An assessment view to evaluate whether Spatial Data Infrastructures meet their goals

Łukasz Grus a,⇑, Watse Castelein b,c, Joep Crompvoets d, Theo Overduin b, Bastiaan van Loenen b,e, Annemarie van Groenestijn b, Abbas Rajabifard f, Arnold K. Bregt a

a Wageningen University, Centre for Geo-information, The Netherlands
b Geonovum, The Netherlands
c Universidad Politecnica de Madrid, Spain
d Katholieke Universiteit Leuven, Belgium
e Delft University of Technology, The Netherlands
f University of Melbourne, Australia

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ABSTRACT

The motives for constructing Spatial Data Infrastructures (SDIs) are often based on their anticipated benefits for society, economy, and environment. According to those widely articulated but rarely proven benefits, SDI coordinators have been defining more specific objectives to be achieved by their SDIs. However, there is a limited number of assessment approaches that are able to demonstrate whether SDIs indeed realize the intended goals. In this article we develop, apply and evaluate an assessment view for evaluating the extent to which SDIs realize their goals. The assessment view has been developed stepwise using the Multi-view SDI assessment framework as a guideline. The application of the proposed view in the Dutch SDI demonstrates its potential. In addition, the evaluation of the proposed view by the potential users confirms to a certain extent its usability. The results also show that the ease of determining assessment indicators depends on the precision with which the SDI goals are formulated.

1. Introduction

Since the beginning of the 1990s, many local governments, countries, and regions have been building Spatial Data Infrastructures (SDIs) (Crompvoets & Bregt, 2007; Crompvoets, Bregt, Rajabifard, & Williamson, 2004; Masser, 1999, 2005, 2007; Onsrud, 1998, 2007; Rajabifard, 2002; Rajabifard, Feeney, Williamson, & Masser, 2003). The aim of SDIs is to facilitate the exchange and sharing of spatial data between stakeholders in the spatial data community (Crompvoets, Rajabifard, van Loenen, & Delgado Fernandez, 2008). SDI is also about coordinating spatial data assets. The establishment and management of SDIs is in many cases coordinated by mapping agencies or political or administrative organizations. These organizations integrate standards, data access facilities, policies and technologies to enable the spatial data exchange within SDIs. The proponents of SDIs articulate many dimensions of goals and benefits that SDIs can realize and bring to the society, for example: economic (e.g., reduced costs of data production), technical (e.g., improved development of applications), social (e.g., better management and decision making) and environmental (e.g., the integration of spatial information and knowledge from different sectors for solving environmental issues). SDIs also have the potential to spatially enable governments, i.e. providing better service to decision-makers, politicians and societies by using spatial concepts and technology (Bennett & Rajabifard, 2009; Masser, 2007; Masser, Rajabifard, & Williamson, 2007; Rajabifard et al., 2003; Rajabifard, 2007). The goals for an SDI can also be more specific. The SDI policies written for a specific jurisdiction (e.g., province, country or region) define specifically what the SDI being designed and developed aims to achieve. For example, the specific goal of the INSPIRE directive is to create an SDI that would assist policy makers in their activities affecting the environment (European Commission, 2007). Given this wide array of intended but rarely proven SDI benefits and goals, it is natural for policy makers, government representatives and the public to be interested in the assessment studies measuring the benefits of SDIs and the level of realization of the goals.

The Dutch SDI implementation provides an example of governmental demand for monitoring SDI goals. Since 2008, the Dutch SDI is being constructed by implementing the vision and strategic plan called GIDEON (VROM, 2008). GIDEON establishes four goals that need to be realized by 2011. In 2009, the Ministry of Housing, Spatial Planning and the Environment (VROM), which

⇑ Corresponding author. Tel.: +31 317 481697.
E-mail address: lucas.grus@wur.nl (Ł. Grus).

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is responsible for GIDEON implementation, requested monitoring of the extent to which the four GIDEON goals have been realized. However, a “ready-to-use” approach to monitor the realization of SDI goals, which could also be applied to monitor the realization of the GIDEON goals, does not exist.

An extensive body of literature on SDI assessment (or its components) already exists. Many SDI assessment views have already been proposed (Crompvoets et al., 2008; Delgado Fernandez, Lance, Buck, & Onsrud, 2005; Georgiadou, Rodriguez-Pabón, & Lance, 2006; Kok & van Loenen, 2005; Lance, Georgiadou, & Bregt, 2006; Masser, 1999; Onsrud, 1998; Rodriguez-Pabón, 2005; Spatial Application Division Leuven (SADL), 2005). The majority of them were developed within the SDI scientific community. The character of these studies was rather intuitive and curiosity-driven. Their aim was to explore and build knowledge about the performance and benefits of SDI. These studies were natural in the early stage of SDI development when knowledge about SDI was limited. However, in recent years, a shift from an intuitive to more rational SDI assessments can be observed (Bregt, Grus, Crompvoets, Castelein, & Meerkerk, 2008). The increasing demand for rational assessments requires generic assessment approaches that measure, for example, the extent to which SDIs programs meet their objectives (Lance, Georgiadou, & Bregt, 2009; Lance et al., 2006). There is also a growing awareness across governments and communities of practitioners that much more attention needs to be paid to assessing the social and economic impacts of SDIs. These impacts need to be articulated when a significant number of such infrastructures have already been established (Craglia & Nowak, 2006). Up until now, SDI impact studies have mainly had an ex-ante character, i.e., focused on predicted SDI impacts and benefits (Craglia, 2003; Craglia, Garcia Almirall, Moix Bergadà, & Queraltó Ros, 2008; Dufourmont, 2004). Ex-post studies of SDI benefits and impacts are still rare (Lance et al., 2006) and only a few theoretical considerations and best practices in this matter can be mentioned (see e.g. Castelein, Bregt, & Pluimers, 2010; Craglia & Campagna, 2010; European Commission, 2009; Genovese, Cotteret, Roche, Caron, & Feick, 2009; Geoconnections, 2008).

