Exploring and defining the Open SDI Concept

SPIDER - open **SP**atial data **I**nfrastructure e**D**ucation n**E**two**R**k

ERASMUS+ Strategic Partnerships Grant 2019-1-DE01-KA203-005042

Subject:	IO 2 Report: Exploring and defining the Open SDI Concept
Creator:	The SPIDER Consortium
Date of publication	2020-06-10
Subject	This document reports on the common understanding of the OpenSDI term and definition – considering the project focus on education
Status	Version 1.0
Licence	Creative Commons Attribution (cc-by)4.0

Co-funded by the Erasmus+ Programme of the European Union

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IO2: Exploring and defining the Open SDI Concept

1 Introduction

The main aim of this second Intellectual Output is to further investigate, develop and explain the Open SDI Concept, by addressing the concept from four different relevant perspectives (research, practice, technology and education) and by integrating views and findings from these perspectives into one integrated definition of a conceptual approach to Open SDI. The Open SDI concept was introduced by several of the researchers involved in this project to characterize and describe ongoing developments towards making the traditionally government focused SDIs more open to non-government actors, including citizens, businesses, NGOs and research and education institutions. The concept already was innovative, since it particularly highlights and investigates the openness of SDI initiatives, i.e. the recognition of non-government actors as key stakeholders in the SDI. This Intellectual Output brings several additional elements of innovation since it will further investigate the Open SDI Concept, by linking it with relevant concepts and developments in different domains: research, practice, technology and education. The Intellectual Output will invite researchers, educators and practitioners to further reflect on this concept, and its relevance and importance to their own field of work. Also, the link with the integration of knowledge from other domains is innovative.

1.1 Purpose

Spatial Data Infrastructures (SDI) are well established in the daily work of many users and providers of geographical information. Those infrastructures comprise technologies, policies and institutional arrangements connecting the geographical data to their users (Abbas Rajabifard et al., 2002; Doug Nebert, 2004). In more detail, a spatial data infrastructure covers actions in following fields (see e.g. Swiss National Spatial Data Infrastructure (e-geo.ch, 2008)):

- **Metadata**: search for relevant data, assessing suitability and quality
- **Technical Infrastructure**: provision of databases, network structures and supporting services
- **Legal Framework**: laws and directives for the provision and use of the infrastructure
- **Education and Research**: training material, courses and supporting research activities
- **Core Services**: provision of interoperable services for access and usage of spatial data
- **Core Data**: well defined basic information datasets for common use – e.g., administrative units or topographic data
- **Standards**: defined service and data standards for an interoperable exchange and usage of data
- **Licenses:** effective and useful license models covering the use, the modification, the dissemination and the accountability
- **Community**: managing the information and knowledge exchange, outreach activities

There are numerous examples of spatial data infrastructures. Most of them are focusing on the provision of governmental data, not only on different hierarchical levels (Abbas Rajabifard et al., 2000) but also for different spatial data domains (e.g. geological information http://www.onegeology.org/),

for specific user groups such as researchers (e.g. https://www.pangaea.de) or even for closed communities like defense (see https://www.dgiwg.org).

Of course, Spatial Data Infrastructures are evolving systems; beside a steady growth of available datasets, metadata and services (see e.g. INSPIRE Summary of Implementation (Cetl et al., 2017)), policies, used standards, technology and architectural patterns change over time. This evolution can be characterized by a three-generation model – from 1st generation SDI ("data-centric") and 2nd generation ("process based") to a "user-centric" 3rd generation of SDI (Hennig & Belgiu, 2011). Following the ongoing discussions (e.g. the current EUROGI debate "Beyond Spatial Data Infrastructures" http://eurogi.org/category/beyond-sdi/), still the common SDIs do not really meet the requirements of different user groups (see, for example, Van Loenen et al. 2014; Welle Donker et al. 2016; Welle Donker et al. 2019) and connections between different user domains are missing (sometimes called 'desilofication' see e.g. https://www.w3.org/2014/03/lgd/report). Influenced by open data initiatives and the FAIR principles for scientific data management, several trends can be found to allow a more "open" usage of spatial information; like adaption of mainstream standards and technologies, using linked data concepts, widening the user communities, inclusion of community data, open licenses and agile patterns for development and policies.

Coetzee et al. (2020) depicted a circle of six components of openness in geospatial information: (1) open source software, (2) open data, (3) open hardware, (4) open standards, (5) open education and (6) open science. Ray et al. (2016) introduced the term "Open SDI" as an SDI using open software, following open standards and providing data according to open data principles allowing data reuse. Vancauwenberghe et al. (2018) used the term "Open SDI" for spatial data infrastructures as concepts that are open for participation by non-government actors and include open data from non-government parties.

1.2 Methodology and Overview

In this intellectual output, different aspects of "openness" are elaborated and discussed according to four different perspectives:

1. Open SDI Research (Chapter 2)
In a study carried out by KU Leuven, relevant literature is selected and investigated in depth. The key developments and open questions related to "openness" of spatial data infrastructures are depicted and current research trends are noted.

2. Open SDI Policies and Practices (Chapter 3)
Following the methodology of their previous work (Vancauwenberghe et al., 2018), TU Delft performed a status-quo estimation on aspects of "openness" in the public SDI initiatives of the partners' countries. The focus is on the readiness of policies and institutional arrangements, the implementation and accessibility of two high value datasets as well as on impact from a user's perspective.

3. Open SDI Technologies (Chapter 4)

University of Zagreb focusses their study on the technical aspects of “openness” for SDI. Especially the current work topics and future agenda of key-driver organizations like OGC will be reflected.

4. Open SDI Education (Chapter 5)
Open Education as a key to “openness” is discussed by Lund University. The situation of open education aspects like available courses, programs, personal exchange and use of open data or software was collected within the consortium.
In addition to this formal approach, an internal discussion on a more personal perspective on “openness” of SDI was started; every partner was asked for a short statement on “What is Open SDI” (see

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Appendix I: Perspectives on Open SDI).

The concluding chapter 7**Error! Reference source not found.** (Approach to Open SDI) picks up key results from chapters 2-5, but also takes the Open SDI statements of the partners into account. Those aspects of “openness” will drive the development of Open SDI education.

3 Open SDI Research

In the past 30 years, public administrations in Europe and worldwide have invested considerable resources in the development and implementation of Spatial Data Infrastructures (SDIs) for promoting, facilitating and coordinating the exchange and sharing of geographic data. SDI research has been an important driver and enabler for SDI development and implementation, as researchers across the world have been exploring various issues around the development and implementation of SDIs. While over the last decade SDIs significantly matured and new researchers and research disciplines entered the domain of SDI research, also new research challenges emerged. The development and implementation of open forms of SDIs could be seen as one of these research challenges. The aim of this chapter is to investigate how SDI research has been dealing with the issue of openness in the past years. An explorative meta-analysis is made of scientific publications on the topic of SDI, in order to identify key topics dealing with openness in the context of SDIs.

3.1 Methodology

For the collection of scientific publications dealing with SDI, a literature search was executed via Web of Science (WoS), on the following terms (as so-called topics):

- spatial data infrastructure(s)
- geospatial data infrastructure(s)
- geographic data infrastructure(s)
- spatial information infrastructure(s)
- geospatial information infrastructure(s)
- geographic information infrastructure(s)

In total 1237 publications were identified, in which any of the above-mentioned terms were included in the title, abstract and/or keywords of the publication. These included 772 articles, 441 proceedings papers and 62 book chapters. An overview of the 20 most prolific source titles on the topic of SDI is provided in Table 2.1.

Table 3.1: Sources on SDI related research

Source title	Source Type	Number of retrieved publications
International Journal Of Spatial Data Infrastructures Research	Journal	78
International Archives Of The Photogrammetry Remote Sensing And Spatial Information Sciences	Conference proceedings	65
Lecture Notes In Computer Science	Conference proceedings	47
Isprs International Journal Of Geo Information	Journal	42

International Journal Of Geographical Information Science	Journal	39
International Journal Of Digital Earth	Journal	33
International Multidisciplinary Scientific Geoconference Sgem		27
Earth Science Informatics	Journal	22
Lecture Notes In Geoinformation And Cartography	Conference proceedings	21
Gim International The Worldwide Magazine For Geomatics	Journal	20
Transactions In Gis	Journal	19
Ieee International Symposium On Geoscience And Remote Sensing Igarss	Conference proceedings	18
Computers Geosciences	Journal	17
Computers Environment And Urban Systems	Journal	14
Geodetski Vestnik	Journal	14
Land Use Policy	Journal	13
Survey Review	Journal	12
Geographic Information Systems Concepts Methodologies Tools And Applications Vol 1	Book	11
Journal Of Spatial Science	Journal	11
Proceedings Of Spie	Conference proceedings	11

The first publication included in the analysis dates from 1991, and in total 28 publications were published before 2000. The peak of publications occurred in 2013, with 118 publications on SDI published that year. Also in 2016 more than 100 publications on SDI were published (104), while a high number of publications also were produced in 2010 (95), 2012 (94), 2015 (97) and 2017 (95). Figure 3.1 shows the distribution of papers per year between 1996 and 2020.

The focus of the analysis in this chapter is on the topics addressed and investigated in these publications on SDI. To better understand the content of SDI research so far and the extent to which the issue of openness has been investigated, we identified and analyzed publications dealing with openness. This was done by investigating publications in which the term ‘open’ is included in the title of the publication, the abstract or as a keyword.

3.2 Presence of openness in SDI research

We identified those publications explicitly dealing with 'openness', by searching for publications in which the term 'open' was included in the title of the publication, the abstract or the keywords. In this way, 285 publications were identified: 37 of these publications had open in the title, in 50 publications open was included in the keywords and in 209 publications the term open was used in the abstract.

Figure 3.1 shows the distribution of the year of publication, by comparing the publications on SDI with the publications on SDI and open (which is a subset of the first group of publications).

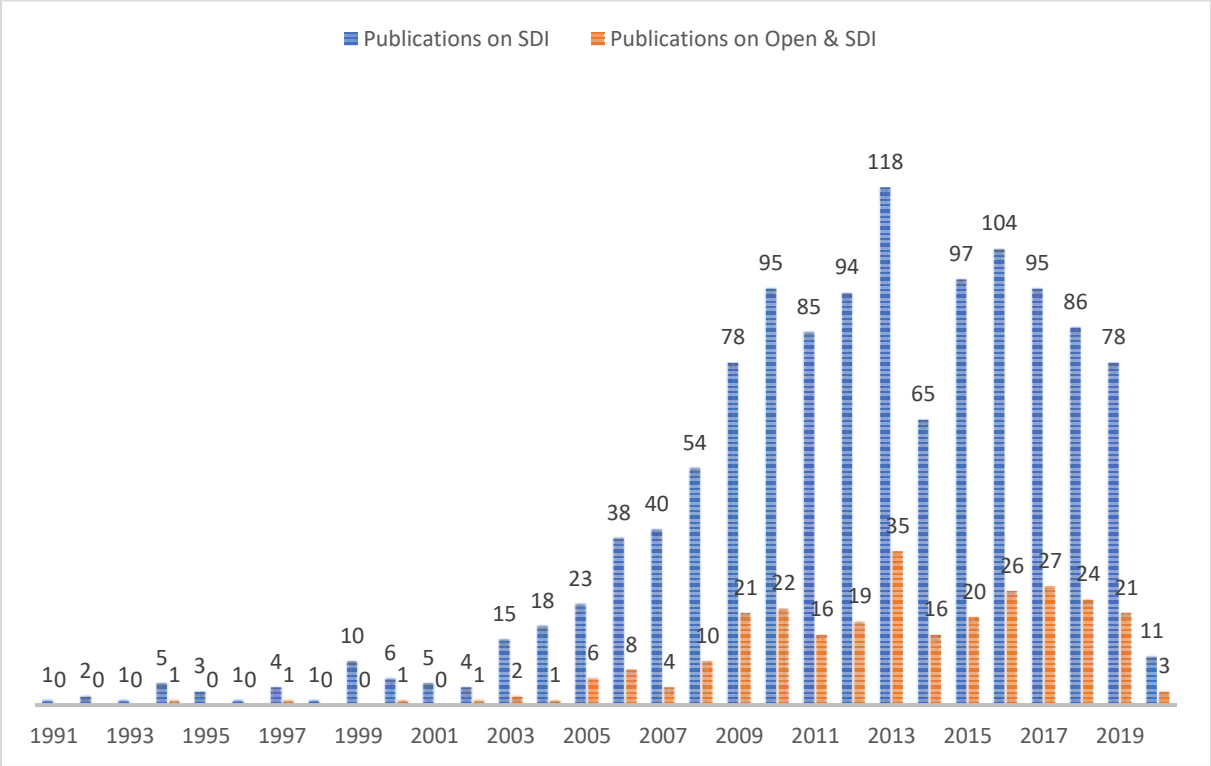

Figure 3.1: Publications on 'SDI' (blue) and on 'SDI an Open' (red)

It can be seen from this data that on average approximately 1 out of 4 publications in SDI research is dealing with the issue of openness. Since 2012, we see that yearly at least 1 out of 5 publications in SDI research were dealing with a topic on openness. In the last four years, since 2017, the percentage of publications on openness even was above 25%. The low number of publications on openness prior to 2003 (except in 2002 and 1997) mainly is due to the rather low number of publications on SDI in general.

3.3 Topics on openness in SDI research

The next step in our analysis was to identify the precise topics or aspects of openness that were addressed in SDI research. When looking first at the SDI publications in which open was included in the title of the publication, we were able to detect five word combinations with the term open that were

recurring in multiple publications. These include: open source (14), open data (5), open SDI (4), open GIS (4) and open science (2). To a certain extent, the same combinations or topics were included in the keywords of publications and in the abstracts. However, some new aspects of openness emerged, such as the Open Geospatial Consortium (11 times used as a keyword, 74 times in the abstract), open standards (20 times included in the abstract), and open access (twice as a keyword and 5 times in the abstract).

Figure 3.2 shows the presence of different topics on openness in the title, keywords and abstract of the publications on SDI.

