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Assessing the Openness of Spatial Data Infrastructures (SDI): Towards a Map of Open SDI*

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Abstract

This paper introduces the Open Spatial Data Infrastructure (SDI) Assessment Framework as a new approach for assessing the openness of SDIs. Open SDIs are SDIs in which non-government actors such as businesses, citizens, researchers and non-profit organizations can contribute to the development and implementation of the SDI, use spatial data with as few restrictions as possible and benefit from using these geographic data. A pilot application of the new framework resulted in the Map of Open SDI in Europe, which aims to show the level of openness of national SDIs in Europe. The map could become a relevant and practical tool that shows the status of Open SDIs in Europe and supports decision makers and practitioners in making their own SDI more open.

Keywords: Spatial Data Infrastructure, assessment, open data, open SDI

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1. INTRODUCTION

While spatial data infrastructures (SDIs) already exist for many years, technological, institutional and societal developments have caused them to shift towards more open SDIs in which businesses, citizens and other non-governmental actors are also considered as key stakeholders of the infrastructure (Vancauwenberghe and van Loenen, 2018). An SDI can be defined as a collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data (GSDI, 2012). The development and implementation of an open SDI is not only about making spatial data available to the public as open data (i.e. for free without restrictions to everyone), but also about organising and governing the infrastructure in an open manner, enabling and stimulating the participation of non-government actors. Over the past 20 years, a broad range of SDI assessment frameworks has been developed and implemented by SDI researchers and practitioners (e.g. Crompvoets *et al*., 2008). While these frameworks address various aspects and components of SDIs, none of them have investigated the openness of SDIs, and little is known about the extent to which existing SDIs can be considered as open.

Approximately ten years ago, governments started setting up open data initiatives, which led to assessment frameworks being developed and applied to support and monitor the implementation of these initiatives. Since the introduction of the Socrata Open Government Data Benchmark in the U.S. in 2010, many other open data assessment frameworks have been developed and implemented, including the well-known Global Open Data Index (Open Knowledge International, 2017) and the Open Data Barometer (World Wide Web Foundation, 2017). Most of these frameworks have a strong focus on the openness of the data and of the infrastructure, and thus provide a foundation and inspiration for the development of an assessment framework for Open SDIs.

The aim of this paper is to introduce the Open SDI Assessment Framework as an approach for assessing the openness of SDIs. The framework builds further on existing approaches for assessing SDIs and open data, but particularly focuses on the openness of SDIs. To demonstrate the relevance and test the applicability of the Open SDI Assessment Framework, the framework was used to create a Map of Open SDI in Europe, which shows the level of openness of National SDIs in Europe. National SDIs refer to SDIs organised by national level, and are, in reality, often made of many subnational and local SDIs. This paper describes and discusses the main elements of the Open SDI Assessment Framework in Section 2, then shows some potential applications of the framework in Section 3, and finally provides a discussion of how the framework could be further improved in Section 4.

2. ASSESSING OPEN SDIS IN EUROPE

2.1. The Open SDI Assessment Framework

According to Davies (2013), open data assessments can be divided into three assessment categories: (1) readiness assessments, (2) implementation or data assessments, and (3) impact assessments. *Readiness* assessments analyse whether conditions are appropriate, and whether necessary components are in place for opening open government data. *Implementation* or *Data* assessments evaluate whether data are actually available and open. *Impact* assessments explore the extent to which open data initiatives lead to benefits for government, citizens, business and society in general. As an example of an overarching open data assessment, the Open Data Barometer (World Wide Web Foundation, 2017) assesses the readiness, implementation and impact dimensions of open government data initiatives, and integrates these three dimensions of openness into one assessment framework.

