Running a Spatial Data Infrastructure for Interdisciplinary Research - How we did it & what we learned so far.

Stefan Steiniger
CEDEUS
Los Navegantes 1963,
Providencia,
Santiago de Chile, Chile
ssteiniger@uc.cl

Helen de la Fuente
CEDEUS
Victor Lamas 1290,
Concepcion, Chile
helendelafuente@udec.cl

Abstract

Using Spatial Data Infrastructures (SDI) for research data allows researchers to share their data with each other, but also allows to distribute spatial data and documents to the public and other interested parties. This permits transparency, showing the public how research funds are used and allows research results to be reproducible. The research center CEDEUS, focused on interdisciplinary urban sustainability research, has implemented such a Research SDI (RSDI). We outline the four operational pillars of this RSDI: (1) Hardware & Software, (2) Data, (3) User Services, and (4) Communication. Then we describe how the RSDI was implementation with respect to its technical architecture and the software used, and we describe how it is used today - in the 4th year of operation. We discuss disappointments and surprises that we experienced while running the SDI. The biggest disappointment was that researchers rarely contribute data voluntary, whereas a positive experience has been that SDI users were gained by having data indexed through Google Search and by publishing data and maps news on Twitter. Given the RSDIs implementation context and intended audience we argue that a user-centric SDI with a strong focus on services and communication is key to an SDI's success, which is needed to justify investments.
Keywords: Spatial Data Infrastructure, research data, open data, free software, GeoNode

1 Spatial Data Infrastructures for Research / Research SDIs

The need to distribute spatial data, and in particular authorative data, has long been recognized by governments to improve administrative processes. Distribution of such governmental data is most often performed in a top-down fashion, whereby on the top one finds a responsible agency or ministry that is tasked with producing such data. To ease spatial data distribution and sharing, many countries around the world have implemented government-run Spatial Data Infrastructures, short SDIs (Crompvoets et al. 2004).

Spatial Data Infrastructures are not only a good way to distribute authorative, i.e. official, data, but offer further benefits such as to permit (i) sharing of geospatial data, so that others do not need to create the same information from scratch, (ii) providing a central point of managed access that offers data from multiple parties, (iii) using it as a remote data service that can be used in processing workflows and that provides always the latest official version, and (iv) sharing responsibilities of data maintenance among different parties while still having the data available in a central place (see Rajabifard and Williamson 2001, Steiniger and Hunter 2012, Harvey et al. 2012). SDI benefits can also be transferred to the context of research data. In particular, the benefit of sharing data and (!) documents is of interest as it allows access to unique data, plus faster access to new data, without the need to wait for the final dataset that is at some point published after all research is done.

However, while there is certainly a benefit to distribute - or in this case "share" - research data via an SDI, there is currently a demand for making research data and results available for two reasons: First there have been a number of cases where a few scientists fudged data to be able to present novel results in journal articles, with the consequence of the retraction of papers by journals after protests (see the blog www.retractionwatch.com). This has triggered publishers to ask or even require authors to submit their data together with the papers to ensure testing and reproducibility of research results and data (Nature Editorial 2016). Second, since most research is funded via public funds, funding agencies are starting to ask researchers not only to report results and methods back to them by attaching publications, but also to gain direct access to research results and underlying data, as there is also an interest in reusing produced research data at some point later on.

The requirement for *Research Data Management Plans* as part of funding applications, as introduced for instance by the Swiss National Science Foundation in 2017 (Swiss NSF 2017), are a first step towards ensuring that (a) public investments are at some point accessible not only to other researchers, but also to the public, and (b) that research results are reproducible by not relying on abstract (textual) data descriptions, but rather being able to use the original data in similar experiments - or - being able to at least compare with the original data.

In the following we consider a Research SDI as "*a type of Spatial Data Infrastructure that makes geospatial data and documents discoverable, accessible and usable for research and the public, that is hosted primarily within universities and research institutes*". This definition is somewhat different to the definition of an Academic SDI by Coetzee et al. (2017a) who describe that the purpose of an *Academic SDI* is to "*make geospatial data produced for and by research and education discoverable, accessible and usable, primarily within universities and research institutes*". The difference is here in the audience, but also in who are producers of data.

