quality of these datasets. Furthermore, detailed assessments of the appropriateness of targeted quality features in light of provided metadata values and thorough data annotation will help to ensure a higher ratio of datasets published in the area of environmental protection. Ultimately, adequate support from data publishers will be crucial in ensuring a positive impact and a higher ratio of high-quality datasets in environmental protection domain.

References

1 Milić P, Veljković N & Stoimenov L, Using OpenGovB transparency indicator to evaluate national open government data, *Sustainability*, **14(3)** (2022) 1 – 16.

2 Chokki A P, Simonofski A, Clarinval A, Frenay B & Vanderose B, Fostering interaction between open government data stakeholders: An exchange platform for citizens, developers and publishers, *Proc of the e-Gov Conf* (Tallinn, Estonia) 2022, 1 – 16.

3 Nikiforova A, Open Data Quality Evaluation: A comparative analysis of open data in Latvia, *Balt J Mod Comput*, **6(4)** (2018) 363 – 386.

4 Domingo A, Bellalta B, Palacin M, Oliver M & Almirall E, Public open sensor data: revolutionizing smart cities. *IEEE Technol Soc Mag*, **32(4)** (2013) 50 – 56.

5 Sallami K, Idlebi N & Nahar M, Legal aspects of open government and open data. *Economic and Social Commission for Western Asia (ESCWA)*, United Nations, Beirut, 2020.

6 Nikiforova A., Rizun N, Ciesielska M, Alexopoulos C & Miletič A, Towards High-Value Datasets determination for data-driven development: a systematic literature review. *Proc of the EGOV 2023 Conf*, (Budapes, Hungary) 2023, 1 – 15.

7 Hrustek L, Tomičić M F, Varga F, Džidić A, van Loenen B & Šalamon D, Towards digital innovation: stakeholder interactions in agricultural data ecosystem in croatia, *Interdisc Desc of Complex Syst*, **20(2)** (2022) 189 – 207.

8 Marques da Silva G D, Bartholomay P, Cruz O G & Garcia L P, Evaluation of data quality, timeliness and acceptability of the tuberculosis surveillance system in Brazil's micro-regions, *Cien Saude Colet*, **22** (2017) 3307 – 3319.

9 Nikiforova A, Smarter open government data for society 5.0: Are your open data smart enough?, *Sensors*, **21(21)** (2021) 1 – 30.

10 Velsberg O, Westergren U H & Jonsson K, Exploring smartness in public sector innovation - creating smart public services with the Internet of Things, *Eur J Inf Syst*, **29(4)** (2020) 350 – 368.

11 Marzouk O A, Compilation of smart cities attributes and quantitative identification of mismatch in rankings, *J Eng*, **2022** (2022) 1 – 13.

12 Fortes S, Santoyo-Ramon J A, Palacios D, Baena E, Mora-Garcia R, Medina M, Mora P & Barco R, The campus as a smart city: University of Málaga environmental, learning, and research approaches, *Sensors*, **9(6)** (2019) 1 – 23.

13 Sebestyen V, Bulla M, Redey A & Abonyi J, Network model-based analysis of the goals, targets and indicators of sustainable development for strategic environmental assessment, *J Environ Manage*, **238** (2019) 126 – 135.

14 Schiavo F T & de Magalhaes C F, Smart sustainable cities: The essentials for managers' and leaders' initiatives within the complex context of differing definitions and assessments, *Smart Cities*, **5(3)** (2022) 994 – 1024.

15 Nikiforova A, Comparative analysis of national open data portals or whether your portal is ready to bring benefits from open data, *Proc of the IADIS Conf on ICT*, *Soc and Hu Bei* (Lisbon, Portugal) 2020, 1 – 9.

16 Veljković N, Bogdanović-Dinić S & Stoimenov L, eGovernment openness index, *Proc of the ECEG* (Ljubljana, Slovenia) 2011, 571 – 577.

17 Vitolo C, Elkhatib Y, Reusser D & Macleod C J A, Web technologies for environmental big data, *Enviro Mod & Soft*, **63** (2015) 185 – 198.

18 Gibert K, Horsburgh J S, Athanasiadis I N & Holmes G, Environmental data science, *Enviro Mod & Soft*, **106** (2018) 4 – 12.

19 Gibert K, Sanchez-Marrie M & Izquierdo J, A Survey on pre-processing techniques in the context of environmental data mining, *Artif Intel in Com*, **29(6)** (2016) 627 – 663.

20 Demuzere M, Kittner J, Martilli A, Mills G, Moede C, Stewart I D, van Vliet J & Bechtel B, A global map of local climate zones to support earth system modelling and urban-scale environmental science, *E Sys Sci D*, **14(8)** (2022) 3835 – 3873.

21 Gao Y, Janssen M & Zhang C, Understanding the evolution of open government data research: towards open data sustainability and smartness. *Int Rev Adm Sci*, **89(1)** (2023) 59 – 75.

22 Sharifbaevich R N, Digitalization of environmental regulation: Legal aspects, *Asian J Soc Human Res*, **3(6)** (2022) 374 – 380.

23 Wilkinson M D, Sansone S A, Méndez E, David R, Dennis R, Hecker D & Jael Castro L, Community-driven governance of FAIRness assessment: an open issue, *An Open Discussion,* (2022).

24 Green Agenda for the Western Balkans, https://api.pks.rs/storage/assets/Zelena%20agenda%20za%20Zapadni%20Balkan_info.pdf (accessed 14 February 2023).

25 Croatia national Open Data Program, https://mint.gov.hr/UserDocsImages/2022_dokumenti/POLITIKA%20OTVORENIH%20PODATAKA.pdf, (accessed 14 February 2023).

26 Regulation on ecological network, *Republic of Croatia: Official Gazette*, No. 124/13, 105/15, 80/19.

27 Regulation on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation), No. 21016/679, *The European Parliament and of The Council*, 27 April 2016, *European Union*.

28 A European strategy for data, Communication From The Commission To The European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions, COM/2020/66 final, 19 February 2020, *European Union*.

29 Directive on public access to environmental information and repealing Council Directive 90/313/EEC, No. 2003/4/EC, The European Parliament and of the Council, 28 January 28 2003, *European Union*.

30 Freedom of Information Act - FOIA, 5 U.S.C. § 552, *Public Law* No. 114 – 185, (2016).

31 Spalević Ž, Veljković N & Milić P, QODA – Methodology and Legislative Background for Assessment of Open Government Datasets Quality, *J Sci Ind Res*, **82(1)** (2023) 38 – 49.

32 United Nations Environment Program (UNEP), https://www.unenvironment.org (accessed 14 February 2023)

33 Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, The United Nations Economic Commission for Europe (UNECE), Denmark: Aarhus, June 25, 1998, https://unece.org/DAM/env/pp/documents/cep43e.pdf (accessed 14 February 2023).