As a response to the growing need for SDI assessment, a Multi-view SDI assessment framework has been proposed (Crompvoets et al., 2008; Grus, Crompvoets, & Bregt, 2007). The core of the Multi-view SDI Assessment Framework is represented by the multiple assessment views that can be classified in terms of (1) assessing different SDI aspects e.g., organizational, technical, etc., and (2) assessing SDIs for different purposes, i.e., knowledge, development and accountability. The theoretical reasoning for the Multi-view SDI Assessment Framework originates from the principles of assessing complex systems where the use of multiple assessment methods simultaneously provides more holistic and less biased assessment result of complex phenomena. As SDIs can be viewed as Complex Adaptive Systems (CAS), the principles of assessing CAS can also be applied in assessing SDIs (Grus, Crompvoets, & Bregt, 2010). The Multi-view SDI Assessment Framework by combining multiple SDI assessment views, which have been developed for different purposes and for different users, can provide a comprehensive and realistic SDI assessment to satisfy many SDI stakeholders (Grus, Crompvoets, Bregt, van Loenen, & Delgado Fernandez, 2008). However, there is a growing demand, especially from policy makers and politicians, for more rational SDI assessments which can provide evidence if the SDI intended goals has or has not been met. According to the authors of this article, there is currently no SDI assessment approach that could answer this specific demand for SDI goals monitoring.

In this paper, the authors develop and present a generic assessment view to assess the extent to which SDIs realize their goals. The view is implemented in the Dutch SDI and evaluated by the potential users.

This article is structured as follows. Section 2 presents the methodology used to develop the assessment view. Section 3 presents the developed SDI goal-oriented assessment view. Section 4 discusses the assessment view implementation in the Dutch case study. Section 5 presents and discusses the results of users' evaluation of the developed assessment view. Section 6 closes the paper with conclusions and recommendations for the further research.

2. Methodology

To develop a SDI goal-oriented assessment view, the authors first reviewed the existing evaluation models. Hansen (2005) presented a typology and classification of several evaluation models. They differ in the questions that they aim to answer and the evaluation criteria they use (see Table 1). From the overview of these evaluation models and the questions they aim to answer it is evident that the “goal-attainment model” model best fits the objective of developing a goal-oriented SDI assessment view. The “goal-attainment model” falls into a broader category of “result models” that focus on the results of a program or organization. In the “goal-attainment model,” the results are assessed only in relation to the predetermined goals. The evaluation criteria should be derived from these goals. The “goal-attainment model” does not

<table>
<thead>
<tr>
<th>Evaluation models</th>
<th>Questions</th>
<th>Criteria for evaluation</th>
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<tbody>
<tr>
<td>Result models</td>
<td>(a) Goal-attainment model</td>
<td>(a) To what degree has the goal(s) been realized?</td>
</tr>
<tr>
<td></td>
<td>(b) Effects model</td>
<td>(b) Which effects can be uncovered?</td>
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<td></td>
<td>Explanatory process model</td>
<td>Is the level of activity satisfactory? Are there implementation problems?</td>
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<td></td>
<td>System model</td>
<td>How has performance functioned as a whole?</td>
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<tr>
<td>Economic model</td>
<td>(a) Cost-efficiency</td>
<td>Is productivity satisfactory?</td>
</tr>
<tr>
<td></td>
<td>(b) Cost-effectiveness</td>
<td>Is effectiveness satisfactory?</td>
</tr>
<tr>
<td></td>
<td>(c) Cost-benefit</td>
<td>Is utility satisfactory?</td>
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<tr>
<td>Actor model</td>
<td>(a) Client-oriented model</td>
<td>Are clients satisfied?</td>
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<td></td>
<td>(b) Stakeholder model</td>
<td>Are stakeholders satisfied?</td>
</tr>
<tr>
<td></td>
<td>(c) Peer review model</td>
<td>Is professional quality in order?</td>
</tr>
<tr>
<td>Programme theory model</td>
<td>(theory-based evaluation)</td>
<td>What works for whom in which context? Is it possible to ascertain errors in programme theory?</td>
</tr>
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</table>

Table 1 Classification of the evaluation models (Hansen, 2005).
provide a ready-to-use assessment view to assess the realization of the SDI goals and it is rather a conceptual foundation that can guide the further development of a goal-oriented evaluation.

To develop a SDI goal-oriented assessment view the authors used the Multi-view SDI assessment framework (Crompvoets et al., 2008; Grus et al., 2007) (see Fig. 1). In this framework, each assessment view is applied in four phases. Phase (1) assessment purpose; Phase (2) assessment approach; Phase (3) application; and Phase (4) evaluation (see Fig. 1). The task of the first phase is to determine one of the three purposes of assessing SDIs: (1) accountability; (2) knowledge; and (3) development (Chelimsky, 1997; Grus et al., 2007). The second phase focuses on developing an assessment approach. By an assessment approach, the authors understand the whole assessment methodology of assessing SDI from a particular viewpoint, e.g., assessing data access, assessing SDI organization, or assessing SDI goals realization (Grus et al., 2007). The third phase concentrates on the application of the assessment approach. The main activity in this phase is collecting necessary assessment data and measuring the values of indicators. The fourth phase concentrates on interpreting indicators’ values. In this phase, the merit of a particular SDI is judged. The merit is evaluated based on the indicators’ values and their relation to target values, for example. The result of this phase should provide an evaluation of SDI from a specific view.

The same four phases can also serve as a comprehensive and usable guideline for developing a new SDI assessment view. Moreover, the phases are generic for all other SDI assessment views so the newly developed goal-oriented assessment view can later easily be applied simultaneously with the other SDI assessment views. Therefore, the proposed goal-oriented SDI assessment view is developed and applied according to the four phases of the Multi-view SDI Assessment Framework.

3. A goal-oriented assessment view

Fig. 2 presents a schematic picture of the proposed assessment view for assessing the extent to which SDI realizes its goals. The view is divided into four phases, according to which it is developed.

Phase one focuses on the purpose of the assessment. According to Hansen (2005), the purpose of the “goal-attainment model” is to answer the question: to what degree have the goals been realized? This assessment purpose can be classified as accountability (Chelimsky, 1997; Grus et al., 2007).