Furthermore, the Academic SDI itself is also the subject of teaching, while the Research SDI is only a tool.

Implementation of SDIs for research have been reported, but still seem to be scarce. Coetzee et al. (2017a,b) analyse seven initiatives that aim to implement an academic or research SDI with some being more successful and others less. Of the seven initiatives presented by Coetzee et al. (2017b) one academic SDI was implemented, run for several years and finally died (ITC, Enschede) - probably because it was just to early for a general interest in research SDIs. Two of the seven initiatives are still at an SDI planning stage, but with a group of interested parties formed already; and only four of the seven initiatives have an operational SDI or at least a prototype. Apart from those seven initiatives Pettit et al. (2014) and Willmes et al. (2014) have reported on efforts to build data infrastructures for interdisciplinary research. Bernhard et al. (2014) discuss, however, the general requirements and functionalities of what they call Scientific GeoData Infrastructures (SGDI).

The CEDEUS research center has implemented a Research SDI to facilitate data exchange between researchers with the hypothesis that this will stimulate research between the different research groups, i.e. clusters, of the center. A second goal was that the SDI team should collect and provide basic data needed for urban research, reaching from topographic base data over statistical data to municipal development plans and planning guidelines.

In the following sections we will first describe the context of the CEDEUS Research SDI leading to a few SDI requirements and objectives. Then we will outline in Section 3 the main operational pillars of the CEDEUS research SDI, and describe subsequently the SDI's implementation state. Afterwards, in Section 5, we outline our disappointments and surprises and discuss what we have learned from those.

2 Implementation Context - the CEDEUS Research Center

The Chilean Center for Sustainable Urban Development, (in Spanish: Centro de Desarrollo Urbano Sustentable; CEDEUS) was founded in 2013 to tackle urban development problems that emerged in Chile in the context of the (almost) absence of urban planning and an urban development that is mainly in the hands of Chiles construction and housing industry. To find solutions to the pressing urban development problems related to a fast growing population and rapid urbanization, a holistic, i.e. interdisciplinary, perspective was sought. Therefore, the center’s researchers, in 2014 around 50-60 university professors plus 6-8 postdocs and several thesis students, are grouped around four thematic research clusters: (1) transport and mobility, (2) built environment, (3) socio-spatial dynamics, and (4) critical resources.

The center’s researchers are coming from very different fields, e.g. hydrology, construction engineering, architecture, geography, transportation engineering, sociology, medical sciences, etc. and are based in different university faculties and departments. The center itself is hosted by two universities in two different metropolitan areas in Chile: Santiago and Concepcion, and with one university having CEDEUS researchers in at least four different campuses. Given the conditions that (a) CEDEUS researchers are from very different fields with the majority having no background - or even any knowledge - in geographic data and GIS use, and (b) the particular spatial and organisational constraints, it is paramount for a successful utilization of the research SDI that its structure and services reflect these two conditions.

Given an analysis of the needs of the center researchers (elaborated from a survey) the original objectives of the CEDEUS SDI, also referred to as "CEDEUS observatory", were the following:

(i) to provide urban geographical data needed by CEDEUS researchers and affiliates;

(ii) to provide a platform for urban data exchange – similar to a drop box for spatial data; and

(iii) to enable center researchers to distribute research results and data to the public.

Later on a fourth and fifth objective were added: The fourth objective: "to provide basic training in spatial data use and analysis" was added when it became clear that only a few researchers and thesis students received basic training in the use of geographic data and mapping software. The fifth objective: "to create and calculate a set of urban sustainability indicators" finally contributes to the original naming of "CEDEUS observatory" in the sense of an urban observatory. With adding the 5th objective the SDI received a strong push from a data-centric SDI towards a service-centric SDI.