Since our aim is to assess the different aspects of Open SDIs in a complete and accurate manner, our Open SDI Assessment Framework builds on the example of the Open Data Barometer and identifies three key dimensions of Open SDIs: Readiness, Data and Impact. In our Open SDI Assessment Framework, *Readiness* focuses on the development and implementation of the SDI, and assesses the extent to which non-government actors can participate in and contribute to developing and implementing the SDI. Non-government actors can be involved in both the governance and implementation of the SDI, and various instruments could support or enable this involvement: a national vision, a strategy on open geographic data, or on opening the SDI, a government-wide open data policy for all geographic data or a governance structure in which also non-government actors are represented. An open SDI also means that non-government actors could add their data to the SDI, thereby making it an infrastructure for sharing all types of geographic data, including government, business, citizen and research data.

The *Data dimension* of our framework deals with the availability and accessibility of geographic data to different types of users including businesses, citizens, non-profit organizations and other users within and outside public administration. The *Data dimension* adds some other requirements to spatial data, in addition to more traditional requirements such as metadata availability, accessibility through discovery, and viewing and downloading services. Users should be able to easily find the data they need, via generic web search services or national data portals. Other important features or characteristics of data in an Open SDI can be derived from open government data principles and existing open data assessments: spatial data should be openly available to anyone, free of charge and openly licensed.

The *Impact dimension* focuses on the benefits of using geographic data for businesses, citizens, non-profit organizations and other actors. In order to realize these benefits, non-government actors should also use geographic data to make more informed decisions, to improve their existing processes, products and services, or to create new products or services. Benefits of using open spatial data include at least three main categories: increased transparency, public participation, economic growth and innovation, but also increased government efficiency and effectiveness.

2.2. Indicators

A pilot application of the Open SDI Assessment Framework resulted in a Map of Open SDI in Europe, which aims to show the status of open SDIs in different European countries and the differences within Europe with regard to the openness of national SDIs. Data for the first prototype of the Map of Open SDI were collected by students of the M.Sc. program in Geomatics at Delft University of Technology. Since data had to be collected in a limited time-span of 4 weeks, only a small set of openness indicators were defined and applied. The evaluators were not professionals of the field nor had expert knowledge concerning national SDIs. Since the students did not assess the SDI of their home country, they mainly relied on information made available in English.

A first set of indicators covering the three dimensions of open SDIs was used to steer the assessment. An overview of the indicators is given in Table 1. The indicators were selected and defined on the basis of a literature survey of existing SDI and open data assessment frameworks. The selected indicators allow for the assessment of the openness of an SDI in terms of its readiness, data and impact. These indicators are different from existing SDI assessments in the sense that they strongly focus on the openness of the infrastructure, i.e. the extent to which stakeholders are involved in and benefit from the development and implementation of the infrastructure. They can be considered as an extension to more traditional SDI assessments, in which the aspect of openness is hardly addressed or even omitted. In open data assessments, the issue of openness is more central, and many of the indicators are derived from existing open data assessments and applied to spatial data infrastructures.

For most indicators, the assessed country was given a score of 0 (low), 0.5 (medium) or 1 (high), indicating how well the country matches the indicator, and can therefore be considered as open with regard to the indicator. For some indicators, only two values were possible: 0 (no/absent) or 1 (yes/present). In the prototype assessment, the scoring for the three dimensions was aggregated from all the underlying indicator scores. For calculating the aggregated scores on the dimensions and on the openness of the SDI in general, all indicators were considered to be equally important, i.e. no weight factors were allocated.

Table 1 Openness indicators used in the Map of Open SDI

Dimension	Openness indicator	Description
Readiness (of the Open SDI)	Open spatial data vision/strategy	Existence of clear vision and/or strategic document on open spatial data *(score: low, medium or high)*
	Open decision making	Participation of non-government actors in decision making on the SDI *(score: low, medium or high)*
	Open data policy	Existence and implementation of open data policy for all geographic data *(score: low, medium or high)*
	Non-government data	Inclusion of spatial data provided by non-government actors in the SDI *(score: low, medium or high)*
Data *(applied to two key datasets)*	Search engine score	Assessment of the easiness for which data could be found using a web search *(score: low or high)*
	Portals	Publication of the dataset on both the national geoportal and open data portal *(score: low, medium or high)*
	Multilangual metadata	Availability of metadata in the national language(s) and in English *(score: no or yes)*
	Online availability	Data are available online without mandatory registration *(score: no or yes)*
	Free of charge	Data are available free of charge *(score: no or yes)*
	Network services	Accessibility of the data via view and download services *(score: no or yes)*
	Open license	Release of the data under an open and international interoperable license *(score: no or yes)*
	Level of interoperability	Data published using open standards and open formats *(score: no or yes)*

