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[1]Multi-view SDI Assessment Framework

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Abstract

When developing Spatial Data Infrastructures (SDI) initiatives it is increasingly important to assess their outcomes in order to justify the resources spent on those infrastructures. Many researchers throughout the world have been struggling with the issue of assessing SDIs. The task is difficult due to complex, dynamic and constantly evolving nature of SDI. As SDI can be treated as a Complex Adaptive System, the assessment should include strategies for evaluating those kinds of systems. One strategy is to use multiple assessment approaches and methods. The general evaluation research and experience provide additional motives for adopting such a strategy. We present the multi-view framework for assessing SDI initiatives around the world, and argue that the strength of this assessment design lies in its flexibility, its multidisciplinary view on SDI and a reduced bias in the assessment results. The multi-view framework contains methods that not only evaluate SDI performance, but also deepen our knowledge about SDI functioning, and may assist in its development. The article presents the assessment framework and describes its theoretical grounding in complexity theory and evaluation research. The application of the framework is beyond the scope of this paper.

Keywords: Spatial Data Infrastructure, Assessment framework, Evaluation, Complexity

1. INTRODUCTION

Over the last few years Spatial Data Infrastructures (SDIs) have become an important issue in Geo-Information Science, its significance was demonstrated by numerous initiatives all over the world at global, regional, national and local levels. The growing number of clearinghouses may be a good indicator for the development of Spatial Data Infrastructures. According to Crompvoets (2006) the

number of national SDI clearinghouses increased rapidly from the first initiative in 1994 in the USA to 83 national clearinghouses in April 2005. Large sums of money have been invested into SDI initiatives over the last few years. Worldwide around €120 million is spent each year just on clearinghouse management (Crompvoets, 2006). The investment requirements for an Infrastructure for Spatial Information in the European Community (INSPIRE) at European, national, regional and local levels are estimated to be from €202 to €273 million each year (INSPIRE, 2003). Given this expenditure and society's interest in the proper and effective use of public funds, it is imperative that these SDI initiatives should be assessed (Shadish et al., 1991). SDI assessment is an increasingly hot topic because SDIs are mainly established by governmental bodies and resourced from the public funds, and the demand for such research is increasing. For example, implementation of the European directive establishing an Infrastructure for Spatial Information in the European Community will require monitoring and regular reporting of the implementation of the Directive as well as reporting on the use and the (positive) impacts of the infrastructure (European Commission, 2007).

Many researchers have tried to assess SDIs (Crompvoets, 2006; Steudler et al., 2004; Rodriguez-Pabon, 2005; Delegado-Fernandez and Crompvoets, 2007; Delgado-Fernandez et al., 2005; Kok and van Loenen, 2004; Masser, 1999; Onsrud, 1998; SADL, 2005). All these attempts, however useful and valuable, either concentrate on one aspect of SDI (Crompvoets, 2006; Delegado-Fernandez et al., 2005), or are bounded by one region (SADL, 2005),or describe SDI development in few particular countries (Masser, 1999; Onsrud, 1998), or are still conceptual in nature (Kok and van Loenen, 2004; Rodriguez-Pabon, 2005; Steudler et al., 2004). What is needed is a multidisciplinary framework that could evaluate the full extent of SDIs worldwide.

Assessment and evaluation of SDI initiatives is problematic for a number of reasons. Even within the SDI community there are differences in the understanding of SDI and its potential benefits. Craglia and Nowak (2006) raise this issue when reporting on the key findings of the International Workshop on SDI's Cost-Benefit. They argue that there is much confusion resulting from the lack of an agreed definition of SDI, its components and the relationships between them. Moreover, different studies on SDI assessment identify different benefits and assign them to different categories. Similar conclusions are formulated in the report of the workshop 'Exploring Spatial Data Infrastructures' (Grus et al. 2006a). This makes it difficult to identify uniform criteria of merit for SDI inputs, utility, outputs and outcomes. SDI is also difficult to assess because of its complexity and dynamic and constantly evolving nature. SDIs also differ between countries as the same implementing rules may cause different results. For example, at the European level, the INSPIRE directive lays down general rules for establishing an SDI for the European Community (European Commission, 2007). Nevertheless, despite the fact that SDIs in the member states will behave

and operate in a similar general way as indicated by the directive, they will never be the same, and sometimes will differ considerably depending on political, economical and cultural national circumstances. The directive acknowledges this diversity and assumes that INSPIRE will be build upon SDIs that are established and operated in member states.