3 How we did it: Building the reserach SDI

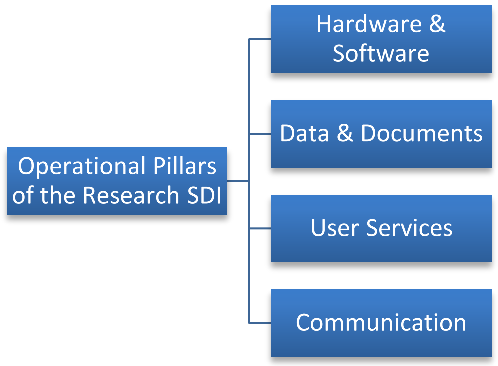
To realize the CEDEUS SDI we first explored the needs of researchers using an online survey (see Steiniger et al. 2017). Based on that we developed an operational SDI framework for the CEDEUS Observatory consisting of four pillars detailed below and in Figure 1. Then we implemented the SDI in three basic steps: First, defining the technical architecture that - given the available resources (funds for hardware, software and staff) - allows to operate the SDI in a resource-efficient way. Second, we selected and installed the software and hardware to run the SDI, which is outlined in the second subsection. Finally and Third: we identified and added the datasets and documents that are of general interest to CEDEUS researchers.

3.1 The Four Operational Pillars of a Research SDI (RSDI)

Different authors have identified basic components of SDIs, including (Rajabifard and Williamson 2001, Smits et al. 2002, Crompvoets et al. 2004, Steiniger and Hunter 2012): (1) spatial data, (2) technologies, (3) laws and policies, (4) people, and (5) standards. However, for building the SDI we assume that trained staff to run the SDI is not an issue, and policies within a research center are important, but as long as no other parties are directly involved in the SDI management, then this is a minor issue. Hence, we identified and argue that a Research SDI has the following essential components (Figure 1):

(i) *Hardware and Software (Technologies)*: The hardware necessary to run the SDI, such as servers and client devices, e.g. from a workstation to a mobile phone, or nowadays also a cloud service; and the SDI software-package itself. This includes several types of software on the server and user side, such as the Database Management System (DBMS), a Web Map Server, a Catalog Service, the user facing Geoportal (Steiniger and Hunter 2012), and the desktop or mobile GIS software on the user side.

Figure 1: Essential components of a Research SDI.



(ii) *Data and Documents (Spatial Data PLUS)*: data hosted by a research SDI does not only include spatial data, but may also include other data that at a first glance have an implicit geographic reference only, such as socio-demographical data, social network messages, or sensor measurements. Furthermore, for a research SDI it needs to be considered to store documents such as images, pdfs, xls/tabular data, zip files, among others, that can contain photos, maps, or description of sampling procedures and research methods, etc.

(iii) *User Services*: With services we do refer here to services for the researcher such as data acquisition, creating perhaps a map, geocoding statistical information, doing spatial analysis and answering questions on these and similar GIS topics. Services do also include training for researchers, staff and students without a background in GIS use on geographical data creation, management, analysis and visualization.

(iv) *Communication*: How can the researchers ask questions? How do the researchers know about the latest data? How can the public find the data in the SDI? All these questions point to the need for communication tools for the RSDI "customers". The user-facing geoportal is only a first step to inform the user. Additional methods, and in particular easy to use and also bi-directional communication tools are key to a successful SDI adoption.

3.2 RSDI Implementation: Architectural Model, Hardware and Software

For the RSDI implementation we had to chose between two different architectural models. Architectural model A is a "Centric SDI" model where people are sitting in a central office and all data are stored in one major database on perhaps one server. Model B resembles a "Federated SDI" (Coetzee and Bishop 2009) with staff, or at least one GIS expert, sitting in each university department, maintaining a local, departmental research database on a local server, and a central Geoportal server that allows to search and access the data in the different departments. As it may be clear from the description, model A is less costly than model B with respect to technical requirements, i.e. servers, and staff needs. For this reason, the CEDEUS SDI was implemented as centric architecture with respect to its technical part. However, the services counter part is realized by placing staff in the center offices of the two cities.