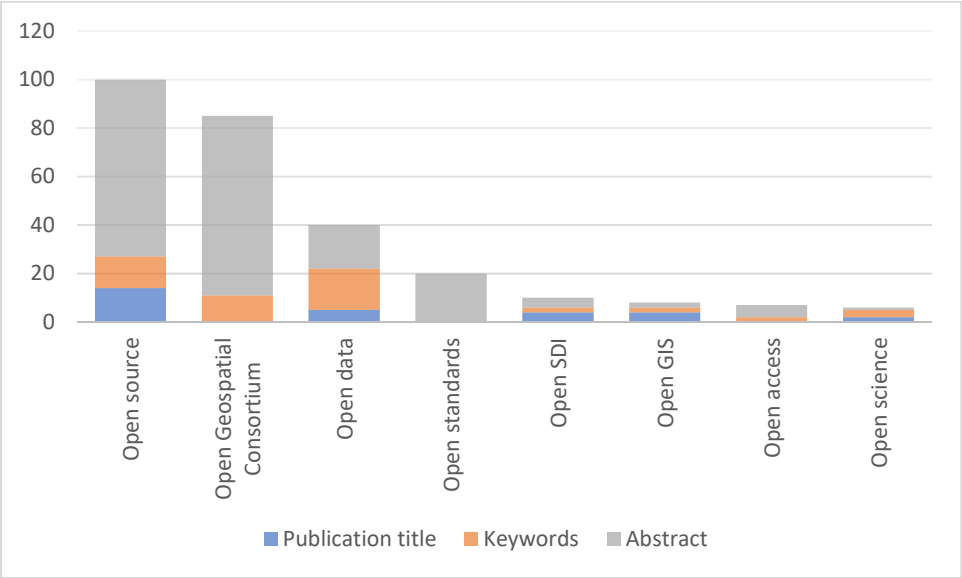

Figure 3.2: Topics of 'Openness' and their occurrence in SDI publications

The analysis demonstrates that several aspects of openness already are covered in past and current SDI research. This means the concept of SDI in itself already contains certain elements of openness. Most of these elements are still relevant and should be taken into consideration in our definition of and further research on the Open SDI concept. The analysis showed that the concept of Open SDI in itself is only used in a few publications.

We can identify five main aspects of openness already recognized in SDI research and thus - explicitly or implicitly - included in the SDI concept:

- **Open standards**: SDI to a strong extent rely on open standards for documenting, modelling and sharing geospatial data. In this context, the work of the ***Open Geospatial Consortium (OGC)*** is extremely relevant, as this international standardization organizations develops open standards for the geospatial community.
- **Open source:** Technological components of an SDI often consist of or are built on open source solutions. This applies to many of the components of an SDI architecture, which is reflected in various concepts related to open source in SDI research (e.g. open source metadata catalogue, open source geospatial server, open source data portal, etc.)

- **Open data:** The majority of data shared and made available through SDI nowadays consist of open data, i.e. data that can be freely used, re-used and redistributed by anyone.
- **Open science:** SDIs can be considered as an enabler of open science, i.e. sharing research data, tools and other research resources in such a way that others can collaborate, contribute, reuse and reproduce the research
- **Open projects & initiatives:** Several projects, initiatives but also resources in the geospatial domain - or relevant to the domain - explicitly refer to openness in their name. This applies to the Open Geospatial Consortium, but also to OpenStreetMap, the UN Open GIS initiative, OpenLayers, the Reference Model of Open Distributed Processing (RM-ODP) and various other concepts already addressed in SDI research.

3.4 Conclusion

The aim of this chapter was to investigate the extent to which the concept of 'openness' already is recognized and addressed in past and current SDI research. An explorative literature study was performed on 1237 publications on the topic of SDI, that were published between 1991 and 2020. Within this selection of SDI publications, we identified those publications dealing with 'openness', by selecting the publications in which the concept 'open' was included in the title, abstract of keywords of the publications.

The analysis showed that around a quarter of SDI research in a certain way also is dealing with openness. We identified five aspects of openness already recognized in SDI research so far: open standards, open source, open data, open source and open projects and initiatives. We consider the research presented in this chapter as explorative, since the approach followed has some limitation. Key limitation is that it explicitly looks at publications in which the term 'open' is used, and not takes into consideration publications dealing with aspects of openness without using the term 'open'. An example of this is the large body of research on volunteered geographic information, crowdsourcing and related concepts, which definitely is relevant to the Open SDI concept.

For a better understanding and definition of the Open SDI concept, it is important to take into consideration all developments and trends related to or relevant to increasing and strengthening the openness of SDIs. Besides developments in the geospatial domain itself, such as the increased importance of citizen-generated data and VGI, this also applies to more general developments and trends. Key examples of these are themes and topics such as open government, open governance, open innovation, open platforms and many others. The relevance of each of these topics and their contribution to the Open SDI concepts should be further investigated.

4 Open SDI Policies and Practices

This chapter will map and investigate past and ongoing policy initiatives and practices related to Open SDI in Europe. This includes both initiatives at EU level and at the country level. This task builds further on TU Delft's Map of Open SDI initiatives (see https://kcopendata.eu/opensdi), that shows the level of openness of national SDIs across Europe. The Map covers three key dimensions of Open SDIs (readiness, implementation and impact), and was developed to provide SDI decision makers, practitioners and researchers with a more comprehensive understanding of the openness of spatial data infrastructures in Europe. Evidence of Open SDI policies and practices collected in the creation of this map are further investigated, and new policies and practices added. The different partners contributed to this task by providing information on relevant policies and practices in their own country and other countries they know well.

4.1 Introduction

Assessment of the status of open data can be divided into three assessment dimensions (Davies, 2013): (1) readiness assessments, (2) implementation or data assessments, and (3) impact assessments. ***Readiness*** assessments analyse whether the conditions in public administrations are appropriate and necessary components are in place for opening open government data. ***Implementation* or *Data* assessments** evaluate whether data actually are available and open. ***Impact* assessments** explore to what extent open data initiatives lead to benefits to government, citizens, business and society in general.

Open data is one of the components of the concept of Open SDI. In this chapter we hold that open SDI concerns open data and open participation of all sectors (government, business, non-profit, academia, citizens). For our assessment of the status of Open SDI in Europe, we will use these three key dimensions as well: Readiness, Data and Impact.

For each of these dimensions we explored the situation in five EU Member States: Belgium, Croatia, Germany, the Netherlands and Sweden. In this chapter's discussion we will identify the main trend and/ or developments.

4.2 Open SDI assessment

In Vancauwenberghe et al. (2018) we summarised the Readiness, Data and Impact components of the Open SDI Assessment Framework as follows:

> *The Readiness dimension focuses on the development and implementation of the SDI, and assesses the involvement of non-government actors in developing and implementing SDIs. 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 or 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, making it an*

infrastructure for sharing all types of geographic data, including government data, business data, citizen data and research data.

The Data dimension 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, and accessibility through discovery, view and download 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 the open government data principles and existing open data assessments: spatial data should be publicly available, free of charge and openly licensed.

The Impact dimension focuses on the benefits for businesses, citizens, non-profit organizations and other actors of using geographic data. In order to realize these benefits, also non-government actors should actually use geographic data to make better informed decisions, to improve their existing processes, products and services, or to create new products and 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.

4.2.1 Open SDI Readiness in 5 EU MS

In Vancauwenberghe et al. (2018) it is explained that

Readiness assessments analyse whether conditions are appropriate, and whether necessary components are in place for opening government data. 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 of the implementation of the SDI, and various instruments could support or ve their existing processes, products and services or create new products or services. Benefits of - using - open spatial data, at least include three main categories of benefits: increased transparency and public participation, economic growth and innovation as well as increased government efficiency and effectiveness. 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.

In Table 4.1 the indicators for the readiness aspect are shown.

Table 4.1: Indicators for the readiness aspect of open SDI

Dimension	Openness indicator (KPI)	Description
Readiness (of the Open SDI)	1. Open spatial data vision/strategy	Existence of clear vision and/or strategic document on open spatial data

	2. Open decision making	Participation of non-government actors in decision making on the SDI
	3. Open data policy	Existence and implementation of open data policy for all geographic data
	4. Non-government data	Inclusion of spatial data provided by non-government actors in the SDI

By using an internal questionnaire amongst the project partners, we assessed the Open SDI Readiness in Belgium, Croatia, Germany, the Netherlands and Sweden. We refer to Appendix II for the individual results of each individual country. Table 3.2 summarizes the results for Open SDI Readiness. It shows that Belgium, Germany, the Netherlands and Sweden are very similar in Open SDI Readiness by having a vision on both open data and SDI (except for Belgium not having a national SDI vision, but regional strategies), government as the decision making body with advisory roles for non-government parties and an overarching single policy for all public geographic information (with for Germany variations on the main policy line at the federal level). The inclusion of non-government data may in theory be different in these countries in practice it concerns none (Sweden), almost none (Netherlands) or non-government data mandated by government organisations (Germany) which in some contexts can also be considered public sector information.[1]

Croatia differs for the Readiness dimension from its European counterparts: although open spatial data is available, a national vision on open data is lacking, and government parties take part in the decision-making processes in SDI together with some participation of business representatives. Academia and citizens are not directly involved in SDI decision making. Their participation is limited to public e-consulting.

Table 4.2: Assessment for the readiness aspect of open SDIs in five EU MS

KPI	BEL	HRV	DEU	NLD	SWE
KPI1: Vision/Strategy on open SDI	vision on open data	Vision on SDI; no vision on open data	Vision on SDI and vision on open data	Vision on SDI and vision on open data	Vision on SDI and vision on open data
KPI2: Open decision making	govt, non-govt has an advisory role	govt and non-govt	govt, non-govt has an advisory role	govt, non-govt has an advisory role	govt, non-govt has an advisory role
KPI3: Open GI policy	Yes, one policy for all public GI	Yes, one policy for all public GI	Yes, one policy for all public GI	Yes, one policy for all public GI	Yes, one policy for all public GI

[1] See, for example, DIRECTIVE (EU) 2019/1024 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 on open data and the re-use of public sector information

KPI4: Non Government Data in SDI	Very few	None	Just mandated by public authorities	Anybody can add (in theory)	None

4.2.2 Implementation of Open SDI in five EU MS

In Vancauwenberghe et al. (2018), we explained that:

> *Implementation or Data assessments evaluate whether data are actually available and open. It deals with the availability and accessibility of geographic data to different types of users including businesses, citizens, non-profit organisations and users within and outside public administration. In addition to more traditional requirements such as metadata availability, accessibility through discovery, and viewing and downloading services, users should also be able to easily find the data they need, via generic web search services or national data portals. Other important features of data in an Open SDI are: data should be openly available to anyone, free of charge and openly licensed.*

Indicators for the implementation aspect are listed in Table 4.3. In the assessment we focused on two potential High Value Datasets: topographic data 1:10,000 and address data (in local language)[2].[2]

Table 4.3: Key Performance Indicators for the Data component

Dimension	Openness indicator (KPI)	Description
Data *(applied to two key datasets)*	5. Search engine score	Assessment of the ease to find dataset through a web search: First 10 results in startpage.com?
	6. Portals	Publication of the dataset on both the national geoportal and - open - data portal
	7. Multilingual metadata	Availability of metadata in the national language(s) and in English
	8. Legal availability	Can you access it if you accept the financial and use restrictions)?
	9. Free of charge	Data are available free of charge, i.e. users do not have to pay for the data
	10. Network services	Accessibility of the data via discovery, view, download and API services

[2] These datasets are among the datasets frequently referred to as high value and potential candidates for appointed datasets in the context of the geographic data category of High Value Datasets in the DIRECTIVE (EU) 2019/1024 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 on open data and the re-use of public sector information; see also European Parliament: Committee on the Internal Market and Consumer Protection, 2018/0111(COD) 19.10.2018.

	11. Open license	Release of the data under an open and international interoperable license
	12. Level of interoperability	Data published using open standards and open formats, machine readable and data specification (data model) adheres to (international) standard
	13. Use	How often is the dataset used per year?

We assessed the Open SDI Implementation in Belgium, Croatia, Germany, the Netherlands and Sweden. We refer to Appendix III for the individual results of each individual country. Table 4.4 summarizes the results for Open SDI Implementation.

Table 4.4: Assessment of the implementation dimension of open SDIs in five EU MS

Openness Indicator (KPI)	**BEL**	**HRV**	**DEU**	**NLD**	**SWE**	**BEL**	**HRV**	**DEU**	**NLD**	**SWE**
	1:10,000 topography					**national address dataset**				
5. Search engine score (Within first 10 or 20 results)	No	first 10	first 10	first 10	first 10	No	first 10	first 10	first 10	no
6. Available through geo-portal and open data portal?	Yes	only geo	Yes	Yes	?	Yes	only geo	Yes	Yes	No[3],
7. Language metadata	national +English	national	national	national	national	national + English	national	national	national	national
8. Publicly available?	Yes	Yes	Yes	Yes	Yes[4]	Yes	Yes	Yes	Yes	Yes
9. Accessible through										
- d**iscovery**	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	No
- view	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
- d**ownload**	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes

[3] Data is available through a webpage, not a standard OGC portal.
[4] At least major parts are available

- API	No	No	No	Yes	No	No	No	No	Yes	Yes
10. Costs	No	Yes	Mixed[5]	No	No[6]	No	Yes	Mixed[5]	No	Mixed[7]
11. Licence	CC-BY-NC	No commercial reuse	Mixed[8]	CC-BY 4.0	CC0 for the open part	No commercial reuse	No commercial reuse	Mixed[8]	CC0	n/a
12. Intero-perability										
- standard metadata	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
- open format	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
- machine readable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
- data specs adhering to (int/ nat) standard	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
13. Use per year	?	?	?	286 Mio[9]	?	?	?	?	222 Mio[9]	?

At the individual country level, both datasets received almost identical scores. This may be an indication that countries have already adopted national wide policies for (high value) geographic datasets.

Both datasets in Belgium and the national address dataset of Sweden were not listed in the first 20 results of the search engine startpage.com. In the other countries both datasets were in the first 10 results. If a dataset is not in the first 10 results of a search query, it is likely that it will not be found and as a result not be used.

In Belgium, Germany and the Netherlands both datasets are available in both the national open data portal and in the national geoportal. In Croatia they are both available in the national geoportal. In Sweden both datasets are not available through national portals.