Phase two focuses on developing the assessment approach and consists of six steps. The aim of an assessment approach is to derive the assessment criteria and indicators from the SDI goals (see Table 1 – “goal-attainment model”).

![Fig. 1. The Multi-view SDI assessment framework.](image-url)
Step one: Identify the SDI goals.

Step two: Compile the long list of potential indicators.

Step three: Identify the key SDI stakeholders.

Step four: Organize a workshop where the stakeholders will discuss, work on and propose their own ideas for a goal-oriented SDI assessment approach.

Step five: Select from the long list those indicators that can potentially best measure the realization of each SDI goal. The SDI stakeholders participating in the workshop should be asked to select the indicators. In addition, the stakeholders can also propose their own indicators that are not in the long list. To keep the final number of indicators manageable final list of indicators should be limited to only those that were proposed the most frequently.

Step six: Formulate a goal-oriented SDI assessment approach. The goal of this step is to make the selected indicators operational. The indicators selected from the long list by the workshop participants (Phase 2 Step 4) indicate only the general direction of what should be measured. To make the indicators operational, they have to be adjusted. A group of SDI experts, preferably the representatives of the workshop stakeholders and experts in the field of assessment, should review and assess each indicator. The indicators can be assessed against the criteria in Table 2. The criteria are partly derived from the characteristics of SMART indicators (WHO, 2000) and adjusted to the needs of SDI goal monitoring.

Phase three focuses on the application of the approach. The application process concentrates on measuring the assessment indicators using the methods defined in the previous phase.

Phase 4 focuses on interpreting the meaning of the indicators’ values measured in the previous phase. The indicators values should be evaluated against the criteria of merit defined for the goal-oriented SDI assessment view. The main criterion of the approach is the extent to which SDI goals have or have not been realized. The interpretation of the indicators’ values should allow judgment on this main criterion.

4. Case study

To demonstrate how the developed view is implemented in a real-world case, it was applied to measure the extent to which the goals of the Dutch Spatial Data Infrastructure (GIDEON) are realized. This section is divided into two parts. The first part
describes the GIDEON strategy and the plan to develop a Dutch SDI. The second part discusses the implementation of the developed view in the GIDEON case.

4.1. GIDEON as a case study

4.1.1. GIDEON approach and implementation strategy

In 2008, the Dutch government approved GIDEON, a policy aimed at the implementation of the National Spatial Data Infrastructure (NSDI) in the Netherlands. The document has been developed in close cooperation with the stakeholders and aims at developing a key geo-information facility for the Netherlands that all parties in Dutch society will be able to use. In June 2009 a new Dutch SDI clearinghouse (nationaalgeoregister.nl) has been launched. The clearinghouse provides currently (September 2010) 2445 metadata of datasets and six metadata of services. It provides also a map viewer which provides functionality to connect, display and overlay map layers conforming to the Web Mapping Service (WMS) standard of Open Geospatial Consortium (OGC). The catalogue of the Dutch clearinghouse uses the Catalog Service for the Web (CSW) protocol for metadata. The current version of the clearinghouse does not provide any processing services.

The execution of GIDEON should take place by pursuing seven implementation strategies (see Fig. 3) that lead to the achievement of the GIDEON goals (see Section 4.2). GIDEON also expresses the need to monitor the progress of implementing its strategies and realization of its goals.

4.1.2. Implementation of a managerial set-up of GIDEON

At the beginning of 2008, the policy document had been accepted by the Geo-information Council (GI-Council) and National Council for E-government Services, which act as advisory boards for the Ministry of VROM and Minister of Interior, respectively. The administrative responsibility and coordination for geo-information policy had been given to the Ministry of VROM, which adopted the document. The document was subsequently also approved by the Dutch parliament. In the middle of 2008, the implementation was begun under the leadership of the Ministry of VROM. The GI council is acting as the steering committee for the implementation of GIDEON. The GI Council has representatives of all important governmental SDI stakeholders, and in its role as steering committee, it creates conditions for GIDEON implementation and monitors progress and consistency in its implementation. Geonovum is the SDI coordination body and is supporting VROM in its coordination role by monitoring the progress of GIDEON and reporting to the GI-Council.

One of the first steps in the GIDEON implementation process has been to clarify the plans in more detail to provide a clear picture of the milestones of the implementation strategies and their interrelationship. Roadmaps have been designed that form the basis for a half-yearly reporting to the GI-Council about the status of the different milestones. However, these reports inform the GI-Council only about the status and progress of the predefined milestones of the seven implementation strategies. They do not measure the extent to which the four GIDEON goals are realized. Therefore, the Ministry of VROM expressed the need to also monitor the realization of the goals of GIDEON.

4.2. Implementing a goal-oriented SDI assessment view in GIDEON

The request of the Ministry of VROM forms an appropriate test case to apply the developed goal-oriented assessment view. The text below describes the process of implementing the goal-oriented assessment. The assessment view has been applied according to the four phases of the Multi-view SDI assessment framework.

4.2.1. Phase 1 – assessment purpose

The Ministry of VROM was seeking an answer to the question: to what degree have the GIDEON goals been realized? This assessment could be classified as the accountability purpose because it explicitly asked about the results of SDI implementation.

4.2.2. Phase 2 – assessment approach

The goal of this phase was to formulate an assessment approach to measure the realization of the GIDEON goals. The process of formulating the approach included the following six steps.

In the first step, the GIDEON goals were identified. The GIDEON document (VROM, 2008) explicitly identifies the following four goals to be realized within four years from the GIDEON policy implementation:

- the public and businesses will be able to retrieve and use all relevant geo-information about any location;
- businesses will be able to add economic value to all relevant government-provided geo-information;
- the government will use the information available for each location in its work processes and services;
- the government, businesses, universities and knowledge institutes will collaborate closely on the continuing development and enhancement of the key facility.

In the second step, a long list of potential indicators were compiled. As a basis for collecting the potential indicators, the authors used indicators from four assessment approaches of the Multi-view SDI assessment framework (Grus et al., 2007): Clearinghouse suitability, SDI-readiness, INSPIRE State of Play and Organizational approach. These four assessment approaches were chosen because they were fully operational, i.e., their indicators could be measured and had been applied before. The authors compiled a list consisting of 72 potential indicators (see Appendix A for the list of potential indicators). The order of the indicators in the list was random.