To build the SDI we chose to buy two servers, one to run the user-facing web services, i.e. the geoportal, the observatory webpage and communication tools, and another server to store the data. As SDI software we chose the free and open source software package GeoNode (www.geonode.org). The package contains all necessary software to run the SDI: including a geoportal and user management software build on top of Django that uses OpenLayers and GeoExt for browser-based visualization of geographical data, the spatial database management system Postgres/PostGIS, the catalog software PyCSW and as web map server the GeoServer software that provides data access and visualization services. For communication with users we hosted a general webpage, we did setup an email and Twitter account, installed a wiki (Mediawiki), a user forum and a blog. More details on the implementation can be found in Steiniger et al. (2017).

4 Where we are now & What we offer

The SDI team is/was composed of 2 persons full-time staff that concentrate on data and services, having their work places in each of the research centers two offices of either university/city. Additionally, a developer is/was contracted about 3 months a year for software and hardware maintenance and development of additional tools. In the beginning of 2018 the SDI team grew to 7 people, since the observatory got tasked with the implementation of a set of sustainable city indicators for Chile.

Starting with the SDI implementation in the beginning of 2014, the tasks of hardware and software selection, acquisition, setup, customization and testing, took until the middle of 2014. Efforts afterwards concentrated on adding data, so that the SDI was operational with a number of useful dataset by the end of 2014 - see http://observatorio.cedeus.cl for the general webpage, and http://datos.cedeus.cl for the geoportal based on GeoNode (Figure 2). User services for researchers were offered around that time too. The Twitter account @idecedeus was setup much later by the end of 2015.

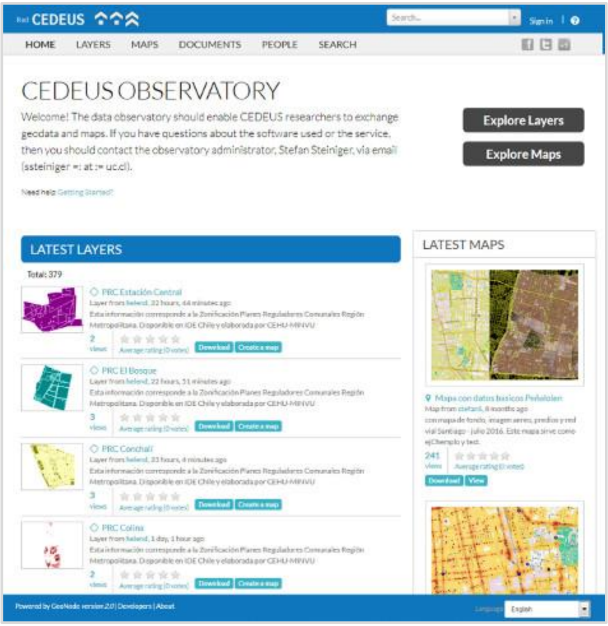
Currently (February 2018), the CEDEUS SDI hosts about 420 geographical datasets and 170 documents that are accessible to everybody, i.e. without a user login. More than 90% of these datasets have been added, however, by the SDI administration team. If someone wants to add a dataset or document s/he needs an account and receives a personal introduction on how to upload data and how to fill the metadata forms. Alternatively, it is offered that a staff member can upload the data. Required metadata are kept to a minimum to set barriers for contribution low on the one hand, while ensuring satisfactory search results on the other hand.

Currently the data website registers 400+ unique visitors monthly (measured with the software Piwik), with some geographic dataset having reached now more than 1000 page visits (which is not equal to downloads).

In 2016 several GIS 101 one-day crash courses were held that did focus on an audience of researchers and students with no previous GIS knowledge. About 40 people were trained on GIS basics in a hands-on fashion with QGIS, coming from different fields such a transportation engineering, architecture or environmental engineering. The help-desk service is used rather infrequent, around 1-2 times a month, with requests either by email or by people dropping in.

Analysing the access statistics only superficially and talking to known users we can say the following about the SDI users: A huge portion of visitors to the data webpage comes actually from outside of the research center and the two hosting universities. And, the most frequent users from within the university are thesis students and postdocs.

Figure 2: The geoportal, i.e. data webpage, of the CEDEUS research SDI accessible at http://datos.cedeus.cl.