In all countries, both datasets are publicly available. Only in Sweden this applies to a major part of the 1:10,000 topographic dataset.

The available means of accessing the datasets are very diverse. We asked for access through discovery, view, download and API services. Croatia is providing access to both datasets only through a view

[5] Depending on the state with/without fee. Aggregated nationwide dataset with fee.
[6] Major parts without fee
[7] Download with fee, service usage free
[8] Different licenses for federals states – often usage of the harmonized Data License Germany
[9] Hits in Jan. and Feb 2019

service. Belgium is providing access to both datasets through a discovery and view service. Sweden does it by view and download service and for the address dataset also through API. Germany offers access through discovery, view and download services. Only the Netherlands is offering access to both datasets through all the access mechanisms including discovery, view, download, and API services. The result of this question is quite surprising since both topography and address data are part of the INSPIRE data themes which should be available through discovery, view and download services. For the API service: these are required for high value datasets in the context of EU/2019/1024.

Also, on the price of the datasets, there are differences between countries. In Belgium and the Netherlands both datasets are available free of charge. In Croatia and Germany (national level) they are both available at a fee. In Sweden and Germany (state level) there are mixed pricing models varying from free to a fee.

On the licences we can see that Belgium and Croatia both datasets cannot be used for commercial purposes. In Germany the licensing model varies depending on the federal state. The Netherlands and Sweden (for the open part of topography) the licence restrictions are at the most attribution and sometimes even no restrictions.

The interoperability characteristics included in the assessment are standard metadata, open format, machine readable, and data specs adhering to (national or international) standard. All datasets come with standard metadata, are machine readable, and the data specifications adhere to a standard. Only the Croatian address dataset is not provided in open format.

Only the Netherlands is publishing per dataset the use per year. For the other countries this information was not found.

4.2.3 Open SDI Impact assessment in five EU MS

In Vancauwenberghe et al. (2018) we explained that:

> *Impact assessments explore the extent to which open data initiatives lead to benefits for government, citizens, business and society in general. The Impact dimension focuses on the benefits of using geographic data for 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 and 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.*

Table 4.5: Indicators for the OpenSDI Impact dimension

Dimension	Openness indicator (KPI)	Description
Impact (of the open SDI)	KPI 14. Use cases	Number of use cases of non-government actors using open spatial data
	KPI 15. Socio-economic benefits	Existence of studies showing the benefits of open GI

	KPI 16. Portal use	Number of visitors and/ or downloads through the national geoportal

We assessed the Open SDI Impact in Belgium, Croatia, Germany, the Netherlands and Sweden. We refer to Appendix IV for the individual results of each individual country.

It appears that the impact of Open SDI in the five researched countries varies significantly. In the Netherlands many use cases of open spatial data use by non-government actors exist, multiple studies into the socio-economic benefits were performed and the use at individual datasets level and portal level is monitored and published. In Belgium only a few open spatial data use cases are known, no socio-economic studies were performed according to the national expert and use numbers of the national portal are unknown.

Table 3.6 Assessment of the impact dimension of open SDIs in five EU MS

KPI	BE	HRV	DEU	NLD	SWE
14. Use cases in non-government	between 2 and 5 cases	>5	>5	>5	>5
15. Evidence of social-economic benefits of open GI?	No	Yes, at least one study	unknown	Yes, multiple studies	Yes, at least one study
16. Portal use	n/a	15,000 users per year	>17,5 billion hits per year[10]	>14,4 billion hits per year	unknown

4.3 Conclusion

In this chapter we assessed the status of open SDI in five EU Member States: Belgium, Croatia, Germany, the Netherlands and Sweden. Although each of these countries has its own needs, we do see an impact of European legislation dictating to certain extent openness at national levels. The INSPIRE legislative framework[11], for example, determines the data specifications, and other quality aspects for both address data and topographic data. Therefore, not many differences were found in the interoperability indicators of the implementation dimension. For the access policy component, the extent to which a dataset is available as open data (i.e., free of charge and without restrictions in the reuse) is, and in the near future will be, highly influenced by the Open Data and Re-use of Public Sector Information Directive[12]. Several of the countries have moved towards a full open data policy for the

[10] According to INSPIRE Monitoring

[11] DIRECTIVE (EU) 2007/2 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)

[12] DIRECTIVE (EU) 2019/1024 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 on open data and the re-use of public sector information.

assessed datasets. Others (Croatia, Sweden and several federal states of Germany) are charging for access to these datasets. It is likely that these charging policies and even funding models of the data providers will be impacted by the Open Data Directive requiring that High Value Datasets (HVD) are provided free of charge. The Open Data Directive also requires these HVD to be provided through APIs. Also, here four out of the five countries will need to make additional investments to fulfill this requirement.

For the Readiness dimension Croatia is most advanced because of the inclusion of private parties in the national SDI decision making body. In the other countries non-government parties only have an advisory role.

For the Impact dimension Germany and the Netherlands might be a little more advanced than the other countries. This, however, may also be due to the knowledge of the national experts involved in the study. For example, information on the use of the national geoportal is readily available to all in the Netherlands, Germany and Croatia. Similar data may very well exist in Sweden and Belgium, but only for those responsible for the portal. The Netherlands is unique in the amount of performed research on open spatial data impact. This may be explained by two universities (TU Delft and Wageningen University) that pushed the SDI assessment research agenda since 2004. This expertise and knowledge was welcomed by Dutch policy makers in also assessing the impact of open spatial data since 2012.

5 Open SDI Technologies

This chapter will focus on the technological aspects of an SDI, and how technological solutions can be used to make SDIs more open. The task will investigate the shift of more traditional SDIs towards more open SDIs for the future, and the different technologies and standards that are important to this development. Also, future trends and developments will be taken into consideration. A key source of information for mapping and investigating relevant technology trends is the OGC Technology Trends Repository (Open Geospatial Consortium, 2019). In this task, the focus will be on Technology Trends that are relevant to or have an impact on the openness of SDIs.

5.1 “Linked Data” is out, “Data on the Web” is in

Setting new realm of Open Data

Technological aspects of SDI can be discussed from different standpoints (e.g. providers vs. users, humans vs. machines, interoperability vs. freeform). Nevertheless, SDI main purpose is usually seen as an infrastructure that provides access and interoperability of spatial information based on policies, regulations and coordination mechanisms (Abbas & Ojo, 2013). This understanding is reflected also on technological aspects in published research.

For example, even recently, (Merodio Gómez et al., 2019) in their assessment of Americas’ SDIs investigated technological aspects primarily as access network component of SDI, and assessed it by inquiring access mechanisms, interoperability of services between institutions, uses/visits to main platform or SDI tool, and software and hardware used. They found that technological aspect in this form is second best developed component of SDI. Human resources were found to be the most

developed component, while geoinformation, norms and standards components were least developed. Even though they see technological aspects primarily for data management and data interoperability purposes, with the main goal to ensure user access, exchange and easy and effective use of spatial data, the study itself only concentrates on access and exchange parts, thus omitting easy and effective use of spatial data offered by SDI. For assessing the openness of SDI, openness to (re)use, easy and effective use, is a dimension that should be considered, too.

Some earlier researchers already considered the movement of the technological aspect of SDI towards other trends. For example, Abbas & Ojo (2013) propose the integration of Linked Data technology into SDI by creating linked geospatial data. Thus, creating linked geospatial data in SDI can be seen as opening the SDI data component to the Web of Data Cloud and Linked Open Data community. While their model investigates how linked data can be integrated in all SDI elements (technical, people and organizational requirements, standards and policy), the major impact of linked data integration is on the technical component which is seen as two parts, data and network access. From all the aspects that would move spatial data to linked geospatial data, we can select some that are related to perspectives of openness, namely:

- SDI Geoportals: need to provide geoportals that enable use cases of stakeholders
- SDI Applications: should provide location-based applications that support Semantic Web and Linked Data
- SDI Clients: should support semantic and linked data-based query and retrieval of spatial information
- SDI Services: Support RDF and OWL based Semantic web services, resource-based services and Geoweb services that interact with other components.
- User Generated Content: given the social contexts for SDIs support for semantic annotations of user-generated content
- Knowledge Model: ontologies, vocabularies and other semantic assets should be managed as part of knowledge model

While Linked Data is already on a stage for a while, not much was done in SDI to move towards this direction. Its importance is still present and recognized, but the OGC Technology Trends (Open Geospatial Consortium, 2019) subsumed it together with Knowledge Graphs, APIs for the Web and Web Scale Platforms under the title ‘Spatial Data on the Web’:

- ***Web of Data****: Data published on the web are made discoverable, accessible and interoperable using WWW best practices for data formats, data access, data identifiers, metadata, licensing and provenance.*

- ***Ontologies and Semantics****: Ontology is a formal naming and definition of the types, properties, and interrelationships of the entities. Semantics is primarily the linguistic, and also philosophical study of meaning—in language, programming languages, formal logics, and semiotics.*

- ***APIs for the Web****: The explosive growth of public APIs for geospatial applications, and the accompanying variability in API practices across the IT industry, as well as in geospatial APIs specifically, has created new opportunities and challenges in supporting geospatial*

services. The application of standards in APIs to ensure interoperability is an apparent next step.

- ***Web Scale Platforms**: Web scale platforms hosted on large cloud services with web-friendly techniques, enable extreme levels of service delivery as compared to many of their enterprise counterparts.*

(from Open Geospatial Consortium, 2019)

From the OpenSDI point of view, trends that OGC placed in the group of Spatial Data on the Web are very important, and one was already used in the assessment of Open SDI in the SPIDER project. It is about the ***Web of Data,*** a trend which among other things, enables spatial data discovery over WWW mechanisms (see chapter 4.2.2 KPI 5) and not only through mechanisms of dedicated geoportals (see chapter 4.2.2 KPI 6).

Integration of SDI into ***Web Scale Platforms*** (example of such a platform could be Google Earth Engine) is another trend that could open SDI to a wider group of users and applications.

APIs for the Web (see chapter 4.2.2 KPI 10) and ***Ontologies and Semantics*** together affect interoperability of data, thus contributing also to opening of SDI towards other services and communities.

5.2 Data from VGI, IoT and Sensors feed Open SDI

Setting new realm of Open Participation

While many of the geospatial tech trends proposed by the OGC (e.g. the discussed Data on the Web trend) can be addressed to the usage aspect of OpenSDI, the trends in Sensing and Observations are connected to open participation aspect of an OpenSDI.

The four trends in this topic, also put together under the meta-trend “New Geo Data Sources”, are:

- ***IOT and Sensor Webs**: The internet of things (IoT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data.*

- ***UxS/Drones**: While large UAVs have been in use for defense, ISR, and remote sensing purposes for many years, the platforms now range in complexity from large, jet-propelled aircraft to palm-sized drones. Similarly, Unmanned Underwater Vehicles (UUVs) also have a long history of operations, becoming increasingly sophisticated in recent years with respect to capabilities and autonomy.*

- ***Crowdsourcing/VGI**: Geo Crowdsourcing includes Social Media and Voluntary Geographic Information (VGI). Crowdsourcing refers to the process of obtaining geo inspired services, ideas, or content by soliciting contributions from a large group of people, especially an online community, rather than from employees or suppliers. VGI is the harnessing of tools*

to create, assemble, and disseminate geographic data provided voluntarily by individuals (Goodchild, 2007). VGI is a special case of crowdsourcing.

- ***Commodity Remote Sensing/Smallsats**: MicroSatellite is referring to small and compact satellites. They are often the size of two shoe boxes (smaller than 50kg in weight). Planet "will be imaging the entirety of Earth's earth daily."*

(from Open Geospatial Consortium, 2019)

Especially, VGI plays a major role in Open Participation which is directly connected to Open SDI. As defined by Goodchild (2007) VGI is the harnessing of tools to create, assemble, and disseminate geographic data provided voluntarily by individuals. The prominent example of VGI is OpenStreetMap, where anyone can participate either in creating or accessing spatial information. While OpenStreetMap in the beginning gave the users the free opportunity to add any kind of data in any form and with freely defined attributes, in the last years mapping rules were created and documented for different kinds of entities of the living environment. When a user creates new spatial information within the OpenStreetMap Online Editor, he/she has now the option to select a certain entity for his/her objects according to those mapping rules. Still users are allowed to add further attribute fields. Data quality is ensured by certain editing tools, like e.g. making a square out of four points and by cross-check of data amongst users. Every change in the data set is monitored with date and username. Other tools allow to download OSM raw data, either by location or by entity.

Opening an SDI to all kind of sensors and IoT is not a new idea since the Sensor-Observation-Service was already established by the OGC in 2007. Adding a spatial information to all available sensors on the other hand gives the opportunity to overlay them with background information of an SDI or to update datasets for each of SDI themes.

5.3 Opening the Power of Location

Setting new realm of Open Usage

A big part of the new technological trends seen by the OGC focus on using spatial information in new use cases, named "The Power of location", which means that location and place are effective means to organize, analyse and understand our world and how we live (Open Geospatial Consortium, 2019).

The technological trends under this meta-trend are:

- ***Spatial Thinking**: Trends in spatial thinking includes how GPS affects how we think about our world and navigation. Also the use of place, and how vernacular geography is used to describe it. One must avoid the temptation to think of place only as a location. A place is distinguished by its people, markets, governments, and institutions, as much as it is by its physical landscape and natural resources, transportation systems (including streets and roads), buildings, and boundaries- (US National Academies).*

- ***Location as Indicator of Intent**: "Location targeting is holy grail for marketers"- Sir Martin Sorrell, WPP CEO, MWC 2011.*
  By measuring the entropy of each individual's trajectory, we find a 93% potential

predictability in user mobility - Limits of Predictability in Human Mobility, Science 2010
1st law of geography: "Everything is related to everything else, but near things are more related than distant things." - Waldo Tobler.