Impact (of the Open SDI)	Use	Number of use cases of non-government actors using open spatial data *(score: low, medium or high)*
	Benefits	Existence of studies showing the benefits of open spatial data *(score: no or yes)*

Four openness indicators were defined to measure and assess the readiness of open SDIs: the existence of a vision or strategy on open spatial data, the involvement of non-government actors in decision making on the SDI, the existence of an open spatial data policy and the inclusion of non-government data in the infrastructure. For measuring the availability and accessibility of spatial data, the assessment focused on two high-value spatial datasets: nationwide address data and large-scale topographic data (1:10,000). These datasets were selected as sample datasets because they feature on lists of high-value spatial datasets both from a government perspective (cf. G8 Open Data Charter, 2013; European Commission, 2014) and from a user perspective (e.g. Welle Donker and van Loenen, 2016). For both datasets, eight indicators were used to assess the availability and accessibility, mainly in line with existing assessments on the openness of data. The Impact dimension of Open SDI was assessed through two indicators, which were also derived from existing open data assessments: the number of use cases of non-government actors using open spatial data and the existence of studies showing the benefits of open spatial data. Since each country is assessed on all indicators and thus on all three dimensions (readiness, data and impact), it is possible to investigate the relationships and links between different indicators and between the three dimensions.

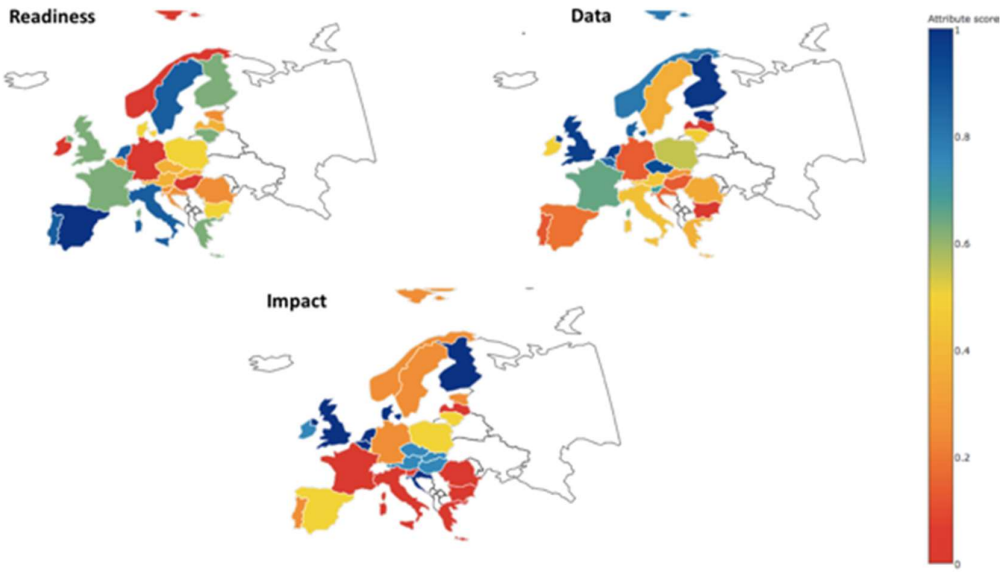
3. APPLYING THE FRAMEWORK: PRELIMINARY RESULTS AND FIRST FINDINGS

Figure 1 shows the first prototype of the Map of Open SDI in Europe based on preliminary data as collected by students, which were afterwards validated by the authors of this paper. This resulted in a full overview of the 28 EU Member States as well as Norway. It should be noted that the prototype was only used to introduce the rationale and approach behind the Open SDI Assessment Framework, since the process of validating the data was still ongoing and the preliminary data contained some missing and incorrect values. Figure 1 shows how the Open SDI Assessment Framework allows for the comparison of countries with respect to the openness of their SDI.