In the third step, the key Dutch SDI stakeholders were identified. The 21 organizations whose representatives were involved in creating GIDEON are listed in the policy document (see VROM, 2008 p. 3). The authors treated this list as a complete record of the stakeholders involved in creating the Dutch SDI.

In the fourth step, on October 22, 2008, a one-day workshop called “Monitoring GIDEON” was held at Wageningen University in the Netherlands. The objective of the workshop was to develop
an approach for goal-oriented SDI assessment using GIDEON as a case study. In total, 23 representatives of 21 organizations listed in the GIDEON document as the stakeholders were invited to the workshop.

In the fifth step, the indicators were selected and matched with the GIDEON goals. The participants selected from the long list these indicators that, according to them, would best measure the realization of the goals of GIDEON. The participants were asked to select a maximum of five indicators per goal. In addition to selecting indicators from the long list, the workshop participants proposed 18 new indicators. To formulate the final SDI assessment approach (see step six) we took these indicators that were selected by a minimum of five stakeholders. The reason for limiting the number of indicators was to include only those indicators about which a certain level of consensus among stakeholders could be observed. In total, for all four GIDEON goals, 21 indicators were selected by a minimum of five stakeholders. To formulate the final SDI assessment approach the authors took also all 18 unique indicators proposed by the stakeholders.

In the sixth step, the final goal-oriented SDI assessment approach was formulated. In the previous step, 39 indicators (21 selected and 18 proposed) were identified as the candidate indicators. To finalize the approach, each of those 39 indicators were assessed and analyzed by an expert team. The team included two members of the Dutch SDI implementation executive body Geonovum and two members of the Centre for Geo-information, Wageningen University. These members were considered as experts due to the following reasons. Firstly, the two members of Geonovum were well acquainted with the details of the assessment request of the Dutch Ministry VROM. Moreover, they had extensive knowledge about the Dutch SDI and especially about the availability and reliability of the potential data sources for measuring the indicators. Secondly, the two members of the Centre for Geo-information of Wageningen University were specialized in scientific approaches to perform assessments. In addition they were already experienced with developing applicable assessment framework for SDIs. Due to the request of the Dutch Ministry of VROM for a short and compact assessment report, the number of 39 indicators was considered still too high. It was decided to select no more than three indicators per goal. The selection was based on the five criteria from Table 2. Indicators that were selected by the majority of experts were considered to be the key indicators for monitoring the realization of the Dutch SDI goals (see Table 3).

4.2.3. Phase 3 – application

The developed approach was applied in the summer of 2009. The indicators’ values were measured by an employee of a Geonovum who collected data from the sources specified for each indicator. On the basis of the collected data, the indicators were calculated. Table 4 presents the values of the indicators.

4.2.4. Phase 4 – evaluation

The indicators’ values were presented to the participants of the workshop “Evaluating the goal realization of the Dutch SDI” organized in October 2009 in Wageningen by Geonovum. The objective of the workshop was to evaluate and discuss the realization of the GIDEON goals. The workshop participants consisted of 20 representatives of 21 organizations participating in the Dutch SDI. The values of the indicators were visualized in several graphs to provide a thorough understanding of the meaning of the indicators’ values. Three questions were raised to the participants: (1) Is the correct quantitative data acquired? (2) Are the proposed indicators representative enough to assess the GIDEON goal attainment assessment? (3) What is your opinion about the progress in implementing GIDEON? The overall opinion of the workshop participants was that the determined indicator values are correct. However, some of these data are not entirely complete, or the reliability of the data source is not optimal (yet). From the answers to the second question, the general conclusion could be drawn that the representativeness of approximately half of the selected indicators to assess GIDEON goal attainment is doubtful. In other words, some indicators for some goals are not completely suitable for assessing the particular GIDEON goal in question, mainly because the selected indicator values may not correctly reflect the GIDEON goals. Nevertheless, approximately half of the total number of indicators and their values were qualified as useful and effective, such as Indicator 3.2, belonging to the third goal and the indicators belonging to the fourth goal. In the discussion on

<table>
<thead>
<tr>
<th>SDI goal</th>
<th>Indicator measuring goal realization</th>
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| Goal 1: The public and businesses will be able to retrieve and use all relevant geo-information about any location | Indicator 1.1 The number of visitors of the Dutch National GeoRegister (NGR). (Indicator source: Google analytics linked to National GeoRegister [NGR])
| Goal 2: Businesses will be able to add economic value to all relevant government-provided geo-information | Indicator 2.1 Information on general governmental policy terms for (re)use of geographical information (indicator source: NGR)
| Goal 3: The government will use the information available for each location in its work processes and services | Indicator 3.1 The level of cooperation within 5 chains of GIDEON (Indicator source: see Geonovum, 2009)
| Goal 4: The government, businesses, universities and knowledge institutes will collaborate closely on the continuing development and enhancement of the key facility | Indicator 4.1 The number of Geo-information events (Indicators source: www.geoinfo.nl)

**Table 3** Final list of indicators for monitoring the Dutch SDI goals realization.
the third question, the presented indicator’s values convinced around 90% (19 participants) of the workshop participants that the implementation of GIDEON is on the right track and are optimistic about the progress of goal realization, while 10% (2 participants) had an opposite opinion.

4.3. Discussing the implementation of the goal-oriented SDI assessment view to GIDEON

The goal-oriented SDI assessment view was implemented in GIDEON according to the four phases of the Multi-view SDI Assessment Framework (see Fig. 2). The results show that the assessment view could be applied that delivered a basis for the assessment of GIDEON goals realization.

As a basis for compiling a long list of indicators, the authors selected 72 indicators from the four existing SDI assessment approaches. The stakeholders also proposed a large number of their own indicators, which potentially were more accurate than the indicators used. However, the majority of these indicators were not attainable because they could not be measured or information about their values was not available. It should also be noted that, for some selected indicators, the exact target values could not be specified. However, a growing value of indicator over a period of time was considered a good result. In this case, it was decided that the series of measurements showing a trend gives a much better base for interpreting indicators’ values than the measurement taken at one point in time.