- ***Micro-Geography**: Personal electronic devices now measure much of our activity and context. New methods to capture, quantify and communicate individual human activity at a micro level are now available, e.g., OASIS's Classification of Everyday Living (COEL). Rating services for individual behaviors, e.g., risk rating, will develop similar to credit risk rating services.*

- ***Location Authentication**: Confirmation of location is critical for many activities, e.g., location of transactions can determine what taxes apply, the location of the boundary of a property forms the basis of its registration, and the location where evidence is discovered in a crime scene can have an impact on judicial proceedings. Considering the threats to location information, e.g., spoofing, a greater level of security is emerging for location-referencing.*

(from Open Geospatial Consortium, 2019)

These trends are driven by the need to understand human behavior and to use it mainly for economic purposes. In this context, spatial information is the so often called gold-mine, which is to be extracted so that the potential financial value of spatial and open information can be taken.

Another approach is based in classical geography, where it is important to gather information about location to understand the environment and human impact on it. The (spatial) documentation and monitoring of the Sustainability Goals of the United Nations is one example where OpenSDI and Open Data provide the basis for the analysis and actions.

These trends can be seen as a rebirth of classical Geography but with the focus on individuals´ needs and economic rise. OpenSDI can support both approaches.

The OGC meta-trend "Data Science and Analytics", combining data science, analytics and decision in the context of spatial-temporal data, provides further technological trends and tools, which can be used for opening the "Power of Location":

- ***Text and Graph Analytics**: Text Analytics refers to the process of deriving high-quality information from text. Applications of this are Natural Language Processing (NLP) and Social Media harvesting. An example is to scan a set of documents written in a natural language and either model the document set for predictive classification purposes or populate a database or search index with the information extracted.*

- ***Spatial-Temporal Analytics**: Although real-time spatiotemporal data are now being generated by almost ubiquitously and their applications in research and commerce are widespread and rapidly accelerating, the ability to continuously create and interact in real time with this data is a recent phenomenon. This real-time space–time interactive functionality remains today the underlying process generating the current explosion of*

fused spatiotemporal data, new geographic research initiatives, and myriad mobile geospatial applications in governments, businesses, and society - (NGAC).

- ***Fusion, Conflation Analytics**: Conflation refers to the act of combining two distinct maps into one new map. It is similar to the practice of image mosaicking. It is usually carried out by registration of an overlapping area. Conflation for digital maps refers to the process of associating real world coordinates to digital ones and it is named Map Matching - (DSTL).*
- ***Machine Learning/CNNs on Imagery**: Machine learning is the subfield of computer science that gives computers the ability to learn without being explicitly programmed. Deep learning and Convolutional Neural Networks (CNNs) - a sub type of machine learning - consists of multiple hidden layers in an artificial neural network - (Wikipedia).*
- ***Modeling, Simulation and Prediction**: Simulation modeling is the process of creating and analyzing a digital prototype of a physical model to predict its performance in the real world. Models and simulation can be used for analysis and for training.*

(from Open Geospatial Consortium, 2019)

5.4 Conclusion

Based on OpenSDI perspectives drafted in this Intellectual Output by project partners (see chapter 7 and Appendix I), and discussion given in this chapter, it is possible to match OGC's prominent technological trends with OpenSDI aspects.

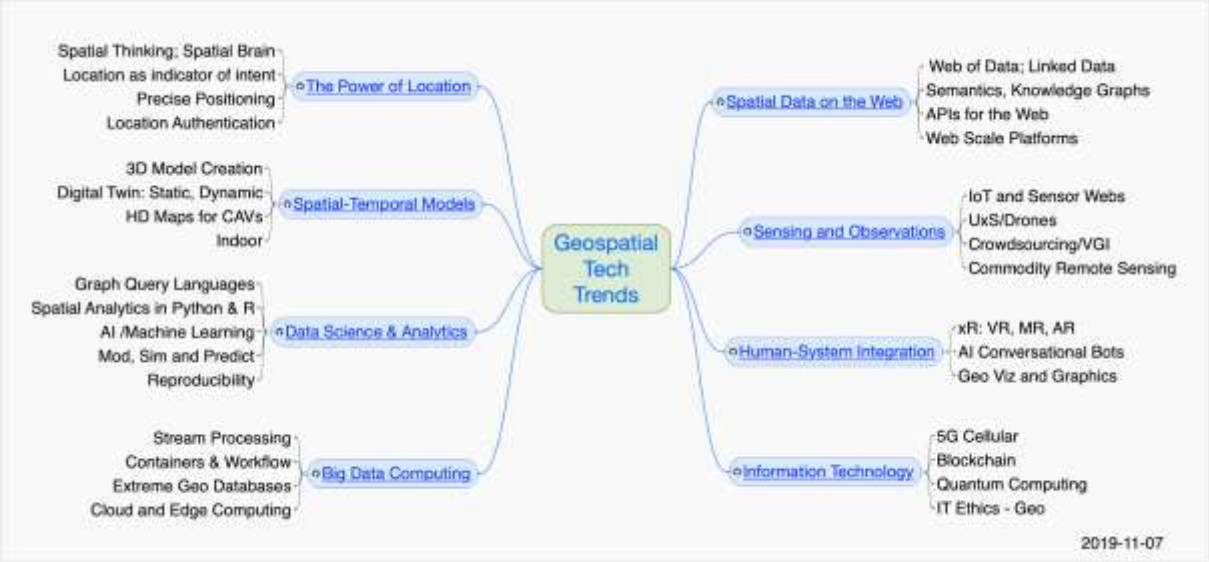

Figure 5.1: OGC-Technology-Trends (trends and meta-trends - groups)(Source: Open Geospatial Consortium, 2019)

Table 5.1:Technology trends supporting different aspects of Open SDI

Aspect of Open SDI	Supportive Technological Meta-Trends - Trends

Open data	Spatial Data on the Web
Open participation	Sensing and Observations - IoT and Sensor Webs, VGI
Findable data	Spatial Data on the Web - Web of Data
Accessible data	Spatial Data on the Web - Web of Data
Interoperable data	Spatial Data on the Web - Semantics
Re-usable data	Data Science & Analytics, The Power of Location, Big Data Computing
Change of organizational paradigm	Spatial Data on the Web - Web Scale Platforms
Development of new purposes	Data Science & Analytics, The Power of Location, Big Data Computing
Standards	Spatial Data on the Web - Semantics, Linked Data
Access network	Spatial Data on the Web - Web Scale Platforms
People	The Power of Location
SDI governance (drivers)	-

Table 5.2: Aspects of Open SDI supported by technological meta-trends

Technological Trend	**Supported Aspect of Open SDI**
The Power of Location	People, Development of new purposes, Re-usable data - **Open Usage**
Data Science & Analytics	Development of new purposes, Re-usable data - **Open Usage**
Big Data Computing	Development of new purposes, Re-usable data - **Open Usage**
Spatial Data on the Web	Findable data, Accessible data, Interoperable data, Change of organizational paradigm, Standards, Access network - **Open Data**
Sensing & Observations	**Open participation**

From grouping and linking trends and aspects in previous tables (Table 5.1, Table 5.2), it can be seen that technological trends are supporting the development of Open SD in three main aspects: ***Open Data, Open Participation*** and ***Open Usage***. But before any technological change can happen and potentials can be developed, new governance rules and a new vision of Open SDI must be implemented. Otherwise, the technology trends will change governance rules or might render SDI obsolete.

6 Open SDI Education

Open education has been conceived as education without the need for academic admission. It has been promoted in the last two decades through widespread access to the Internet (Bliss & Smith, 2017). The Internet has provided free access to a wide range of practical courses and other educational materials to anyone who wants to use them (Brown & Adler, 2008).

From a broader perspective, open education is one of the two building blocks of the open knowledge principle. The Open Knowledge Foundation defines the main components of knowledge as science, the process of building knowledge, and education, the process of transferring knowledge. In this sense, free and unrestricted access to education promotes open knowledge and improves equity and equality in societies, as the pivotal values of the 21st century (Coetzee et al., 2020).

Open Educational Resources (OERs) was initially developed during the 2000s. Remarkably, MIT created and published a broad set of OERs by releasing its course content in 2002. The first open courses were developed in 2007 (Rodriguez, C. Osvaldo, 2012), and since then, open access policy has been adopted by several universities around the world (Baker, 2017). In parallel to the activities by the universities, not-for-profit organizations like Khan Academy, College Board, or online course providers like edx have started to develop and provide online learning resources for the massive audience on the Internet.

Generally, open education can be achieved through open and unrestricted access to the following resources (Baker, 2017; Brown & Adler, 2008; Rodriguez, C. Osvaldo, 2012; Yuan & Powell, 2013):

- Educational materials (e.g., online lectures, tutorials, and exercises, to name a few)
- Courseware (open educational platforms and services)
- Communicational facilities (e.g., virtual classrooms and discussion forums) and Social networks (to provide human to human interaction across the globe)
- Open and free software (free software for educational purposes, which can be open source)
- Open data (freely accessible and usable data for educational purposes)
- Open hardware (freely available machine or cloud services that support the execution of exercises and assignments or tools like telescopes, electron microscopes, and supercomputers for simulation modeling)
- Open standards (open standards that promote data and software sharing)

This chapter will focus on the topic of Open Education and the way it is already applied in GI and SDI education. It mainly emphasizes on the usage of open source geospatial software and open geospatial data in educational practices. This also included the sharing of teaching material, software, teaching outcomes (e.g., new data, tools, or studies) related to geospatial data processing and analysis.

Another aspect that will be considered in this chapter will be the collaboration among parties (mainly universities, but also between universities, businesses, and public administrations) involved in SDI education. This task will explore the different aspects of Open SDI Education and see how they are linked to the overall Open SDI concept. To do the task, a questionnaire survey was conducted to study the above-mentioned criteria with the five partner countries.

There are two types of SDI and spatial data sharing education in the universities, with focus on non-technical (such as organizational, economic and policy-making) and technical (e.g. web GIS, web services, standards, and tools) aspects of SDI. None of the courses which are focusing on non-technical

aspects of SDI and data sharing use open data and/or software, since they are not needed in practice. However, all partner universities use a wide range of open data and open software in the courses that focus on technical aspects of SDI and data sharing. The use of open tools/data is different in different parts of the course:

- Open source tools are used for setting up geospatial web services
- Open free source tools are used for spatial data analysis and then sharing in web GIS
- Students are encouraged to searched for, find and use open data for exercises and projects

In terms of cooperation with other institutions, the situation is different in different partner universities. For example, Lund University (LU) invites professors from other European universities in a PhD course on SDI. TU Delft and Bochum University of Applied Sciences (BO) have cooperation with governmental and private organizations for defining case studies for e.g. projects. TU Delft collaborates with GIScience universities and exchange students at BSc., MSc. and Ph.D. levels. Bochum takes care of the whole course using university colleagues.

To draw a conclusion on this chapter, the level of openness varies in different courses and in different universities. Meanwhile, the general trend is towards increasing interest in Open SDI Education.

The following table (Table 6.1) summarizes the answer of the universities to the questionnaire for just the SDI courses offered in the universities.

Table 6.1: Results of the questionnaire on SDI courses at the partners' universities

	TU Delft	Bochum UAS	Lund University	KU Leuven	Uni Zagreb
Open Data	x	x	x	x	x
Open software	x	x	x	x	x
Cooperation with other universities	x		x		
Cooperation with private sector	x	x			
Cooperation with governmental organizations	x			x	x

7 Approach to Open SDI

The intention of this IO is to develop a working definition of 'Open SDI' or 'Openness' in Spatial Data Infrastructures for educational purposes. Based on the well perceived definition of Vancauwenberghe et al. (2018), relevant topics in research, policy, education and technology are investigated to be included in the training material, curricula and online resources of the following IOs. With this approach it will be guaranteed that beside the well-established concepts of SDI, also new and innovative approaches are included, which foster cross-domain aspects, openness to citizens, promising technologies and evolving technologies.

7.1 Summary of the perspectives

Open SDI in research:
In the literature study on 'Open SDI' resp. 'SDI and Openness', a remarkable high number of publications deal with the topics of 'open source', 'open data' and 'open standards' whereas 'open government', 'open science' or 'open access' gain only limited attention by the geospatial science community. This is remarkable, because in internal discussions of the SPIDER team (see Appendix I) and in public statements (e.g. EUROGI discussion 'Beyond SDI'), especially the cross domain topics like 'open government', 'open policies' or 'citizen science' play an important role.

Open SDI policies and practices:
The study on the aspects of 'readiness', 'implementation' and 'impact' among the project partners, confirmed the conclusions made in previous publications (Vancauwenberghe et al., 2018; Vancauwenberghe & Van Loenen, 2017), on relevant policy and government instruments for openness in SDI.
First there is a need to incorporate the private sector and citizens as user groups in all aspects of SDI design, steering and control, to arrive at a true user-oriented approach. Second, open and standardized license models shall be fostered to stimulate data and service usage and to gain most benefits of the existing infrastructure. These open data models should not be limited to government data (current situation in the five case study countries), but be extended to the scientific and commercial data domains. In this context, the new EU Open data and reuse of public sector information directive is a very welcome construct: it promotes open scientific data and explores legal direction towards open commercial data (see Dalla Corte 2020).

Open SDI technologies:
The review of the current geospatial technology trends depicted by the Open Geospatial Consortium (Open Geospatial Consortium, 2019), shows a strong linkage to the aspects of openness for spatial data infrastructures. Especially the accessibility of data and aspects of open usage are fostered with according technologies subsumed in the meta-trends like 'spatial data on the web', 'big data computing', 'data science & analytics' or 'power of location'. The aspects of open participation are highly relevant in opening infrastructures for 'sensing and observation' technologies.

Open SDI education:
Open education is one of the two building blocks of the open knowledge principles. In a broader definition, open education not only offers open access to educational resources, but also includes the usage of open data, open software and open standards. In addition, the output of academic work (e.g. BSc./MSc. theses including collected data, developed coding and software) should be openly provided. In the section on Open SDI education, different SDI related courses and curricula of the partners' universities were examined with respect to their open education aspects. It was found that two main education tracks on SDI can be differentiated – a technical track, focusing on standards and software, as well as a non-technical track, with the key elements of like licenses, policies and organizations.

In addition to the described, formal approach, lively discussions within the project's consortium led to individual statements of each partner on their perception of 'Open SDI' (see Appendix I). Those definitions/statements were also considered in the analysis and the conclusion, as they reflect the variety of 'openness' aspects and their individual prioritization amongst the SDI community quite well.