Figure 1 shows three separate maps representing the Readiness, the Data and the Impact dimensions. The maps not only show the differences between countries, but also how the situation within one country can be different for these three

dimensions. While in some countries, the national SDI can be considered to be open with respect to all three dimensions (e.g. Finland, the Netherlands, and the United Kingdom), other countries are doing especially well with respect to one single dimension (e.g. Estonia with its high score on the Data dimension).

Figure 1: Prototype showing the three key dimensions of the Map of Open SDI Europe (dark blue implies fully open, whereas red implies not open)

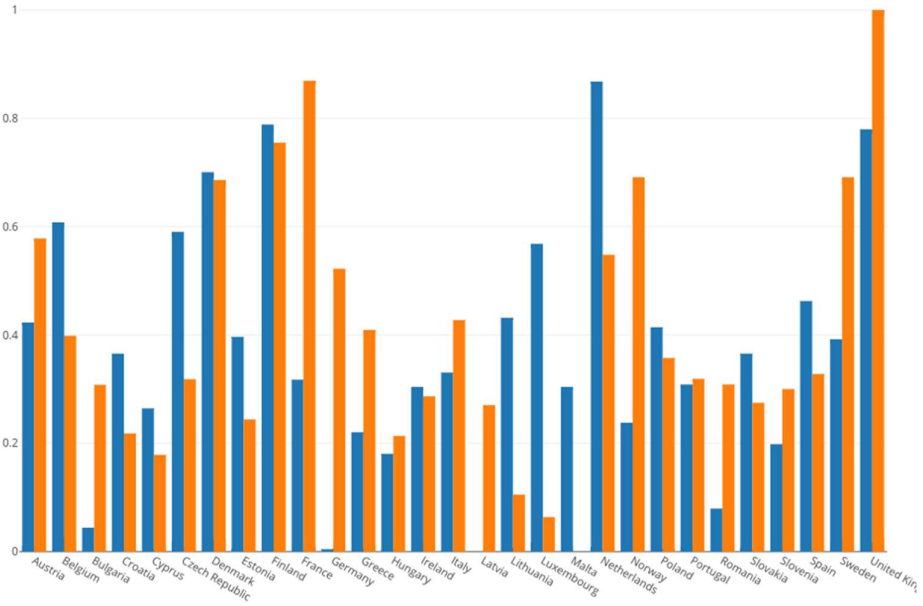


Since the Open SDI Assessment Framework collects data and assesses all three dimensions, it could also be used for analysing the links and relationships between the different dimensions. The Open SDI Assessment Framework may identify differences between the three dimensions of a certain country. It may then raise questions such as "*To what extent does the Readiness of an Open SDI affect the availability and accessibility of spatial data?"* and "*Will an Open SDI only have an impact once it is fully ready and spatial data are available and accessible to all stakeholder groups?"*. The application of the Open SDI Assessment Framework will provide basic insight into the status of the Open SDI. This may result in new insights and new questions to better understand how the openness of the SDI can be improved.

Another illustrative application of the Open SDI Assessment Framework is demonstrated in Figure 2, in which the scoring of the Openness of the SDI is compared with the scoring of the status of open data. The 'open SDI' scoring

aggregates the scores on all three dimensions (readiness, data and impact). The 'open data' scoring presented in Figure 2 is based on an aggregation of the most recent results of the Global Open Data Index (OpenKnowledge International, 2017), the Open Data Barometer (World Wide Web Foundation, 2017) and the European Data Portal Maturity Assessment (Capgemini Consulting, 2016) for each country. Many national open data programs in Europe are driven by the Digital Agenda for Europe (European Commission, 2010) and the Re-use of Public Sector Information Directive (2003/2013), while open spatial data in the EU are also driven by the INSPIRE Directive. This makes it interesting to investigate the correlation between the statuses of open data and open SDIs in Europe by comparing the results of different assessments.