In this paper we try to build a coherent SDI assessment framework that acknowledges this complexity. First we identify and analyse the key SDI characteristics that underlie the dilemmas affecting the assessment strategy. To deal with these dilemmas we examine SDI through the lens of Complex Adaptive Systems (Grus et al., 2006b). From this analysis we construct an assessment framework based on the principles of evaluating Complex Adaptive Systems (Eoyang and Berkas, 1998; Cilliers, 1998; De Man, 2006b) and evaluation theory applying to multiple-approach evaluation, using existing SDI evaluation approaches.

In section 2 we introduce the key characteristics of SDIs that influence the way in which SDI should be evaluated: multi-definitions, multi-objectives, complexity and dynamism are the issues of interest. Section 3 presents the theory of Complex Adaptive Systems (CAS) and its assessment issues, with a discussion on the issue of using multiple approach strategy in general evaluation practice. Section 4 presents the prototype evaluation framework for SDI infrastructures. The article closes with a discussion, conclusions and recommendations, especially on the potential difficulties with applying the framework. We do not discuss the drawbacks or benefits of the particular approaches as these will become evident after use of the framework.

In this paper we use several terms regarding the evaluation domain. For clarity, we explain the following terms used in the text:

- SDI assessment framework – a construct of various assessment approaches and methods built around CAS assessment principles and general assessment theory to structure and organize SDI evaluation.
- Assessment purpose or perspective – one of three main purposes or perspectives for performing an assessment: accountability, knowledge and development.
- Assessment approach – whole methodology of assessing particular SDIs from a certain viewpoint, e.g. SDI development, clearinghouse, or performance.
- Assessment methods – the techniques used in SDI assessment approaches to collect indicators. They include different types of surveys such as questionnaires and web surveys, document studies such as country reports, key informants having unique knowledge related to the issue being evaluated, such as SDI coordinators, and case studies (Frechtling and Sharp, 1997).

Whenever the terms ‘evaluation’ and ‘assessment’ are used, they both refer to the characterization and judgement of the merits of SDI.

2. SDI NATURE AND ASSESSMENT ISSUES

Assessing SDI, especially in worldwide comparison or benchmarking studies, remains problematic. The reason for this might be the nature of SDIs, particularly their multifaceted and dynamic nature, complexity and vaguely defined objectives. Hansen (2005) stresses that the characteristics of the evaluated object determine the choice of the evaluation models. Therefore, before proposing the SDI assessment framework, it is necessary to explore these SDI characteristics in more detail to enable a justification of the choice of the assessment strategy.

SDI is defined in **multiple ways**. For example, Chan (2001) collected the 11 most popular SDI definitions by different organizations and authors in different parts of the world at different times. Each of these definitions describes SDI from slightly different aspects and none of them describe SDI completely. The variety of ways in which SDI is defined reflects its multifaceted character (De Man, 2006). Rajabifard et al. (2002) claim that some SDIs may be treated as products while others as processes, which raises fundamental questions about SDI evaluation. To be able to assess and compare the objects of the evaluation, an agreement must be reached on single definitions of these objects and about criteria and values of merit. Referring back to Rajabifard’s classification, are we assessing SDIs as products in terms of their structure or the processes they should facilitate? The criteria and values of merit may therefore depend on how we understand the SDI concept.

It can be stated that the **conceptual objective** of Spatial Data Infrastructure is to enhance access to and the sharing of spatial data produced by various agencies. The principal purpose of SDIs may be defined in different ways, for example: ‘let geographic information promote economic development, improve our stewardship of natural resources, and protect the environment’ (Clinton, 1994); ‘to help avoid fragmentation, gaps in availability of GI, duplication of data collection and problems of identifying, accessing or using the available data’ (SADL, 2003); and ‘to support information discovery, access, and use of geographical information for example in crime management, business development, flood mitigation, environmental restoration, community land use assessment and disaster recovery’ (Nebert, 2004). Different countries do not define the objectives of their SDI in the same way. Some stakeholders may only accept the facilitating of data exchange role of SDI; others may see SDI only as a facility for spatial data production and storage. To allow the worldwide benchmarking of SDI, we will need a uniform definition of the objectives of SDI, but the variety of interpretations of what SDIs are suggest that it will not be possible to find a single definition of SDI that everybody will agree on.