7.2 Conclusion

The publication 'Governance of Open Spatial Data' (Vancauwenberghe & Van Loenen, 2017), introduced the term 'Open SDI' for SDIs that strongly involve the private sector and citizens, and offer data according to open data principles. This definition emphasizes the governance, legal and policy aspects of spatial data infrastructures.

To educate 'Open SDI', the strong dependency between technical infrastructures, policies, data and users must be considered; i.e. both education tracks – the technical and the non-technical (see chapter 6) need to be aligned. The education shall follow the principles of 'open education' and include the usage of open data, open software and open standards as well as contributing to the open SDI by ensuring that the results of academic research/ education are complying to the open data principles.

Future SDI concepts from research and technologies, esp. regarding the involvement of different user groups, open and linked data, standard web-technology must be included in the curriculum. Competency in the field of 'Open SDI' not only covers knowledge on technologies and policies, but especially the ability to align the different aspects of openness with the user-requirements.

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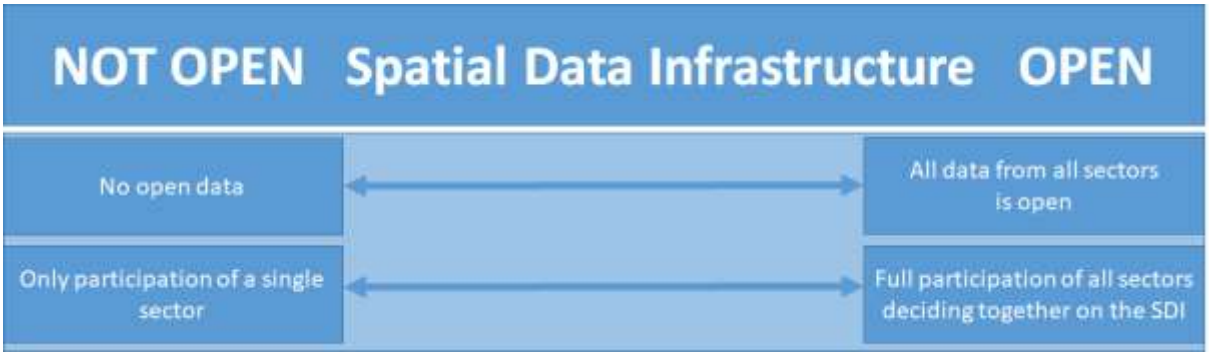
Appendix I: Perspectives on Open SDI

TU Delft perspective on Open SDI

Open SDI concerns open data and open participation of all sectors (government, business, non-profit, academia, citizens).

Open data is data that does not have any barriers in the (re)use. According to the Open Definition, open data can be defined as data that can be freely used, modified, and shared by anyone for any purpose subject, at most, to measures that preserve provenance and openness (Open Knowledge Foundation, n.d.). Open data requires datasets to be either in the public domain, or distributed through an open license. The data must be provided as a whole, free of charge, and preferably downloadable via the Internet, including any additional information that might be necessary to comply with the open license's terms. Openness requires the data to be provided in a readily machine-readable form. The format must be open as well, meaning that it does not place any restriction upon its use, and that the files in that format can be processed with open-source software tools."(van Loenen et al., 2018)

Open participation concerns the participation of all stakeholders in the SDI. Stakeholders can participate in many different fields (any of the five key components of SDI: standards, policy, access network, data, and governance), levels (local, national, regional, global), ways (active/ passive) and roles (informing, advisory, decision making) in the SDI. In the most open SDI open participation would mean that all sectors are participating in the SDI in all possible fields, at all levels and ways, and roles. In an extremely open SDI the open participation may imply that government, business, citizens, academia and non-profit stakeholders decide together on the direction of the SDI.



HS Bochum perspective on Open SDI

Open SDI is interpreted as a collection of aspects describing the openness of data, services, policies and technologies in spatial data infrastructures. Beside the concepts of 'Open Data' and 'Open Participation' as described by TU Delft, aspects of usability e.g. taken from the FAIR principles must be considered (Force 11, 2014).

- **Findable**
  Data must be described with metadata and offer unique identifiers. In practice, data and services are often published in several data infrastructures (e.g. open data Infrastructures, regional spatial data infrastructures, domain specific infrastructures). Open SDI principles address identifier

handling and interoperable (or transferable) metadata, to allow users from different communities the retrieval of spatial data.

- **Accessible**
  Most spatial data infrastructures rely on open standards (OGC and ISO/TC211) for the access of data, metadata and services. Although free and open, those standards are very complex and not used outside the geo-community. Open SDI concepts address the problem of different technical interfaces for different requirements.
- **Interoperable**
  Data formats, vocabularies, data models and encodings are crucial for the interoperability of data and services. Again, the geospatial community uses well defined but very specific formats like GML or GeoJSON. The data models of the common SDI tend to be very complex. This allows a precise and lossless exchange of information but limits the information exchange with other user communities. Open SDI concepts address those difficulties.
- **Re-Usable**
  Beside the legal issues on the reuse of data and services (open licenses), clear provenance and lineage description are of specific importance. Open SDI principles deal with legal aspects on data as well as quality criteria defined in the SDI policies. Those principles directly influence the effort and the openness on producers' side.

It is obvious that several aspects of 'FAIR' or 'Open' data are strongly related and sometimes even exclude each other (e.g. a less restrictive policy regarding publication of data will result in higher variability of data models or data quality, which limits the aspects of interoperability).

An Open SDI education raises awareness on different aspects of 'openness', 'interoperability' and the 'FAIR' principles, it enables students to rate existing SDIs according to different criteria or to balance technology, policy and services and data to meet users' requirements from different domains.

UNIZagreb perspective on Open SDI

Let us suppose that Open SDI is an extension or superset of SDI, i.e. Open SDI has all properties of SDI plus some additional. In other words, SDI is a subset of Open SDI.

Let us also consider "spatial data system" as a more generic term than "spatial data infrastructure". A system is a group of interacting or interrelated entities that form a unified whole. Infrastructure is "a system" with fundamental facilities and sub-systems serving a country, city, or other area, including the services and facilities necessary for its economy to function.

Prominent example of spatial data infrastructure (SDI) in Europe is INSPIRE and according to the definition above it is one of spatial data systems. As a working definition let spatial data infrastructure (SDI) be a data infrastructure implementing a framework of geographic data, metadata, users and tools that are interactively connected in order to use spatial data in an efficient and flexible way. Another definition is "the technology, policies, standards, human resources, and related activities necessary to acquire, process, distribute, use, maintain, and preserve spatial data"

Some prominent spatial data systems, each with its special properties and purposes are:

1. Google Maps, Bing Maps, Here Maps, etc.

2. OpenStreetMap
3. INSPIRE SDI for Europe (and other regional SDIs in the world)
4. COPERNICUS for Europe (and other EO systems in the world)
5. Nautical charts under International Hydrographic Association
6. NATO and military spatial data systems
7. ...

Loosely speaking, each of these spatial data systems has its main properties and purposes. For example, Google Maps (and other similar systems) are aimed at giving reliable location based services to all citizens in everyday tasks. OpenStreetMap is based on volunteer participation, shared governance and responsibility. INSPIRE SDI has the main purpose to exchange governmental data between public bodies and providing public access to these data. COPERNICUS aims to provide timely and accurate Earth observation data for a number of applications. Nautical charts aim at providing safe navigation, and military spatial data at successful planning and execution of military actions.

One approach to Open SDI is an SDI which includes (but is not limited to) properties of other spatial data systems. For example, Open SDI in addition to sharing data between public authorities, is capable of providing reliable location based services to all citizens in everyday tasks (**reuse**), like Google Maps. Or, Open SDI in addition to clear responsibility and governance over datasets has a **shared participation, responsibility and governance**, like OSM.

Usually when we add an adjective to a noun that means specialization, e.g. red birds are a subset of birds. If we in the same way understand Open SDI then Open SDI is a subset of SDI that includes SDI with only a specific set of properties of openness.

Instead of specialization, the concept that is possible to investigate can also be as proposed at the beginning, i.e. that Open SDI is an extension of SDI. An Open SDI is a generalization of SDI that extends, “is open to”, its purpose, policy, function (e.g. accessibility), organization model etc.

Lund U perspective on Open SDI

Open SDI can be understood and defined through the perspectives of the SDI model. SDI model has defined 5 components of data, people, policy, standard, and access network. Taking the model into consideration, we can say that Open SDI is an initiative that is going to promote following changes in the SDI components.

- **Data**: The data component of Open SDI is composed of both governmental and non-governmental data. The non-governmental data in Open SDI includes quality controlled data produced by private companies as well as Volunteer Geographic Information (VGI) which are known and have high reliability, such as Open Street Map. Other types of crowdsourced data or geo-tagged data such as those extracted from e.g twitter are not suitable data for Open SDI. Through accessing networks (clearinghouses and geoportals), the data should be:
    - findable
    - viewable
    - downloadable
    - easily integrate-able

- **Policy**: The main policy bullets in Open SDI are:
    - Data should be FAIR and free of charge
    - Data should be reusable
    - Data should be in legal context
    - There should be no restriction in reuse of the data
        - a license like CC0 or CCBY
        - public domain declaration
    - It should not be only the government who makes policies for data. Private sector and the general public (how?) should also have a role
    - Data produced by the private sector should not be essentially open (range of openness may be defined).
    - If all data are available for free, then how should Open SDI earn money for its survival?
    - Existing SDIs such as INSPIRE focus on Open Metadata, but Open SDI focuses on Open Data
- **Standards**: Standard in Open SDI will try to provide the possibility to use spatial data and services in a wider range of applications. It tries to reduce the technical complexity of dedicated standards that have been developed and used in the geospatial information community for a larger audience in the information science community. Such standards will be more light-weight and more compatible with the existing standards in computer science.

  Standards in Open SDI should be:

    - Open
    - Available for free
    - Easy to understand
    - Easy to implement
- **Accessing Network**: Accessing networks in Open SDI will be open to the public in the society. People in the society will be able to share their data through the accessing network and also search for, find and openly use spatial data and services that are advertised through the accessing network.
- **People**: Besides governmental data, the private sector also has a role in producing and sharing data. Role of citizens is also highlighted. However, it does not mean that everyone can produce data (e.g. a person collects a piece of road by GPS) and upload it to SDI portal. Data produced by citizens in the context of "verified" VGI systems, such as OSM, should be considered as part of Open Data for SDI.

KU Leuven perspective on Open SDI

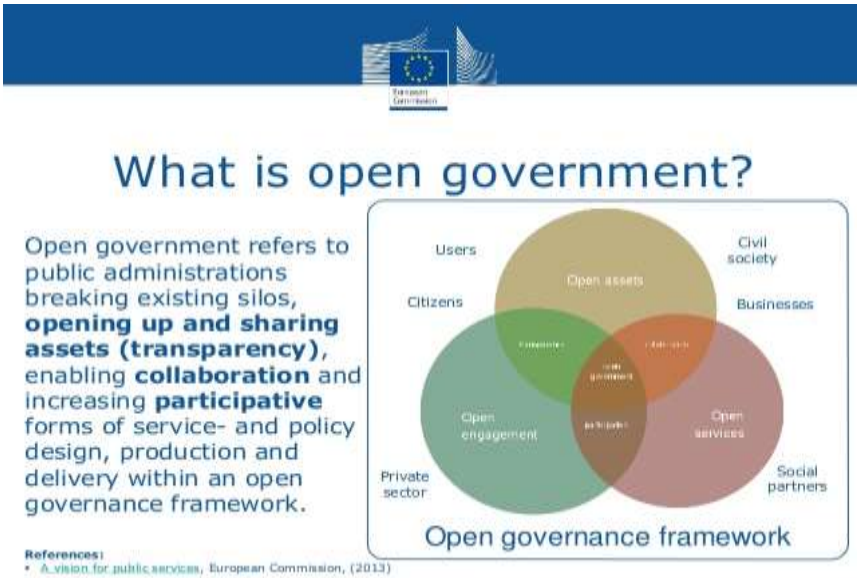
Several potential - conceptual frameworks.

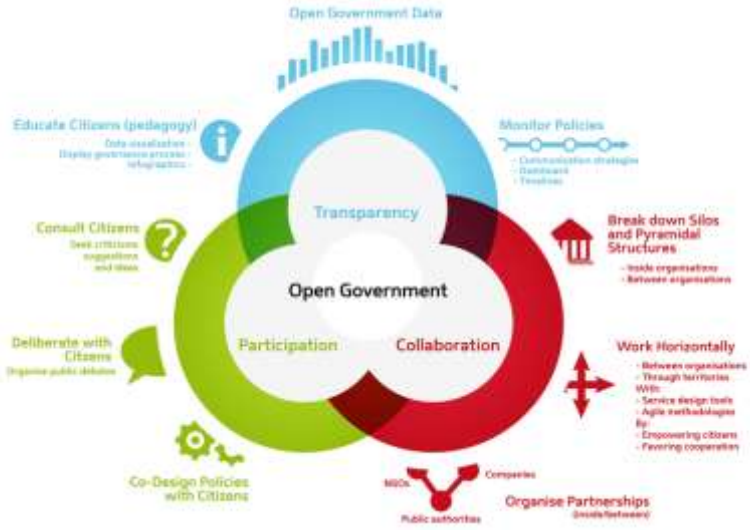
1. Open SDI = Open spatial data + Open Infrastructure ('participation' + technical infrastructure)
2. SDI perspective (discussion from Delft meeting): use SDI definitions/components to explore the meaning of what a more Open SDI could be
3. Focus on evolution and recent developments:
    - open data

- open government
- technologies

4. Open government perspective: data + participation + collaboration
5. Link with data ecosystems (and infrastructures to support these ecosystems)

See some relevant figures below. It depends on the extent we consider SDIs as a government-driven phenomenon (SDI = more open government) or more broader (SDI = supporting open data ecosystems).





Appendix II: Open SDI readiness assessed for five EU MS: detailed reports

Belgium

KPI 1: Is there a vision on open SDI: Does your country have a vision on open SDI?