There are two potential reasons for regarding half of the selected indicators as unsuitable to measure GIDEON goal realization. First, some indicators that seemed valid had to be removed from the final list because they did not conform to the criteria from Table 2 and could not be used. In turn, many stakeholders were reluctant to accept the indicators that were finally used. Second, the accuracy of the definition of the SDI goals plays critical role in the process of indicator selection because assessment indicators should precisely reflect the components of the SDI goals. In the case of GIDEON, the selection of the indicators was hampered by the vagueness of the definition of the goals, which leaves room for interpretation. Consequently, the appropriateness of the final list of the indicators to measure the GIDEON goals may still be questioned by others who interpret the meaning of those goals differently.

Nevertheless, it is interesting to discuss the nature of the final set of indicators. Concerning the data needed to measure the indicators’ values, it can be observed that most of the indicators need quantitative data. The indicators are usually expressed as numbers (indicators 1.1, 1.2, 2.1, 2.3, 3.1, 4.1, 4.3, 4.4) or percentage (indicators 2.2, 3.2, 4.2). Several data sources for the computation of the indicators values were identified. For example, “The Geo-sector in Kaart” (Bregt, Castelein, Pluimers, & van Leeuwen, 2009) is a yearly geo market monitor which provides a number of measures concerning the economic status of the geo-information sector in the Netherlands. “Overheid.nl Monitor” (see Table 4) is a yearly report which monitors the e-government services (including geo-information services) provided by the governmental bodies in their websites. Also, a useful source of data was a website of the Dutch geopolitical [National Georegister (see Table 4)]. Especialy, by linking services like Google Analytics to the clearinghouse websites it was possible to measure various statistical data on the nature of the use of the clearinghouse website. The existence of such reports oriented on measuring the provision of geo-information services certainly helps to evaluate SDIs. It is also remarkable that in the final set of indicators there are no purely qualitative measures such as interviews, stories, case studies etc. The use of such a qualitative measures should be advocated in measuring SDI goals to have a better diversity of measurement methods and data types.

However, in comparison with the available quantitative data, the sources of such qualitative data about the geo information field are scarce. Therefore, the costs of time and effort to collect such data would be much higher. It is also notable that the stakeholders did not select any indicators relating to the technicalities of the Dutch SDI. There are no indicators measuring the existence and/or performance (effectiveness and efficiency) of the services such as WMS, WFS or processing services some of which are already provided by the Dutch clearinghouse. The future assessments and indicators of the SDI technical components, such as clearinghouses, should also follow the newest developments of the data access facilities (such as in Mansournia, Omidi, Toomanian, and Harrie (2010)) to use the state-of-the-art developments in the field as a benchmark.

To make the assessment of the extent to which SDI meet its goals realistic, some general considerations about its future applications have to be made.

Firstly, the accuracy and nature of SDI goals definition have a significant impact on the goal-oriented SDI assessment. On one hand a broad definition of SDI goals encourage to assume a wide spectrum of possible SDI applications and expected benefits. However, such a broad definition makes it problematic to assess SDIs for its accountability due to the problems with selecting indicators. On the other hand defining SDI goals in a very precise way would restrict the evaluator only to the expected SDI outcomes and would pose a threat of missing the unforeseen benefits out. The fact that SDI can be seen as complex and especially unpredictable and dynamic system (Grus, 2010) suggests that limiting the spectrum of potential SDI goals might be incorrect. An interesting questions arises as to how to formulate SDI goals that are sufficiently precise to support good assessment indicators and at the same time permitting the unforeseen benefits. It may be suggested that SDI goals should be defined on two levels of specificity. Generic and broad level of goals descriptions could be accompanied with a more precise level of definition of intended products/services/measures to be achieved by SDI within specified time period. The proposed two levels of specificity would give enough room for monitoring the unexpected outcomes and at the same time would allow to select specific indicators to measure the intended specific outcomes.

Secondly, it is strongly encouraged that the work on defining potential indicators to measure the intended SDI outcomes should start in parallel with formulating SDI goals. The work should include selecting potential indicators, defining them and preparing the data sources and methods used to measure the indicators’ values. In the discussed Dutch SDI case, the pre-prepared indicators, data sources, and methods to measure them would allow for using those indicators that were considered by the stakeholders as valid but which could not be used due to lack of measuring methods and data sources. Inclusion of these indicators would strongly enhance the validity and ‘users’ satisfaction’ of the final set of indicators and the whole proposed assessment view to measure the SDI goals.

Lastly, in the future applications of the proposed assessment view a consideration should be given to assigning the weights to the chosen indicators. The indicators in themselves can be very different in specificity and relevance and these differences should be reflected (e.g. by means of assigning indicators’ weights) to make the assessment more valid.

5. Evaluation of the goal-oriented assessment view

To evaluate the proposed assessment view the authors used the meta-evaluation standard criteria for evaluating assessment frameworks (Shepard, 1977; Stufflebeam, 1974). The evaluation standard comprises three groups of criteria: technical adequacy, utility, and efficiency (see Appendix B). The evaluation was
Table 4
Value of indicators August 2009.