Figure 2: Comparison of results of the Open SDI assessment and Open data assessment *(Open SDI in blue; Open data in orange)*



Although the results presented in Figure 2 should be considered as preliminary and therefore interpreted with prudence, the figure illustrates that in certain countries, both Open SDI and open data appear to be at similar levels (e.g. Denmark), whereas other countries show a clear difference in the status of development (e.g., France and the Netherlands). In a similar manner, a comparison could also be made between the status of Open SDI development and the status of SDI development as defined in traditional SDI assessments. For instance, the results of the official INSPIRE Monitoring process could be used to measure and assess the performance of the SDI in general. Comparing these

results with the results presented here on the openness of the SDI could help us improve our understanding of the extent to which well-performing SDIs are also open SDIs.

4. IMPROVING THE FRAMEWORK

The prototype of the Map of Open SDI in Europe was presented during a workshop at the INSPIRE 2017 conference. The main objectives of this workshop were to introduce the Map of Open SDI as a tool for measuring and assessing the openness of spatial data infrastructures, to discuss the relevance and applicability of the Map, and to collect input from SDI experts and practitioners on how the tool could be further improved. As an introduction to the discussion on the applicability of the Open SDI framework, several experts were invited to present on the concept of Open SDI from their respective backgrounds and experiences. After the experts' presentations, the approach, results and findings of the Map of Open SDI initiative were presented.

In the second part of the workshop, several group discussions were organized on how the existing Open SDI Assessment Framework could be further improved. This was approached by four thematic discussions focusing on the general subject of open SDI and the three dimensions of the proposed assessment framework (readiness, data and impact). The findings were captured by the moderators and further reworked to improve the future implementations of the developed assessment framework.

4.1. General

During the discussion on the framework in general, several ideas on how the framework could be improved or extended were raised. Several participants argued that the Open SDI Assessment could also be an interesting tool for measuring changes over time, i.e. the past as well as ongoing developments, towards a more open SDI in a particular country. In addition, the issue of applying weights to the different components and indicators was discussed. In the first prototype of the Map of Open SDI, the three main dimensions were considered to be equally important; furthermore, all indicators had the same importance or weight for each dimension. Adding weights to the indicators and/or dimensions might be useful to stress the importance of certain indicators or dimensions. For instance, it can be argued that the Data dimension of Open SDI is more relevant and important for measuring the openness of an SDI than the Readiness component, which can be expressed by assigning different weights to both dimensions.

Another way of improving the framework and its application is the integration of data from other assessment initiatives. Several existing SDI assessment approaches and tools, such as the official INSPIRE Monitoring process (European

Commission, 2017), the Spatineo Monitor (Spatineo, 2017) and the recently developed Global Spatial Data Infrastructure Diagnostic Tool (Kelm *et al*., 2017) provide valuable data on the openness of SDIs in Europe. Another suggestion was to integrate the data and results of existing open data assessment initiatives into the Map of Open SDI. Initiatives such as the Global Open Data Index (OpenKnowledge International, 2017) and the Open Data Barometer (World Wide Web Foundation, 2017) assess the availability and accessibility of specific spatial datasets, such as national maps, administrative boundaries, and environmental statistics. Other initiatives, such as the Open Data Impact Map (Open Data for Development Network, 2017), Open Data 500 (OD500 Global Network, 2017), the World Bank Group Open Data Readiness Assessment Tool (World Bank Group, 2017) and the European Data Portal, collect open data use cases, which also include use cases of open spatial data. The relevance of these and other existing assessments, as well as how they could be integrated in the Open SDI Assessment, should be explored further.