In Belgium there is no overall – national - SDI strategy, but at the regional level some strategies have been developed focusing on SDI and their link with open data and open government. The second geospatial strategy for the Walloon Region 2017-2019 highlighted the relevance and importance of geospatial data for government and society in general. The strategy also discusses the importance of open data and proposes an open and participatory governance approach to geospatial data.

At the federal level, the action plan Digital Belgium was introduced by the Minister of Digital Agenda and Telecom and the 'Digital Minds for Belgium', a group of approximately leading digital-world professionals. The key objective proposed in the action plan was to achieve growth and create jobs through digital innovation over the next years. In addition, the Digital Belgium programme has three ambitions to be achieved by 2020: Belgium to be among the European top three in digital terms, to generate 1000 new start-ups, and to create 50 000 jobs in the whole economy.

Although the action plan does not address spatial data and the SDI in particular, several of the priorities and actions included in the plan are extremely relevant to the development and implementation of an open SDI at the federal level. Open data are highlighted under the priority of Digital Government. It is stated that *"public data belonging to the federal government must be accessible, with a few exceptions based on privacy and security. Transparent access to data means a better democratic process."*. The federal government's' view on open data and a series of concrete actions are provided in the federal open data strategy.

Becoming an 'Open Region' is one of the four challenges in Smartcity.brussels, the smart city strategy for the Brussels-Capital Region, developed by the CIBG.

KPI 2: Who can participate in (open) SDI decision making: Are all stakeholders (government suppliers & users/ businesses/ academia/ citizens) included in open SDI decision making?

Decision making on the SDI mainly takes place at the different administrative levels and regions separately. At the national level, decision making and consultation is strongly focused on the implementation of INSPIRE. The INSPIRE Coordination Committee was established in 2010, and consists of representatives – one GIS expert and one1 environmental expert - from the federal level and the three regions. The INSPIRE Coordinating Committee is responsible for the coordination between the Federal State and the regions in order to achieve effective implementation of the INSPIRE Directive in Belgium and to build up the Belgian SDI. Particular SDI governance and decision making structures exist in each of the three regions and at the federal level. From an Open SDI perspective, the governance framework of the Flemish SDI for a long time had a separate advisory body with representatives from non-government sectors and organizations. While originally Flanders had separate governance structures in place for IT and SDI policies, since 2016 there is only one integrated Flemish Steering Committee for Information and ICT-policy, which also deals with SDI-related issues.

There no longer is a separate advisory board of non-government actors. However, two so-called external innovators are participating in the Steering Committee, to represent other sectors (e.g. research, innovation).

KPI 3: Is there an open SDI policy: Is there a national policy on access, sharing and reusing spatial data?

Policies on the access to, sharing and reuse of spatial data have been developed and implemented in each of the regions and at the federal level. The Flemish Region started with the implementation of an open data policy in 2011, with the approval of the memorandum on open data. The memorandum contained a number of strategic guidelines on open data in Flanders, with the aim of bringing Flanders at the same level as the leading countries in open data. An important development was the creation of a license framework consisting of several standard licences for the provision of open data by entities in Flanders. Flemish public administrations now can choose among three standard licenses for publishing data as open data216: a creative commons zero declaration, a model license for free re-use and a model license for re-use for a fee. If a public administration wants to deviate from these model licenses, approval of the Flemish Information and ICT policy steering body is needed.

The latest development with regard to open data Flanders is the adoption of the Open Data Charter in May 2018. The open data charter contains 20 general principles with regard to open data and is a clear declaration of intent from all Flemish departments and agencies, provincial and local authorities to take further steps with regard to the realization of open data. 'Open by default' and 'comply or explain' are the first principles. Open data is the standard, and if data is not open, an explanation should be given why this is the case. Almost all spatial datasets in the Flemish SDI currently are available as open data.

In the Brussels Capital Region, leading organizations and data providers such as the CIBG and Brussels Mobility already in 2014 decided to share their geodata under a regional open data license.

At the federal level, the Deputy Prime Minister and Minister of the Digital Agenda and Telecoms in July 2015 announced the adoption of the open data strategy for Belgium in order to strengthen the digital ecosystem and the evolution towards leaner, more efficient and modern administration. As mentioned before, open data is included as a key element in the Digital Belgium strategy under the priority of 'Digital Government'. The Royal Resolution of 2nd June 2019 introduced a cascading system of model licenses at the federal level, with CC0 as the preferred license model. A motivation is needed in case a data provider would like to apply a CC-BY license. More detailed motivations are needed in case a fee is requested for the data and/or additional specific use conditions are put in place.

KPI 4: Who can contribute to the (open) SDI: Can anybody add their data to the SDI?

Data included in the SDI mainly consist of data provided by public authorities. The Flemish SDI contains a few datasets provided by non-government actors, such as universities and utility companies. All data sets available on the federal geoportal are government data.

Croatia

KPI1: Is there a vision on open SDI: Does your country have a vision on open SDI?

Existence of clear vision and/or strategic document on open spatial data
Score No: 0
Score explained in short: While there is no clear vision or strategic document on open spatial data, open spatial data is in place, along with different perspectives on how much and which spatial data should be open.
There is no specific vision on open SDI beyond openness that is part of SDI vision and agenda. There is SDI vision and mission, as well as strategy and strategic plan, created in 2017. Vision statement of Croatian SDI is: **"Everyone can easily find, understand and use spatial data."**. The mission of all NSDI stakeholders is defined by the following statement: *"Establish an infrastructure that, through standardized network services, provides spatial data to public institutions, businesses, organizations and citizens."*
One of the recent products or services that is in line with vision and mission, is establishing a portal (Nov 2019) aimed for general public http://geohrvatska.hr, which in addition to more professionally oriented geoportals, like national SDI geoportal, mapping agency geoportal, institutions' geoportals and local geoportals, presents SDI over user friendly interface to everyone. This way of presenting SDI data should increase a public interest and use of SDI in Croatia.

In addition to the official SDI vision, portal http://geohrvatska.hr communicates spatial data also with these teasers: "Spatial data for your lifestyle!", "Spatial information on your side!", "Enjoy the space around you!", "Explore the space around you!", "Get to know Croatia!" and "Be aware of the

surrounding space!". Access to data is intuitive and starts with the following categories: Environmental quality (health), Land, Nature around me, Leisure, Protected areas, and Nearby pollution and results can be based on the user's shared location.
Strategy helps all stakeholders, primarily NSDI entities, to achieve alignment with the European Spatial Data Infrastructure defined by the INSPIRE Directive. It aims to further enhance centralized access to spatial data in the state administration system through the national SDI geoportal, which will result in greater efficiency of state administration in areas directly or indirectly related to spatial data. Meeting the objectives of the strategy will increase the number of spatial data present so far, primarily from the regional and local level, where the largest number of new SDI entities is expected. The same principle will prevent the use of non-official spatial data, thereby reducing the risk of administrative procedures as well as the risk of irregularities when downloading them.
Strategic plan with aims and indicators is defined for the period 2017-2020. Complete document (vision, mission, strategy and strategic plan for 2017-2020 in Croatian) can be found at : https://www.nipp.hr/UserDocsImages/dokumenti/dok-nippa/Strategija_NIPPa_2020_za_objavu.pdf

KPI2: Who can participate in (open) SDI decision making: Are all stakeholders (government suppliers & users/ businesses/ academia/ citizens) included in open SDI decision making?

Participation of non-government actors in decision making on the SDI

Score Yes: 1

Score explained in short: There are non-government actors in SDI Council, 3 of 17 representatives. On the other hand not all stakeholders are included in (open) SDI decision making.

SDI bodies are the SDI Council, the SDI Committee and the SDI working groups.

The NSDI Council is the highest NSDI body and is appointed and dismissed by the Government of the Republic of Croatia. Members of the NSDI Council are mostly representatives of various state institutions, but there are also representatives of professional associations of the economy. The NSDI Council is responsible for overseeing the establishment of NSDI to the extent and with the rights defined in the NSDI Law.

More detailed, representatives in SDI Council are coming from (one from each institution):

1. National Contact Point (State Geodetic Administration),
2. Central body of state administration responsible for environmental and nature protection
3. Central body of state administration responsible for construction and physical planning
4. Central government body responsible for e-Croatia affairs
5. Central body of state administration responsible for defense
6. Central government body responsible for transport, transport infrastructure and electronic communications
7. Central government body responsible for agriculture, forestry and water management
8. Central body of state administration responsible for science and education
9. Central body of state administration responsible for the protection of cultural heritage
10. Central government body responsible for the economy
11. Central body of state administration responsible for state survey and real estate cadastre
12. Central government body responsible for official statistics

13. Body of state administration competent for navigation safety
14. Public institutions in charge of hydrographic activity
15. Communities of the Surveying and Geoinformatics Economy
16. Information technology community
17. Professional associations of chartered geodetic engineers.

As we see, the most of decision makers come from government suppliers and users, with some participation of business representatives. Academia and citizens are not directly involved in SDI decision making, and their participation is limited to public consulting, which enables participation in open public consultations in the process of passing laws, regulations and acts.

SDI Council and SDI working groups are not directly involved in SDI decision making and have similar stakeholders' profiles.

Namely, SDI Council consists of 3 representatives of the NSDI Council, 3 representatives of the National Contact Point and Chairs of working groups. The members of the working groups are selected from national authorities at national, regional and local level, as well as other legal or natural persons whose scope is related to the spatial data infrastructure, including users, producers or providers of additional spatial data services.

KPI3: Is there an open SDI policy: Is there a national policy on access, sharing and reusing spatial data?

Existence and implementation of open data policy for all geographic data

Score No: 0

Score explained in short: There is no specific Open SDI Policy. There is a policy for all geographic data included in national SDI, but not for data at local SDIs. On the other hand, most published spatial data on SDIs have a certain level of openness.

There is no specific "open SDI policy". SDI policy on access, sharing and reusing spatial is generally given in the SDI Act and, in more details, in linked SDI documents and spatial datasets' licences. It is connected with EU legislative and Acts on data access (PSI and national laws on open data access).

As a general rule, metadata on spatial datasets is in open access, most web-services for view are available to anonymous and registered users at no charge. The user may use this service to create new value-added products. By accessing the view web-service and the data that it serves, the user acquires the right to use the data, and in no way transmits the ownership over them. When publishing the derived data, the user is obliged to highlight the source of the data. In addition, many SDI spatial data sets are also published on national (and EU) open data portal under CC-BY licence which allows open access, sharing and reuse of these spatial datasets.

KPI4: Who can contribute to the (open) SDI: Can anybody add their data to the SDI?

Inclusion of spatial data provided by non-government actors in the SDI
Score Yes: 1

Score explained in short: It is possible that third parties (non-government actors) include spatial data in SDI under given conditions. On the other hand, not anybody can add their data to the SDI without fulfilling conditions to become subject of SDI.

Contribution to SDI is prescribed by law. It mainly concerns bodies of public authority, but also the conditions for any other entity which must be fulfilled in order to contribute to SDI exists. More precise, the SDI Act says:

"SDI entities are bodies of public authority which, under the jurisdiction or within their activities, have the obligation of establishment or maintenance of spatial data referred to in Article 9, paragraph 1 of this Act and are obliged to participate in the establishment, maintenance and development of SDI within the meaning of this Act.

A third party may become subject to SDI if it fulfills the conditions laid down in this Act and after the SDI Council has taken the relevant decision on the proposal of the National Contact Point. The conditions for a third party to become an NSDI are:

a) it has within its scope sources of spatial data,
b) that the sources within its scope are included in the list of spatial data topics in accordance with Article 9, paragraph 1 of this Act,
c) that the spatial data sources within its scope are in accordance with the technical requirements and / or implementing rules."

Geoportal of State Geodetic Administration (SGA) (https://geoportal.dgu.hr) allows the registered users to add their own data or WMS to the data sets and functionality of the geoportal, but this is intended for personal use and not for sharing over SGA geoportal node.

Germany

KPI1: Is there a vision on open SDI: Does your country have a vision on open SDI?

In Germany, there are visions on 'OpenData' and on 'Spatial Data Infrastructures'. Since 2014 there is an action plan[13] to enforce the publication of governmental data as open data, including spatial data and using existing infrastructures like GDI-DE. There are also visions on the use of spatial information as open data, e.g. noted in the 'Nationale Geoinformationsstrategie 2015 - NGIS'[14] (German National Strategy on Geoinformation), where the OpenData-principles are stressed out. Nevertheless, there is not an explicit 'Open-SDI' vision.

According to the principle of subsidiarity in Germany, with it's 16 federal states ('Bundesländer') and far-reaching competencies, the 'OpenData' visions and implementations differ strongly on the different administrative levels.

[13] see https://www.bmi.bund.de/SharedDocs/downloads/DE/publikationen/themen/moderne-verwaltung/aktionsplan-open-data.pdf
[14] see https://www.bkg.bund.de/SharedDocs/Downloads/BKG/DE/Downloads-Aktuelles/Nationale_Geoinformationsstrategie.pdf

KPI2: Who can participate in (open) SDI decision making: Are all stakeholders (government suppliers & users/ businesses/ academia/ citizens) included in open SDI decision making?

The governmental SDIs – the GDI-DE on national level and GDI-NW (North Rhine-Westphalia) or GDI-BY (Bavaria) etc. on federal state level – are mainly driven from the eGovernment perspective, providing official data to a community. But several measures have been taken to incorporate different stakeholder:

- a variety of user groups (incl. science and private sector) are incorporated in the steering committees
- an open exchange with the user groups take place in moderated online communities as well as in regular open workshops
- the partner program and the GDI-DE Charta strengthen the cooperation between public and private sector

In sum, the official SDIs are designed as part of the eGovernment strategies, focusing on public data with certain quality criteria. Several efforts have been taken to strengthen user communities and private sector.

KPI3: Is there an open SDI policy: Is there a national policy on access, sharing and reusing spatial data?

There is no explicit 'Open SDI' policy, but there are regulations touching the access and usage of spatial data. A part of Germany's eGovernment law is the so called 'Open Data Law'[15] addressing the free provision of government data as open data for all public authorities on state level. Several federal states also follow the rules described in the 'Open Data Law' or/and currently work on their regional open data laws.