<table>
<thead>
<tr>
<th>Indicator measuring goal realization</th>
<th>Indicator value</th>
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<tbody>
<tr>
<td>Goal 1: The public and businesses will be able to retrieve and use all relevant geo-information about any location</td>
<td>Total number of visitors per day: 55 (Indicator source: Google analytics linked to NGR)</td>
</tr>
<tr>
<td>Indicator 1.1 The number of visitors of the Dutch national georegister (NGR) (<a href="http://www.nationaalgeoregister.nl">http://www.nationaalgeoregister.nl</a>) per day</td>
<td>Total number of unique visitors per day: 33</td>
</tr>
<tr>
<td>Indicators 1.2. Availability of datasets and services</td>
<td>217 datasets available from GIDEON Annex 1. From these 217 datasets: 83 have a view service 1 has a download service Of the GIDEON Annex 1 INSPIRE datasets, there are 8 out of 43 datasets available (indicator source: NGR)</td>
</tr>
<tr>
<td>Indicator 1.3. The use of view and download services.</td>
<td>Not available (Source: TNO, DINO)</td>
</tr>
<tr>
<td>Goal 2: businesses will be able to add economic value to all relevant government-provided geo-information</td>
<td>General governmental policy terms of (re)use of geographical information considered as maximal costs of distribution and no restrictive terms of use that may prevent the use of geographical information Of 217 datasets, 36 have clear information on the price of the dataset (gratis or explicit price in €) – (17%) Of these 36 datasets, it is compulsory to pay for 20 – (55%) Of these 36 datasets, 16 are gratis (44%) (indicator source: NGR)</td>
</tr>
<tr>
<td>Indicator 2.1 General governmental policy terms for (re)use of geographical information.</td>
<td>Of the 217 datasets, 150 do not have any use restrictions, and 31 have use restrictions; for 36, the status of the use restrictions is unknown. 150/217 = 69% of the available datasets do not have use restrictions (Indicators source: NGR)</td>
</tr>
<tr>
<td>Indicator 2.2 The percentage of datasets from GIDEON annex 1 that are available without any restrictions.</td>
<td>2007: €747 million 2008: €900 million (Indicator source: Geobusiness Nederland [see Bregt et al., 2009])</td>
</tr>
<tr>
<td>Indicator 2.3 Yearly turnover of the geo-information business in the Netherlands.</td>
<td>Four out of nine milestones of the five chains of GIDEON have been achieved (44%) (Indicator source: Geonovum, 2009)</td>
</tr>
<tr>
<td>Goal 3: the government will use the information available for each location in its work processes and services</td>
<td>Municipalities: (5% + 55.5% + 17%)/3 = 26% Provinces: (33% + 80% + 83%)/3 = 65% Waterboards: (50% + 33%)/2 = 42% (Indicator source: <a href="http://monitor.overheid.nl">http://monitor.overheid.nl</a>)</td>
</tr>
<tr>
<td>Indicator 3.1 The level of cooperation within 5 chains of GIDEON.</td>
<td>Of these 36 datasets, 16 are gratis (44%) (indicator source: NGR)</td>
</tr>
<tr>
<td>Indicator 3.2 The use of geo information within e-government processes.</td>
<td>Of these 36 datasets, it is compulsory to pay for 20 – (55%) Of 217 datasets, 36 have clear information on the price of the dataset (gratis or explicit price in €) – (17%)</td>
</tr>
<tr>
<td>Goal 4: the government, businesses, universities and knowledge institutes will collaborate closely on the continuing development and enhancement of the key facility</td>
<td>Four out of nine milestones of the five chains of GIDEON have been achieved (44%) (Indicator source: see Geonovum, 2009)</td>
</tr>
<tr>
<td>Indicator 4.2 The% of private organizations with unfulfilled vacancies in geo-sector.</td>
<td>78% of the private companies have unfulfilled vacancies (Indicator source: Geobusiness Nederland [see Bregt et al., 2009])</td>
</tr>
<tr>
<td>Indicator 4.3 Expenditure of the private sector in the Netherlands on research and development of geo-information products and – services.</td>
<td>2008: €56 million (Indicator source: Geobusiness Nederland [see Bregt et al., 2009])</td>
</tr>
<tr>
<td>Indicator 4.4 Value of the Dutch geo-information research sector.</td>
<td>€45 million (~450 full time equivalent [fte]) (Indicator source: Geobusiness Nederland [see Bregt et al., 2009]).</td>
</tr>
</tbody>
</table>

conducted by asking the group of respondents to fill out a questionnaire containing standard meta-evaluation statements (see Appendix C). The statements were formulated in such a way that the answers close or equal to "fully agree" confirm the validity of the proposed assessment view to assess the realization of the SDI goals. After each statement, the respondent could fill in a personal comment on a given answer. The respondents were the participants of the workshop “Evaluating the goal realization of the Dutch SDI,” organized in October 2009 in Wageningen, the Netherlands. This group was considered appropriate to evaluate the developed assessment view for two reasons: (1) the group was regularly consulted in the process of the Dutch SDI goals formulation; (2) the group members are the potential users of the goal-oriented assessment view.

A total of 12 participants of the workshop expressed their opinions on the statements of the evaluation. Fig. 4 presents the responses for all of the statements in the questionnaire. For the majority of the statements (except for statement 6), the dominant percentage of respondents indicated answers to the right of the scale rather than to the left, which can be interpreted as a tendency to agree rather than disagree. The highest percentage of respondents agreed with the last statement about the cost-effectiveness of the assessment view, which means that, according to the respondents, the findings of the goal-oriented assessment view are worth more than the costs of obtaining the information. Moreover, the respondents found the proposed assessment view rather generic (statement 2) but at the same time also relevant (statement 5), having adequate scope (statement 7) and rather valid (statement 8) for monitoring the specific Dutch SDI goals. The results of the application of the proposed assessment view in the Dutch case were considered as rather accurate, consistent, and objective (statements 3, 4). It can be summarized that a narrow
The majority of the respondents tend to agree that the application of the proposed assessment view in the Dutch case answers the questions it was supposed to answer (statement 1).

The stronger tendency to indicate “disagree” could be observed for statement 6. This result suggests that the respondents were rather dissatisfied with the choice of the indicators for GIDEON.
goals monitoring. Thus, they found the relevance of the assessment findings rather limited. The potential reasons for this dissatisfaction are discussed in Section 4.3.

The comments written by the respondents to these statements suggest that the accuracy and consistency (statement 3) and objectivity of the assessment results (statement 4) are largely dependent on the choice of the appropriate indicators. For the implementation of the assessment view presented in this article the appropriateness of the indicators was assessed rather critically, which can explain relatively large percentage of the respondents disagreeing with statements 2, 3 and 4.

6. Conclusions

The objective of this article was to develop a goal-oriented assessment view approach for assessing the realization of SDI goals. The methodology was proposed to realize this objective. The proposed assessment view was developed according to the four phases of the Multi-view SDI assessment framework. As a result, a SDI goal-oriented assessment view has been proposed.