5 What we have learned so far

Over the course of the past 4 years we experienced a couple of disappointments but also surprises from a non-technical perspective while building and running the SDI. We outline those below.

5.1 Disappointments

Considering that the idea of the CEDEUS SDI is that researchers share their data, in a voluntary fashion, then one can say that this does - until now - not happen. That is, the CEDEUS researchers, i.e. professors, in general do not use the SDI and only a few have contributed data. This may be due to their position and time available, where priority is given to guiding postdocs, thesis students and research staff. In how far professors spread the word about the centers data webpage is also unclear. It has been noticed, however, that students spread the word among each other.

As mentioned above, thesis students and postdocs seem to be the ones using the RSDI in its intended purpose - at least as a data resource. However, also here the return of data and results to the RSDI produced by those is sparse, and therefore there is basically no data sharing. Interestingly, if we ask recently graduated students about sharing their results, then they are happy to do so. But this requires the SDI team to know who are the recent graduates and what are their thesis about.

Although the GeoNode based data publication system allows to make data accessible only to users with a login, i.e. private, this option has also rarely been used. We infer this from the number-of-visits counter for those layers that are visible to logged-in users only. This may be related to the point that students don't have or ask for a login (we note there are currently no restrictions to obtain an account).

We have also noticed that the open online forum is rarely used to ask questions on data or GIS use. If there are questions, then people prefer to stop by to ask, which assumes a certain spatial nearness between user and SDI team. The blog was planned to distribute news about data and tools, but since we have never received any feedback on it the idea is now to rather use it as a how-to documentation. Frequent updates to it, i.e. new blog posts, are seldom, due to the time it requires to write a post. Hence, it is thought that the time spent on writing is better used by adding new data to the SDI or by working on research support tasks.

Finally, a complicated issue is that some of the centers researchers see the RSDI as a cost factor with low benefits, in particular those that have not used it - or even looked at its webpage. This has generated some tensions as these researchers see the funds rather allocated to their own research budgets. The new task for the SDI team to create and measure a set of urban sustainability indicators, i.e. a particular product that requires dedicated resources and efforts and that also raises the centers profile in the public, has helped to alleviate this issue.

5.2 Surprises

A few times the SDI team has experienced positive surprises in the past. We want to outline these too:

First, already in the first year of operation we noticed a significant amount of page visits to a number of official planning documents that we host in the document section of the geoportal. These visits certainly came not from the center researchers nor from within the university, as such information is not of much interest for research; at least not with the high demand that we experienced. Visits to these documents seem to come from Google Search instead. This has demonstrated us two things: (a) it was easier for the RSDI to have a first impact outside of the center, and (b) that the SDI database is indexed by Google is very important.

Positive experiences and feedback were received when we presented the SDI and its data at local conferences, and when we started to use Twitter to publish news about data, maps, software, etcetera. Although the number of Twitter followers of the SDI is comparably small (only 250 followers in comparison to the centers twitter account @CEDEUS_ with approximately 2900 followers) a few SDI/observatory tweets, and in particular maps, have been received and retweeted well. An advantage of a medium such as Twitter (or Facebook) is definitively immediate feedback, and the related raise of the team's motivation, whereas its drawback is the limited audience that can be reached with it.

The free-of-cost 1-day GIS crash courses were also received well and a number participants asked afterwards if there is a second workshop that offers an introduction to spatial data analysis. Participants of the course have been mostly students that need GIS for their thesis, but also professors who wanted to explore the opportunities that GIS offers for their personal research (or teaching).

5.3 What did we learn

From the disappointments and surprises we have learned a few things so far. The first and perhaps most important experience is that it is difficult to engage researchers in using and sharing data with the SDI as long if the interaction is on a voluntary basis. For the case that data management plans become also a requirement for funding applications in Chile this may change the situation. However, the CEDEUS academic board has decided that from 2018 on researchers need to demonstrate collaboration with the newly formed "Projects and Policies Unit" of CEDEUS, with the SDI being now a formal branch of this unit. This means that researchers can decide to collaborate and share data with the observatory to fulfil their outreach requirements.