Relevant regulations for spatial data and services can be found in the geoinformation laws on national level ('Geodatenzugangsgesetzt'[16]) or federal levels (e.g. 'Bayerisches Geodateninfrastrukturgesetz'[17] or 'Geodatenzugangsgesetz NRW'[18]).

KPI4: Who can contribute to the (open) SDI: Can anybody add their data to the SDI?

The described SDIs on state and federal level are mainly established for the distribution of governmental data. Contribution of data is limited to the public sector or private companies mandated by public authorities.

Netherlands

[15] See https://www.gesetze-im-internet.de/egovg/__12a.html
[16] see https://www.gesetze-im-internet.de/geozg/BJNR027800009.htm
[17] see https://www.gesetze-bayern.de/Content/Document/BayGDIG
[18] see https://recht.nrw.de/lmi/owa/br_bes_text?sg=0&menu=1&bes_id=12584&aufgehoben=N&anw_nr=2

KPI1: Is there a vision on open SDI: Does your country have a vision on open SDI?

In the Netherlands In 2014, Partners in Geo[19], a newly shared vision for the geographic data infrastructure was set out in the Netherlands between the government, private sector and the scientific community (Bregt, A., et al., 2014). It aims at stimulating the use and re-use of geographic information. In the vision, each involved party has clear goals. The government creates the essential infrastructure, providing 'freely accessible location-based information', the private sector develops new innovative products to stimulate the economy and the scientific community conducts research into new technical possibilities. It is stressed that spatial data is too valuable to not be shared. Therefore open standards and an open spatial data policy are part of the vision((Bregt, A., et al., 2014), p. 23).

An important part of the vision concerns user involvement. The objective is to stimulate use as broadly as possible and therefore it is important to know what the user needs. 'It is the demand for, rather than the supply of, location-based knowledge that should be at the forefront' ((Bregt, A., et al., 2014), p. 24). Twice a year a user group that represents the private sector goes in discussion with the government. Advice is given and priorities are readjusted.

KPI2: Who can participate in (open) SDI decision making: Are all stakeholders (government suppliers & users/ businesses/ academia/ citizens) included in open SDI decision making?

In the Netherlands, user involvement is emphasized in the current vision (Partners in Geo). For geo-data, a strategic user group exists in which the private sector is represented to align supply and demand, consisting out the head of the GI council, GeoBusiness Netherlands and Netherlands Centre for Geodesy and Geo-informatics (NCG). Together they determine the priorities and direction of the geo-sector(Bregt, A., et al., 2014). However, government is still the sole party deciding about the quality of government data, the data policies, and policies on allowing other parties to use the public infrastructure.

In addition, open data users are not formally involved. There are official user groups 48rganized by dataset. This is the case for the topographic dataset, for example. But in general users are only informally involved through social media or ad hoc meetings (Van Loenen and Welle Donker, 2014).

Together with the OSGeo.nl community, the Dutch access network PDOK has established the geoforum platform (https://geoforum.nl/) enabling the community to exchange ideas, questions and reviews on PDOK.

KPI3: Is there an open SDI policy: Is there a national policy on access, sharing and reusing spatial data?

In the Netherlands these exist.

For accessing data, there is the general Public Records Act (Wet openbaarheid van bestuur) and the domain specific legislation (Kadaster Act, Act for the KNMI, Act on CBS etc).

[19] see http://geosamen.webjezelf.nl/wp-content/uploads/2019/05/GeoSamen-UK-1.pdf (or https://www.geosamen.nl/over-geosamen/)

Data sharing within government is arranged by the INSPIRE act, together with the legislation on the key registrations (topography, building data, parcel data, addresses, geology).

For reusing data, partly influenced by the INSPIRE Directive and the [Open data and] re-use of Public Sector Information, the Dutch Ministry of Infrastructure and the Environment adopted in 2011 the policy "all geographic information available as open data by 1-1-2015". The policy applied to data from the National mapping agency (Kadaster), Rijkswaterstaat, and the Royal Meteorological Survey (KNMI), amongst others.

KPI4: Who can contribute to the (open) SDI: Can anybody add their data to the SDI?

In the Netherlands, non-government parties can add their data to the national geoportal. According to the INSPIRE legislation non-government parties can use the INSPIRE infrastructure as long as the data provided adheres to the INSPIRE specifications. So far no non-government parties use the INSPIRE infrastructure.

Sweden

KPI1: Is there a vision on open SDI: Does your country have a vision on open SDI?

In Sweden, Landmäteriet, the Swedish mapping, cadastral and land registration authority, is the coordinator of Swedish SDI, with the support of the National Geodata Council (NGC). The organization is in charge of implementing the Inspire directives in Sweden. In 2016, in consultation with the NGC, landmäteriet drew up a new Swedish geodata strategy for the year 2016-2020. Among other things, this strategy has defined four central goals for the geodata related activities during the period up to 2020:

- Geodata is open
- Geodata is versatile
- Geodata is available
- Collaboration is well developed

Considering these goals, we can conclude that the country has an Open SDI vision.

KPI2: Who can participate in (open) SDI decision making: Are all stakeholders (government suppliers & users/ businesses/ academia/ citizens) included in open SDI decision making?

Sweden has an open SDI vision, but activities, to date, are limited to providing some part of the available data in Landmäteriet to public users, open and free of charge. Talking about Swedish SDI, currently the 13 organizations that are considered and acted as members of the National Geodata Council (the counseling body that supports Landmäteriet in coordinating SDI movement in the country) are all governmental organizations.

KPI3: Is there an open SDI policy: Is there a national policy on access, sharing and reusing spatial data?

Yes. Swedish geodata strategy for the year 2016-2020.

KPI4: Who can contribute to the (open) SDI: Can anybody add their data to the SDI?

Swedish Geoportal is called Geodata portalen, which has been implemented based on INSPIRE directives. Only governmental organizations producing INSPIRE datasets and some municipalities (which are also considered governmental in a way) can upload data to the geoportal.

Appendix III: Open SDI implementation assessed for five EU MS: detailed reports

Belgium

Selected datasets are:

- Top10Vector: Top10Vector is the National Geographic Institute's series of topographic vector data. The data come from the topo-geographic inventory of the Belgian territory and, geometrically and semantically, they are the most accurate data of the National Geographic Institute. The data set contains 37 feature classes, which are divided into eight themes (road network, railroad network, power grid, constructions, land use and vegetation, local relief and particular zones), all of which can be obtained separately. https://www.geo.be/#!/catalog/details/e0fdc885-8851-482e-80c9-6a0ba3709761?l=en
- BeST Address: Location of the address points on the Belgian territory. The result is obtained by merging the three regions on the basis of an XML file which has been supplied to BOSA for the BestAdres project. https://www.geo.be/#!/catalog/details/ca0fd5c0-8146-11e9-9012-482ae30f98d9?l=en

KPI5: search engine score: Go to www.startpage.com and search with two key words 1: topographic data/ address data (in local language) 1:10000 AND 2: COUNTRY of your choice (e.g., Netherlands/ France). Where in the list of results is the concerned dataset of that country?

1. Top10Vector: no
2. BeST Address: no

KPI6: findability: portal: Is the dataset available through a portal?

1. Top10Vector: yes (federal geoportal and federal open data portal, no national portal in place)
2. BeST Address: yes (federal geoportal and federal open data portal, no national portal in place)

KPI7: findability: language: In which language is the metadata of the dataset available?

1. Top10Vector: Dutch, French, English and German
2. BeST Address: Dutch, French, English and German

KPI8: availability: publicly available: Is the dataset publicly available (can you access it if you accept the financial and use restrictions)?

1. Top10Vector: yes
2. BeST Address: yes

KPI9: availability: publicly available: Through which services is the dataset publicly available? [discovery service, view services, download service, API, other]

1. Top10Vector: discovery + view + download service
2. BeST Address: discovery + view

KPI10: availability: money: Is the dataset available free of charge?

1. Top10Vector: yes
2. BeST Address: yes

KPI11: availability: use restrictions): What licence applies to the dataset? (specify your answer, eg creative commons ZERO licence)

1. Top10Vector: Terms of use:
    - The NGI holds the rights of property (including the rights of intellectual property) to the geographic files
    - The NGI grants the user the right to use the data for his internal use
    - Commercial use of the data under any form is strictly forbidden
    - The NGI gives the authorization to draw these files for the internal needs of the customer with slow appliances such as plotters and printers. All drawings and plots have to carry the Institute's logo and the mention "© National Geographic Institute – Brussels – Date"
    - When large quantities of paper documents or excerpts from these documents are produced with fast appliances such as printing presses, the customer has to pay reproduction rights to the NGI
    - Specific licensing agreements exist for internet applications
    - The reference and the logo must be mentioned each time the data are being used for presentations and so on.
    - The publication of the data without prior permission and without prior agreement about the reproduction rights is forbidden.
2. BeST Address:
    - The custodian of the resource holds the rights of property (including the rights of intellectual property) to the geographic files
    - The custodian grants the user the right to use the data for his internal use.•Commercial use of the data under any form is strictly forbidden
    - Custodian's name must be mentioned each time the data are being used publically.

KPI12: usability: interoperability: What applies to the dataset? [metadata in a standard format (eg. ISO19115 etc);available in an open format; machine readable; data specification (data model) adheres to (international) standard]

1. Top10Vector: all?
2. BeST Address: all?

KPI13: use: How often is the dataset accessed per year?

1. Top10Vector: no information available

2. BeST Address: no information available

Croatia

The dataset in Croatia that matches vector topographic data 1:10000 the best, is “base topographic database” (*temeljna topografska baza*, in Croatian). The search keywords used were “temeljna topografska baza hrvatska” without scale because it has no specific scale. Description of this dataset is “Topologically processed planimetry data for production of topographic map 1:25000. It consists of 6 object units: geographical names, buildings, infrastructure, traffic, hydrography and vegetation.”. The accuracy of positions obtained from a photogrammetry survey is around 1 m and this is the reason why sometimes it is denoted as data in scale 1:10000. In the following text this dataset is denoted as CROTIS_TTB10.

To search for address data the term “address data” or “address model” suites best. The search keywords used were “adresni podaci hrvatska” or “adresni model hrvatska”. Description of this dataset is “The register keeps records of the following types of spatial units: state, county and city of Zagreb, city, municipality, settlement, delivery area of post office, units of local self-government (city district, city district, area of local committee), protected and protected areas, data on territorial jurisdiction of cadastral offices, as well as data on territorial jurisdiction of municipal courts, cadastral municipality, cadastral area at sea, statistical circle, census circle, street, square and building with associated house numbers”. In the following text this dataset is denoted as RPJ_Address.

Using english keywords to search these data does not give top results that are linking to datasets (on www.startpage.com, Apr 18, 2020).

KPI5: search engine score: Go to www.startpage.com and search with two key words 1: topographic data/ address data (in local language) 1:10000 AND 2: COUNTRY of your choice (e.g., Netherlands/ France). Where in the list of results is the concerned dataset of that country?

1. CROTIS_TTB10: within the first 10 results
2. RPJ_Address: within the first 10 results

KPI6: findability: portal: Is the dataset available through a portal?

1. CROTIS_TTB10: yes, but only available in the national geoportal
2. RPJ_Address: yes, but only available in the national geoportal

KPI7: findability: language: In which language is the metadata of the dataset available?

1. CROTIS_TTB10: in the national language only (Croatian)
2. RPJ_Address: in the national language only (Croatian)

KPI8: availability: publicly available: Is the dataset publicly available (can you access it if you accept the financial and use restrictions)?

1. CROTIS_TTB10: yes, it is publicly available
2. RPJ_Address: yes, it is publicly available

KPI9: availability: publicly available: Through which services is the dataset publicly available? [discovery service, view services, download service, API, other]

1. CROTIS_TTB10: via view service
2. RPJ_Address: via view service

KPI10: availability: money: Is the dataset available free of charge?

1. CROTIS_TTB10: view service is free of charge, dataset itself not (fee is 0.27 EUR/ha)
2. RPJ_Address: view service is free of charge, dataset itself not (fee is 2 EUR/100 addresses)

KPI11: availability: use restrictions): What licence applies to the dataset? (specify your answer, eg creative commons ZERO licence)

1. CROTIS_TTB10: Creative commons equivalent for published data (it is not clear what is meant by published data?) could be CC-BY-NC, and CC-BY for view services (it is not clear is it only WMS or any view service on geoportal) when it is used for new value-added products (see licence below).
   Note: WMS services are allowed to be used for background in OpenStreetMap, but both CROTIS_TTB10 and RPJ_Address can only be viewed on State Geodetic Administration geoportal and are not available over WMS.
   The original terms of use are (https://geoportal.dgu.hr/#/menu/uvjeti-koristenja):
   "All published data are for information purposes only and intended for personal use, and may not be used for commercial purposes or distributed to a third party except for publicly available view network services and data contained therein, for which the terms of use for view network services apply. Content that can be printed using the SGA Geoportal web-site is for information purposes and may not be used as a public document, but for personal use only. The data contained in the view network service are the official data of the Republic of Croatia. All data available through the view network service are for informational purposes only. Printing the content that can be accessed using the view network service has an informative character and cannot serve as a public document. Public documents are issued in the relevant regional cadastral offices and by the State Geodetic Administration.
   The view network service is available to anonymous and registered users at no charge. The user may use this service to create new value-added products. By accessing the Iview network service and the data that it serves, the user acquires the right to use the data, and in no way transmits the ownership over them. When publishing the data, the user is obliged to highlight the source data as follows »Contains the data of the State Geodetic Administration, the type of data, the date of the download and the date of the data status«. The State Geodetic Administration shall not be liable for any direct or indirect, incidental, non-pecuniary or material damages, losses or expenses incurred as a result of the use or inability to use the view network service and the data it serves. The view network service and the data that it serves can be updated and modified at any time and the State Geodetic Administration does not accept liability for any possible consequences resulting from such changes. By using the view network service and the data it serves the user accepts all risks arising from their use at their own risk. The State Geodetic Administration reserves the right, at any time and without prior

notice, to limit or terminate the access rights to view network service if the user uses this service in a manner contrary to these Terms of Use. The State Geodetic Administration is not responsible for any damages that would result from such abolition of the use of the view network service. The State Geodetic Administration does not guarantee that the view network service will always be accessible and available. The State Geodetic Administration reserves the right to modify these Terms of Use and use of the view network service and the data it serves at any time and will not be liable for the consequences resulting from such changes."