The practical applicability of the proposed assessment view has been demonstrated by its implementation in the Dutch SDI case. All of the phases of the assessment view were implemented. However, the evaluation phase was hampered by the limited number of appropriate indicators. As a result, the stakeholders' evaluation of the extent to which SDI goals are being realized was based on a limited number of indicators. The assessment was also evaluated by its potential users. The evaluation results indicate that the users agree with the proposed goal-oriented assessment view design and its applicability to assess how SDIs reach their goals. However, in the Dutch SDI case, the appropriateness of the final list of indicators was a matter of concern. The practical applicability of the developed assessment view was judged by the stakeholders as rather cost-effective in achieving the assessment results (see Fig. 4 item 10). This may be due to the fact that data needed for calculating the indicators were easily available from regularly produced data sources (see paragraph 4 in Section 4.3). This cost-effectiveness of the proposed assessment view may encourage its users to use it for doing a more regular series of assessments of how the SDI goals are being implemented over a longer time periods. Due to a dynamic character of SDIs it can be predicted that stakeholders and policy makers would be interested in such longitudinal studies.

Concerning the application of the proposed assessment view there are two conditions without which the practical use of the view may be problematic: (1) The SDI stakeholders have to be identifiable and approachable and (2) SDI goals have to be defined. The first condition assumes that it is possible to involve the SDI stakeholders in the phases of assessing the realization of SDI goals. This active involvement, especially in the process of selecting indicators, should help to build users' trust for the evaluator and confidence in the evaluation result. The second condition assumes that in the SDI vision or strategic plan, the SDI goals are agreed upon and clearly defined. When the goals are clearly defined, it should be possible to identify the indicators that show the extent to which these goals are realized. Proper indicators relating to the SDI goals are at the foundation of the assessment view (Giff & Crompvoets, 2008). However, the results suggest also that the precision with which SDI goals are defined substantially affects the reliability and relevance of the assessment results. The vagueness of the Dutch SDI goals leads to multiple interpretations of what exactly is going to be achieved by SDI, which in turn leads to the problem of selecting agreeable assessment indicators and evaluating the realization of SDI goals. On the other hand vague goals' definition give room for the unexpected outcomes. The recommendation given in Section 4.3 to define SDI goals on two levels of specificity may be a way to address this problem. Furthermore, keeping the broad and generic definition of SDI goals may also be in the interest of policy makers who usually prefer consensus based and vague goals that satisfy everybody.

The goal-oriented SDI assessment view extends the existing array of assessment views of the Multi-view SDI assessment framework. The SDI assessment views that have been proposed so far were rather intuitive, curiosity-driven and had ex-ante nature. The presented goal-oriented SDI assessment approach complements the existing assessment views as it offers a more specific and rational assessment which helps to evaluate SDIs for accountability purposes. It is also developed as an ex-post assessment. The goal-oriented SDI assessment view extends the Multi-view SDI assessment framework not only by another assessment view but also by a newly developed set of operational indicators. This need for new indicators confirms the need for assessing SDIs in a multi-view way because each assessment approach, in this case a goal-oriented approach, requires specific indicators suited for a specific assessment view and purpose. For a comprehensive SDI assessment, it is necessary to have a wide array of indicators designed for the purposes and views that are involved in the assessment.

It has to be also stated that the proposed goal-oriented view can be regarded as a linear assessment, i.e. an assessment in which it is possible to assign an assessment score on a linear scale out of the maximum possible score. However, as discussed by Georgiadou and Stoter (2010) it is very hard to assess SDI via a linear analysis due to SDIs openness and complexity. The proposed assessment view may satisfy the needs of a certain group of users but it has to be kept in mind that it represents only one specific viewpoint taken on SDI assessment which will always have a certain level of bias. It is also hardly possible to capture the very complex and dynamic SDI picture with one assessment view. The less biased, more realistic and comprehensive SDI assessments which are better suited to address its complex nature can rather be achieved by looking at it from many different viewpoints simultaneously (Grus et al., 2007, 2010).

For further study, it is recommended to implement the proposed assessment view to measure the goals realization of other infrastructures. The design of the assessment view is generic, so it can be used to measure the extent of goals realization of any infrastructures with clearly defined and agreeable goals and where all of the stakeholders can be identified and approached.

In addition to measuring the intended SDI goals and benefits, the unintended impacts and benefits of SDIs cannot be neglected as they may be as equally or more interesting and important as the intended ones. Due to SDIs complexity and its wide ranging effects on a variety of disciplines, it can be presumed that the unintended SDI effects are even more important than the expected ones. However, the question how to measure these unintended effects and to what extent were they caused by SDI remains open. Therefore, in future studies on SDI assessment, it is recommended to develop assessment methods capable of capturing unplanned SDI results.

Acknowledgements

We would like to acknowledge and thank the participants of two workshops on monitoring the GiDEOn goals held in Wageningen on October 21, 2008 and October 14, 2009, for their active participation and contribution to the presented assessment view design. We would like to thank the anonymous reviewers of this paper for their valuable remarks and suggestions that helped to
improve the paper. We also thank the Dutch ‘Space for Geo-
Information’ (RGI) innovation program for providing the necessary
resources to conduct this research.