The second thing that we have learned is that it is important to know the RSDI audience, its data and service needs, and (!) its communication preferences. Apart from the public the main audience of the CEDEUS SDI are thesis students and postdocs. Given the different jobs a professor has, i.e. teaching, supervision & research, and administration, it makes little sense to focus on professors as a prospective user. Here it is rather useful to keep professors updated to ensure they spread the word about the SDI and its data to thesis students and in classes.

So far we reached our audience with different tools: (i) for some professors Twitter seems to be a good, or even best, tool to stay informed, (ii) presenting the center SDI at conferences and in university departments helped to reach other researchers outside of CEDEUS and partly students, (iii) the introductory GIS workshops (i.e. crash courses) where helpful to make the observatory known to students, and finally (iv) the public learned about the CEDEUS SDI via Google Search and Twitter.

To know what basic data are useful for researchers we explored three methods so far: (a) we conducted an online-survey, (b) we met with researchers to ask for their needs, and (c) we made educated guesses what could be useful, acquired the data and checked if the data are indeed used. However, we assume that the best way to explore data needs, and to ensure that produced research data are fed back to the observatory to distribute them more widely is to have a contact person or even SDI staff sitting in each department - close to researchers and available for drop-ins by students and staff. That this model can be successful has been confirmed in personal experiences.

Related to the previous point and in particular communication is the third experience: the CEDEUS SDI team needs to be flexible in the further development of the SDI using a trial and error approach. That is, one should test if things work, and if not, then other solutions need to be explored. Like in the area of user interface design, a "user-centered SDI" is the goal, where the SDI user is considered at the center of services and data. Only this way it is possible to justify resource allocation and show outcomes.

This means also that, if resources can be freed, one should do (sometimes) the extra-mile for a particular user. In our case we did this and in return we get not only happy users, but these helped us also to defend our budget and they argued with their experience for the importance of continuation of or even extending useful services.

As fourth point we learned that it seems to be essential to introduce a "data are open and downloadable by default" policy. This means that all data we receive are considered for use by the public by default, and that a researcher should explain why s/he wants to put them behind a login. The reason for such a policy has been outlined above: all the data that we have stored and is accessible by login only has not been used by others, except in very rather cases.

This brings us to the last point: metadata and semantics. Making datasets visible in search results that are not accessible provides a frustrating user experience and the user will not return to the geoportal. Therefore, search results are based only on those metadata where the dataset or document is indeed available to the user. If the CEDEUS SDI user actually finds what he is looking for, requires further investigation, since as mentioned, only few users have GIS training. That is, in our case data searches are not performed by SDI trained people nor based on GIS jargon, but rather using search terms that either the average person or the expert knows. It is therefore important that the metadata, and in particular the keyword section, contains words that are part of the common language but also part of the experts' dictionary.

6 Conclusions

Our work on a research SDI for CEDEUS provided challenges and insights that we summarized above. In this paper we do not focus on presenting something innovative with respect to software or methods used - and indeed are rather conservative to ensure an operational SDI platform - but instead we wanted to report a few points that seem important to us to make a Research SDI (RSDI) a success. Given our experiences so far we want to close with two conclusions:

First, the creation of the CEDEUS SDI assumed that the SDI will stimulate research between the different research groups through data sharing. We observed however, that new research between the centers' research groups was rarely stimulated, because although research project leaders know about the SDI, they do not utilize it. Instead, thesis students and postdocs make active use of the SDI, whereby the latter are indeed playing a role in performing interdisciplinary research.

Second, we conclude that the set of SDI components (or: pillars) needs to be extended by two components that have rarely be considered in other SDI publications: (a) services provided to the users, and (b) communication with users. The "service" component has been an RSDI pillar already during the planning of the CEDEUS SDI, as we strived to follow a user-centered design approach to SDI implementation. But the "communication" component was thought to be less important given our assumption of "when we build it, then they will come". Our experience has told us here otherwise.