2. RPJ_Address: Same as CROTIS_TTB10.

KPI12: usability: interoperability: What applies to the dataset? [metadata in a standard format (eg. ISO19115 etc); available in an open format; machine readable; data specification (data model) adheres to (international) standard]

1. CROTIS_TTB10: metadata in ISO 19115 standard format; available in an open format; machine readable; data specification adheres to national standard
2. RPJ_Address: metadata in ISO 19115 standard format; machine readable; data specification adheres to national standard

KPI13: use: How often is the dataset accessed per year?

1. CROTIS_TTB10: no information available, dataset is accessible only when viewed over geoportal
2. RPJ_Address: no information available, dataset is accessible only when viewed over geoportal

Germany

Germany is a federal country with 16 federal states (Bundesländer). According to the principle of subsidiarity and the concept of providing data at its origin, the German SDI landscape is designed as a distributed system with several interconnected nodes. Similar, several datasets are collected in a distributed way in responsibility of the federal states but following common rules like data models and quality standards. This implies that some 'base datasets' like addresses or topographic information on a detailed level cannot be accessed as one nation-wide common dataset, but as a collection of federal datasets (sharing a common model and structure).

Datasets 1:10.000 topo and addresses

In Germany, both requested datasets are within the scope of federal ('Bundesland') regulations. The datasets are 1) 'Basis-DLM' and 2) 'Hauskoordinaten', which are collected in all federal states in same quality, model and dataformats. For both datasets, there is a similar approach; offering the original data according to federal regulations (e.g. free and open for NRW or limited license with fee for BY) and offering a commercial, integrated version on a national level[20]. For the questionnaire, the datasets on federal state level were explored for North Rhine-Westphalia (open licenses) and Bavaria (closed licenses).

KPI5: search engine score: Go to www.startpage.com and search with two key words 1: topographic data/ address data (in local language) 1:10000 AND 2: COUNTRY of your choice (e.g., Netherlands/ France). Where in the list of results is the concerned dataset of that country?

1. Top 10
2. Top 10

KPI6: findability: portal: Is the dataset available through a portal?

1. Yes
2. Yes

KPI7: findability: language: In which language is the metadata of the dataset available?

1. German
2. German

KPI8: availability: publicly available: Is the dataset publicly available (can you access it if you accept the financial and use restrictions)?

1. Yes

[20] Topological Model - Basis-DLM can be obtained via Federal Agency for Cartography and Geodesy (https://gdz.bkg.bund.de/index.php/default/digitale-geodaten/digitale-landschaftsmodelle.html) Addresses can be obtained via the 'Zentrale Stelle Hauskoordinaten und Hausumringe' (https://www.ldbv.bayern.de/ueberuns/zshh.html)

2. Yes

KPI9: availability: publicly available: Through which services is the dataset publicly available? [discovery service, view services, download service, API, other]

1. discovery, view, download
2. discovery, view, download

KPI10: availability: money: Is the dataset available free of charge?

1. in one federal state free, the other state with license cost
2. in one federal state free, the other state with license cost

KPI11: availability: use restrictions): What license applies to the dataset? (specify your answer, eg creative commons ZERO licence)

1. in one federal state: specific restricted license, in the other state: Datenlizenz Deutschland BY (similar CC-BY)
2. in one federal state: specific restricted license, in the other state: Datenlizenz Deutschland BY (similar CC-BY)

KPI12: usability: interoperability: What applies to the dataset? [metadata in a standard format (eg. ISO19115 etc);available in an open format; machine readable; data specification (data model) adheres to (international) standard]

1. metadata in standard format, open format (GML format specific for german surveying community), machine readable and services provided, data specification with available UML model
2. metadata in standard format, open format (GML according to INSPIRE), machine readable and services provided, data specification with available UML model

KPI13: use: How often is the dataset accessed per year?

1. ?
2. ?

Netherlands

The Dutch research was performed for the 1:10,000 topographic dataset Basisregistratie Topografie (BRT) and the basisregistratie Addressen (BAG). We used the national geoportal (www.nationaalgeoregister.nl), and PDOK (www.pdok.nl). For the results, please see the overview table in section 3.3.7.

KPI5: search engine score:

1. BRT: within first 10 results
2. BAG: within first 10 results

KPI6: findability: portal: Is the dataset available through a portal?

1. BRT: yes
2. BAG: yes

KPI7: findability: language: In which language is the metadata of the dataset available?

1. BRT: only in Dutch
2. BAG: only in Dutch

KPI8: availability: publicly available: Is the dataset publicly available (can you access it if you accept the financial and use restrictions)?

1. BRT: yes
2. BAG: yes

KPI9: availability: publicly available: Through which services is the dataset publicly available? [discovery service, view services, download service, API, other]

1. BRT: discovery service, view services, download service, API
2. BAG: discovery service, view services, download service, API

KPI10: availability: money: Is the dataset available free of charge?

1. BRT: yes
2. BAG: yes

KPI11: availability: use restrictions): What licence applies to the dataset? (specify your answer, eg creative commons ZERO licence)

1. BRT: CC-BY 4.0
2. BAG: CC public domain declaration

KPI12: usability: interoperability: What applies to the dataset? [metadata in a standard format (eg. ISO19115 etc);available in an open format; machine readable; data specification (data model) adheres to (international) standard]

1. BRT: all applies
2. BAG: all applies

KPI13: use: How often is the dataset accessed per year?

1. BRT: 286 million hits in jan + febr 2019
2. BAG: 222 million hits in jan/febr 2019

Sweden

KPI5: search engine score:

Within the first 10 results.

KPI6: findability: portal: Is the dataset available through a portal?

It is available through a webpage, not a standard OGC portal.

KPI7: findability: language: In which language is the metadata of the dataset available?

Only in Swedish language.

KPI8: availability: publicly available: Is the dataset publicly available (can you access it if you accept the financial and use restrictions)?

A major part of the geographical themes is publicly available.

KPI9: availability: publicly available: Through which services is the dataset publicly available? [discovery service, view services, download service, API, other]

View services, download service, and API are available.

KPI10: availability: money: Is the dataset available free of charge?

A major part of it is available, open and free.

KPI11: availability: use restrictions): What licence applies to the dataset? (specify your answer, eg creative commons ZERO licence)

CC0 for the available open parts.

KPI12: usability: interoperability: What applies to the dataset? [metadata in a standard format (eg. ISO19115 etc); available in an open format; machine readable; data specification (data model) adheres to (international) standard]

The metadata is collected and archived based on a national metadata profile defined by Landmäteriet[21]. The metadata profile is developed on top of ISO19115 and ISO19139 while following the Technical Guidance for the implementation of INSPIRE dataset and service metadata based on ISO/TS 19139:2007, Version 2.0.1 . It means that the output metadata is presented in machine readable formats like XML.

KPI13: use: How often is the dataset accessed per year?

[21] https://www.geodata.se/globalassets/dokumentarkiv/portal/nationell-metadataprofil.pdf

Lund university does not have access to such records of data usage.

Appendix IV: Open SDI impact assessed for five EU MS: detailed reports

Belgium

KPI14: use cases: To what extent is open spatial data used by businesses, citizens and other stakeholders?

- Realo (https://www.realo.be/nl) is a Belgian website that shows real estate properties and provides demographic information about the different places in Belgium. Value of real estate is estimated with algorithm based on open data.
- Aircheckr (https://aircheckr.com/products) offers air quality data at several levels of detail: real-time, forecasting and statistics. Aircheckr can easily be integrated into different applications through API and widgets.
- Spotbooking is a web application developed by the Flemish geo-ICT SME Geosparc (https://www.geosparc.com) that supports the process of applying for, processing and maintaining intakes of public space within a town or city.

See: https://www.europeandataportal.eu/en/using-data/use-cases?title=&body_value=&field_country_value=Belgium&field_region_value=All&field_sector_value=All&field_type_of_use_case_value=All&page=2

KPI15: benefits: Is there any evidence on the socio-economic benefits of open spatial data?

Not aware of any recent studies.

KPI16: portal use: How many times is the data portal accessed (e.g., name portal; total number of downloads/ total number of hits)?

N/A

Croatia

KPI14: use cases: To what extent is open spatial data used by businesses, citizens and other stakeholders?

High: many (+5) use cases can be found of non-government actors using spatial data.

Some identified users (list is not complete):

OpenStreetMap community started to extensively use open spatial data since the license changed in Feb 2019.

Code for Croatia is a non-government initiative that brings together citizens, designers, developers and young entrepreneurs to build awesome things. List of projects using open (spatial) data: https://codeforcroatia.org/projects?tag=topic.otvoreni_podaci

Faculty of Geodesy of the University of Zagreb (as well as other faculties) uses open spatial data in teaching for many years.

Croatian Mountain Rescue Service produce hiking maps based on Topographic Map 1:25000, available at http://www.gss.hr/hgss/kartografija/ .

Orienteering clubs gathered in Croatian Orienteering Association use open spatial data for creating orienteering maps.

KPI15: benefits: Is there any evidence on the socio-economic benefits of open spatial data?

Yes: at least one study exists showing the benefits of open spatial data

Here are some (not complete) available analytics:

https://www.pristupinfo.hr/wp-content/uploads/2018/10/AI-1-2017-Otvoreni-podaci-TJV-objava-informacija-za-ponovnu-uporabu-II.-dio.pdf

http://cdr.eionet.europa.eu/hr/eu/inspire/monitoring/envxnlwmq/

KPI16: portal use: How many times is the data portal accessed (e.g., name portal; total number of downloads/ total number of hits)?

National SDI geoportal has ca 15 000 users per year.

Germany

KPI14: use cases: To what extent is open spatial data used by businesses, citizens and other stakeholders?

There are several applications using open spatial data; e.g. in public transport, regional mapping, education or visualisation. Not aware of studies for governmental open spatial data.

KPI15: benefits: Is there any evidence on the socio-economic benefits of open spatial data?

Not aware of any studies.

KPI16: portal use: How many times is the data portal accessed (e.g., name portal; total number of downloads/ total number of hits)?

According to INSPIRE Monitoring 2018[22]:

- 17537188215 service access to spatial services in sum
- 14071233260 view service access
- 3420329955 download service access

[22] see https://www.gdi-de.org/monitoring2018/EN_gdi-de.html

Netherlands

KPI14: use cases: To what extent is open spatial data used by businesses, citizens and other stakeholders?

In the Netherlands, very limited use cases on open spatial data are documented or available. However, a recent study showed that major users of the PDOK portal are non-government users such as utility companies, financial institutes, research institutes and other private sector parties (F. Welle Donker et al., 2019).

KPI15: benefits (optional): Is there any evidence on the socio-economic benefits of open spatial data?

In the Netherlands, several researches studied the impact of open spatial data. These suggest significant socio-economic impact (see (Bregt, A.K. et al., 2013, 2014; Marc de Vries et al., 2011; Van Loenen, B. et al., 2016; Van Loenen, B. & Welle Donker, F., 2014))

KPI16: portal use: How many times is the data portal accessed (e.g., name portal; total number of downloads/ total number of hits)?

In the Netherlands, the metadata of the geographic datasets, both public and private, are published in a central portal available at www.nationaalgeoregister.com. The portal is linked with and managed by PDOK, the public geo-service provider (www.pdok.nl). Over the past eight years, datasets, view and download services, users and the use of the services increased significantly (PDOK, 2012-2019).

Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
#datasets	41	64	78	91	280			192 datasets 505 services
#hits on services	Not available	580 million	1.1 billion	1.7 billion	4.4 billion		10.8 billion	14.4 billion
#downloads							7.5 million	

Table: Data-use and data-services are increasing (PDOK, 2012-2019, p. 1)[23]

[23] PDOK (2012) *Rapportage 2011*. [Online].Available at: https://www.pdok.nl/nl/actueel/rapportages.
PDOK (2014) *Rapportage Q4 2014*. [Online].Available at: https://www.pdok.nl/nl/actueel/rapportages.
PDOK (2015) *Rapportage Q4 2015*. [Online].Available at: https://www.pdok.nl/nl/actueel/rapportages.
PDOK (2016) *Rapportage Q4 2016*. [Online].Available at: https://www.pdok.nl/nl/actueel/rapportages.
PDOK (2019) PDOK Fact sheet, Available at:
https://www.pdok.nl/documents/1901824/0/20200120_PDOK_Factsheet_2019_NL_v1.pdf

User satisfaction. In 2014, user satisfaction about the open data in the Netherlands was studied by Van Loenen and Welle Donker (Van Loenen, B. & Welle Donker, F., 2014, p. 70; Van Loenen, B. et al., 2016). According to their research the provided datasets cover the basic needs of the user. However, users are critical about quality aspects. They conclude that data are not timely enough, do not sufficiently cover the entire country, lack detail, are in proprietary format and lack sufficient quality control. In relation to the metadata, these are not complete, not up-to-date, the standards should be improved and meta-data are not always relevant. Furthermore, users miss the raw research data that resulted in these datasets (Van Loenen, B. & Welle Donker, F., 2014, p. 71). It is mentioned though, that the user does not exist: what some users appreciate (data accessible through apps) is criticised by others (prefer access to raw data).

Sweden

KPI14: use cases: To what extent is open spatial data used by businesses, citizens and other stakeholders?

Several use cases can be found of non-governmental actors using spatial data in Sweden.

KPI15: benefits: Is there any evidence on the socio-economic benefits of open spatial data?

There are some studies that highlighted the socio-economic benefits of using spatial data. More importantly, the country report of Sweden, submitted to United Nations Committee of Experts on Global Geospatial Information Management[24] has described the country's challenges in five areas of digitization of public sector administration, streamlining of the urban planning process, climate adaptation and environmental threat, and defence and civil contingencies and discussed the role and contribution of spatial data to solving these challenges.

KPI16: portal use: How many times is the data portal accessed (e.g., name portal; total number of downloads/ total number of hits)?

We do not know. Also see our answers to the above questions about how the data are published in Sweden.

[24] https://ggim.un.org/country-reports/documents/Sweden_Land_report_2018_UNGGIM_Final.pdf