Appendix A. List of potential indicators

1. There are one or more on-line services to download core
spatial datasets that contribute the national SDI-initiative.
2. An organization of the type ‘National GI-association is
involved in the coordination of the national SDI.
3. Existence of individual leadership (champion).
4. The national SDI-initiative is supported by someone with
strong leadership.
5. Use of maps for searching in the national SDI geoportal.
6. There is a pricing framework for trading, using and/or com-
mercializing geo-information.
7. Last national SDI geoportal web address change.
8. There are one or more web mapping service available for
core spatial data.
9. The initiative and territorial coverage is truly national.
10. Nature of participants’ involvement in building NSDI.
11. There is an independent thematic environmental SDI.
12. The long-term financial security of the national SDI-initia-
tive is secured.
13. Level of SDI funding from the government.
14. There is a policy focusing on the access of thematic environ-
mental data.
15. Monthly number of visitors of the national SDI geoportal.
16. Organizations which have agreed to the long-term NSDI
vision or strategic plan.
17. There is a coordinating authority for metadata implementa-
tion at the level of the SDI.
18. The SDI-initiative can be implemented by enough qualified
staff capable to lead and work in national SDI-initiatives.
19. Existence of commitment building fora or platforms for
NSDI.
20. There have been taken initiatives in your country to launch
the development of a National Spatial Data Infrastructure
(SDI).
22. The national SDI-initiative takes into consideration capacity
building issues in order to perform appropriate tasks within
the broad set of principles relating your SDI-initiatives.
23. Existence of long-term vision statement or strategic plan for
your NSDI.
24. There are true Public–Private Partnerships or other co-
financing mechanisms between public and private sector
bodies with respect to the development and operation of
the national SDI-related projects.
25. Frequency of the national SDI geoportal website updates.
26. Geo-Information can specifically be protected by copyright.
27. Availability of view (web mapping) services in the national
SDI geoportal.
28. The geodetic reference system and projection systems are
standardized, documented and interconvertable.
29. The national language is the operational language of the
national SDI.
30. Availability in digital format of core spatial datasets crucial
for the national SDI.
31. English is used as secondary language.
32. Metadata-standard applied in the national SDI geoportal.
33. The officially recognized or de facto coordinating body of the
national SDI is a national organization.
34. One national on-line access service for metadata (clearing-
house) is available providing metadata of more than one
data producing agency.
35. There is documented data quality control procedures
applied at the level of the national SDI.
36. Types and extent of participants involved in building the
NSDI and their roles.
37. Number of data suppliers in the national SDI geoportal.
38. One or more standardized metadata catalogues are available
covering more than one data producing agency.
39. There is an institutional framework or policy for sharing
geo-information between public institutions.
40. Kind of NSDI leadership.
41. Availability of commercial or in-house spatially-related
software.
42. Number of thematic environmental datasets available in the
national SDI geoportal.
43. Metadata are produced for a significant fraction of spatial
datasets.
44. Only public sector actors are participating in the national
SDI.
45. Nature of the institution(s) with a role of SDI leader.
46. The officially recognized or de facto coordinating body for
the national SDI is an organization controlled by data users.
47. Thematic environmental data are covered by the described
SDI-initiative.
48. Metadata Availability.
49. Recognition (for example, in Governmental laws or for-
mal orders) of the need to establish or further develop NSDI.
50. Most spatial datasets are available in digital format that pro-
vide a basis for contributing the national SDI-initiative.
51. Availability of data download services in the national SDI
geoportal.
52. The national SDI-initiative is devoting significant attention
to standardization issues.
53. The level of legal support for SDI framework (existence of
legal instruments such as laws, policies, directives and commit-
ments.
54. There are simplified and standardized licenses for personal use.
55. Use of Open source services.
56. Privacy laws are actively being taken into account by the
holders of geo-information.
57. There is a legal instrument or framework determining the
SDI-strategy or development.
58. Languages used in the national SDI geoportal.
59. Concern for interoperability goes beyond conversion
between data formats.
60. Nature of a vision and strategies to accomplish SDI.
61. SDI community addresses issues arising from society to
which geographic information may contribute.
62. Number of datasets available in the national SDI geoportal.
63. Metadata records of thematic environmental datasets in the
national SDI geoportal.
64. Level of capacity building and awareness of the SDI impact
on well functioning of society including business, public,
and academia.
65. Level of funding by means of cost recovery.
66. Spatial data producers as well as end users are participating
in the national SDI.
67. Funding continuity of the national SDI geoportal.
68. Level of private and enterprise sector funding.
69. There is a freedom of information (FOI) act which contains
specific FOI legislation for the GI-sector.
70. Involvement of private parties in developing the long-term
vision or strategic plan of NSDI.
71. Mechanisms for searching available in the national SDI
geoportal.
72. Most recently produced dataset available in the national SDI
geoportal.
Appendix B

I. Technical adequacy criteria

<table>
<thead>
<tr>
<th>Internal Validity: Does the assessment design unequivocally answer the question it was intended to answer?</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Validity: Do the assessment results have the desired generalizability? Can the necessary extrapolations to other populations, other program conditions, and other times be safely made?</td>
</tr>
<tr>
<td>Reliability: Are the assessment data accurate and consistent?</td>
</tr>
<tr>
<td>Objectivity: Would other competent assessors agree on the conclusion of the assessment?</td>
</tr>
</tbody>
</table>

II. Utility criteria

<table>
<thead>
<tr>
<th>Relevance: Are the findings relevant to the audiences of the assessment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance: Have the most important and significant of the potentially relevant data been included in the assessment?</td>
</tr>
<tr>
<td>Scope: Does the assessment information have adequate scope?</td>
</tr>
<tr>
<td>Credibility: Do the audiences view the assessment as valid and unbiased?</td>
</tr>
<tr>
<td>Timeliness: Are the results provided to the audiences when they are needed?</td>
</tr>
<tr>
<td>Pervasiveness: Are the results disseminated to all of the intended audiences?</td>
</tr>
</tbody>
</table>

II. Efficiency criterion

| Is the assessment cost-effective in achieving the assessment results? |

Note: the substitution of assessment as the object of the Meta-evaluation. Assessment is not evaluation, but it may be considered an evaluation activity.

Note: table derived from Stufflebeam, 1974.

Appendix C

Meta-evaluation

Dear participant,

In order to evaluate the goal-oriented SDI assessment approach, we would like you to answer the following questions:

1. The assessment approach design clearly answers the question it was intended to answer.

2. The assessment approach can also be used to assess other SDIs than the Dutch one.

3. The assessment results are accurate and consistent.

4. The conclusions from the assessment are objective.

5. The findings of the assessment are relevant to those interested in GIDEON goals monitoring.

6. All important and relevant indicators have been included in the assessment.

7. The assessment has an adequate scope.

8. The assessment can be seen as valid and unbiased.

9. The approach can always be used whenever it is needed to measure the extend to which SDI goals are met.

10. The assessment is cost-effective in achieving the assessment results.

Your comments:

Thank you for your contribution.

References