We assume that both components have been neglected in discussions of SDIs so far, since contributions to a SDI are rarely voluntary - especially in a governmental/authoritative context, and because SDI users are often trained GIS users. However, the need for a service focus and the importance of communication were not only identified by us, but also mentioned in Coetzee et al. (2017b) for the GeoDienst initiative at the University of Groningen.

Both component aspects change how the SDI needs to operate: from a data-centered and institutional focus toward a user-centered focus. This has in turn also consequences on the tools needed, for instance communication tools, and the capabilities of the team members that run the research SDI, such as educational and communicational skills.

Acknowledgements

The authors appreciate funding for CEDEUS (Conicyt/Fondap/15110020) and the AccesoBarrio Project (Conicyt/Fondecyt/1150239).

References

Bernard, L., Mäs, S., Müller, M., Henzen, C., Brauner, J. (2014) Scientific geodata infrastructures: challenges, approaches and directions. *International Journal of Digital Earth*, 7(7), 613–633.

Coetzee, S., and Bishop, J. (2009) Address databases for national SDI: Comparing the novel data grid approach to data harvesting and federated databases. *International Journal of Geographical Information Science*, 23(9), 1179–1209.

Coetzee, S., Steiniger, S., Köbben, B., Iwaniak, A., Kaczmarek, I., et al. (2017a) The Academic SDI—Towards Understanding Spatial Data Infrastructures for Research and Education. In: M. Peterson (eds): *Advances in Cartography and GIScience*. ICACI 2017. LNG&C, Cham, Springer, pp. 99-113.

Coetzee, S., Steiniger, S., Köbben, B., Iwaniak, A., Kaczmarek, I., et al. (2017b) *SDI implementations at universities and research institutes*. Commission on SDI & Standards of the International Cartographic Association. Available from http://sdistandards.icaci.org.

Crompvoets, J., Bregt, A., Rajabifard, A., Williamson, I. (2004) Assessing the worldwide developments of national spatial data clearinghouses. *International Journal of Geographical Information Science*, 18, 665–690.

Harvey, F., Iwaniak, A., Coetzee, S., Cooper, A. K. (2012). SDI past, present and future: a review and status assessment. In: Rajabifard, A. & Coleman, D. (eds.), *Spatial Enabling Government, Industry and Citizens*. GSDI Association Press, pp. 23-38.

Nature Editorial (2016) Announcement: Where are the data? *Nature*, 537(7619), 138–138.

Pettit, C., Stimson, R., Tomko, M., & Sinnott, R. O. (2013) Building an e-Infrastructure to support urban and built environment research in Australia: a lens-centric view. In *Surveying & Spatial Sciences Conference*.

Rajabifard, A., and Williamson, I.P. (2001) Spatial data infrastructures: concept, SDI hierarchy and future directions. In *Proceedings of Geomatics '80*. Tehran, Iran.

Smits, P.C., Düren, U., Østensen, O., et al. (2002) *INSPIRE Architecture and Standards Position Paper*. Available from: http://inspire.jrc.ec.europa.eu/index.cfm/pageid/241/documentid/809

Steiniger, S., and Hunter, A.J.S. (2012) Free and open source GIS software for building a spatial data infrastructure. In: Bocher, E. & Neteler, N. (eds.), *Geospatial Free and Open Source Software in the 21st Century*. Springer, Heidelberg, pp. 247–261.

Steiniger, S., de la Fuente, H., Fuentes, C., Barton, J. R., Muñoz, J. C. (2017) Building a geographic data repository for urban research with free software – learning from Observatorio.CEDEUS.cl. In: *FOSS4G-Europe Academic Track* (Vol. XLII-4-W2). Marne le Valleé, France: ISPRS, pp. 147–153.

Swiss NSF (2017) Open Research Data: Data management plans are part of project funding. *SNF Newsroom*. Available from: www.snf.ch/de/fokusForschung/newsroom/Seiten/news-170306-open-research-data-kommt.aspx

Willmes, C., Kürner, D., Bareth, G. (2014) Building Research Data Management Infrastructure using Open Source Software. *Transactions in GIS*, 18(4), 496–509.