4.2. Readiness

Regarding Readiness, the participants uniformly agreed that non-governmental stakeholders are essential for open SDI development. The level of involvement of non-government stakeholders in SDI decision-making was considered to be an important indicator for the openness of an SDI. However, it was commented that stakeholders could participate in decision-making on the SDI in many different aspects. At a more operational level, spatial data users could provide input or interact via the national (geo)portal through data ratings, allowing them to rate the quality of particular datasets, to request governments to publish a dataset that is not yet available, and/or feedback systems on the open data operation in general. At a more strategic level, a decision-making structure could be put in place, in which non-government actors are represented in the central decision-making body, in an advisory council, a coordination unit and/or in working groups focused on a particular topic or domain. These examples illustrate that the subject of whom to involve in SDI development, as well as how to do so, are not straightforward. The indicator on the involvement of non-government actors in SDI decision-making should be further discussed and refined.

4.3. Data

The discussions on Data dimension focused on data access and data dissemination. Since the Map of Open SDI prototype in Europe only assessed two types of spatial data, i.e. nationwide address data and topographic data (1:10,000), the commonly proposed method of improving the framework was to include additional datasets. Some datasets suggested by the workshop participants were orthoimagery data, land cover data and elevation data. In addition to new datasets or data categories, new indicators assessing specific properties of each dataset were suggested. The quality of the data was considered to be especially important,

and indicators could be added on the timeliness and actuality of the data, or on the completeness of the data. In addition, the nationwide criterion of the datasets was questioned. Some federated countries only had the address and topographic data available at the local level (e.g. Germany at Laender-level). For these countries, the local datasets were available, some even as open data, but not as a single dataset at the national level. The indicator should take this into account. Another suggestion made by several experts was to not only focus the assessment on particular datasets, but also to assess the portal(s) through which the data were made available. The proposed indicators were the availability of an application programming interface, the presence of feedback mechanisms for rating or prioritizing datasets, and a general scoring of the easiness to find datasets via a certain portal.

4.4. Impact

In the Map of Open SDI in Europe, the impact of Open SDIs was assessed using two indicators: the existence of use cases of non-government actors using spatial data, and the existence of studies showing the benefits of open spatial data. The workshop participants generally agreed that the Impact dimension of Open SDI was the most difficult to assess. Even national practitioners and experts are still struggling to measure the use of the open spatial data and benefits achieved through open spatial data within their own country. Currently, information on the use and impact of open spatial data are collected through web statistics (e.g. number of visitors and number of downloads), the organization of feedback meetings and events with users and developers, and case studies of particular success stories (business cases). While each of these instruments and approaches provide some insight from one perspective into the use and benefits of open spatial data, a complete and correct view on and assessment of the impact are still missing. Benefits of open spatial data for the public sector are relatively easy to identify and estimate (PWC, 2017; Welle Donker, 2016), but measuring the wider socio-economic benefits in a systematic and comparable manner still proves to challenging. Since approaches to assess and compare the impact of open geographic data across multiple countries are still lacking, the Map of Open SDI could contribute by collecting information on existing approaches for measuring both the use of open geographic data and studying the benefits of open geographic data.

5. CONCLUSIONS

The aim of this paper was to introduce the Open SDI Assessment Framework as an approach for assessing the openness of spatial data infrastructures. To demonstrate the relevance and applicability of the framework, a prototype of a Map of Open SDI was created showing two applications of the framework. The Open SDI Assessment Framework allows for the assessment of the openness of national

SDIs, including their comparison between different countries, as well as the analysis of the evolution towards more open SDIs at both national and European levels, and finally linking this move with ongoing SDI and open data developments. As a pilot application of the Open SDI Assessment Framework, the Map also revealed several ways in which the framework could be improved and extended. Existing indicators should be further refined, the weighing of indicators of the dimensions and between the dimensions may need to be introduced, and new indicators as well as new datasets should be added to the assessment. Moreover, the integration of data collected through other assessment initiatives should be further explored. The application also showed that data collection by external experts, such as such students or local experts, is possible, but requires a very detailed, well-defined and transparent data collection procedure supported by manuals and tools. The main challenge in further development and application of the framework is to avoid subjectivity and errors. The pilot application and the open discussion on the framework during the workshop were the first steps in addressing this challenge.

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