This means that the framework should be able to incorporate different understandings and views of the objectives of SDIs.

During the workshop on Exploring SDI held in Wageningen in January 2006, **SDI complexity** was indicated as being one of the main obstacles and challenges to its evaluation (Grus et al., 2006a). The complexity of SDI is due to the dynamic and non-linear interactions between its entangled components. Chan and Williamson (1999) state that its functionality becomes more complex over time as new SDI requirements emerge and are adopted by the users. As an SDI model moves from being data-centric to service-centric, complexity increases and identification and measurement benefits become more problematic (Georgiadou et al., 2006). This means that the nature of SDI and the interactions between its components cannot be described in a simple and uniform way. Moreover, SDI has a different character and works in a different ways in different parts of the world. This complexity of SDI makes it difficult to implement in diverse environments in the same way and with the same results, which in turn makes assessment difficult because of the problems of attributing success or failure of SDI implementation to one or more concrete factors. In other words, because SDIs are complex it is difficult to track cause-and-effect relationships (Rodriguez-Pabon, 2005).

The dynamic nature of SDI is reflected in the intensive flow of information between data producers and users (Masser, 2005). According to Rajabifard et al. (2003b) and Chan (2001) the dynamic nature of SDIs is reflected in changes in SDI technology, people and their needs. As SDI requirements and expectations change, the mediation of rights, restrictions and responsibilities between people may also change. Such changes imply that the system's behaviour is unpredictable, which presents a challenge for assessment practice. The assessment framework should allow assessment practitioners to detect and analyse the predictable as well as the unpredictable changes. Another aspect of the dynamic nature of SDI dynamism is its evolving nature. Most assessment practices measure SDIs at one moment in time, but the SDI assessment framework should also be able to describe its evolution over time, for example through longitudinal assessment approaches.

3. TOWARDS THE ASSESSMENT FRAMEWORK

There is strong evidence that SDIs behave like Complex Adaptive Systems (CAS) (Grus et al, 2006b), and the principle of evaluating Complex Adaptive Systems (Eoyang and Berkas, 1998) underpins the design of the SDI assessment framework. Complex Adaptive Systems are open systems in which different elements interact dynamically to exchange information, self-organize and create many different feedback loops, in which relationships between causes and effects

are non-linear, and where the system as a whole has emergent properties that cannot be understood by reference to the component parts (Barnes et al., 2003). Analyses of the structure and behaviour of Dutch, Australian and Polish SDIs indicate that the SDIs share the same behavioural characteristics as CAS (Grus et al., 2006b). We therefore decided to use the principles of evaluating Complex Adaptive Systems for SDI assessment. These principles specify that the framework should be flexible and have a structure that permits frequent reconsideration and redesign, because the baseline (understanding, definition, and objectives) of CAS (and also SDIs) is constantly changing. The assessment programme should concentrate on both the expected and unexpected system behaviour. It should also capture long-term and short-term outcomes, from close and distant points of view: it should contain more general, regional or cross-national comparisons (distant view) as well as more detailed case study analyses of national or local SDIs (close view). At national and regional levels, the scale of the SDI dramatically affects the amount of detail that can be accommodated in the assessment. Wider national or transnational initiatives (e.g. worldwide assessment of benchmarking) require the involvement of a much broader stakeholder network, many more assumptions (not all of which will be accepted by all stakeholders) and much less specificity than local initiatives. Because of the complex interconnections, assessment programmes should include multiple strategies and approaches, including those for linear systems, and a variety of data should be collected to reflect the variability and complexity of the system. The assessment framework should also contain methods that can capture the patterns of causal relationships. But because these patterns of causation can change in CAS (SDIs) it is essential to capture the baseline (reference point) of these causal relationships (Eoyang, 1998). For example, it may be helpful to describe the relations between the five standard SDI components (people, standards, technology, policy and data) and then observe the emergent patterns, changes and evolution of these relationships. Detailed analyses of case studies may help to reveal these interactions and rules of causation.

The recommendations for complexity assessment given above are in line with Cilliers' (1998) analysis that truly complex problems can only be investigated using complex resources. This is a reinterpretation of the antireductionist position that a complex system cannot be reduced to a collection of its basic constituencies (e.g. SDI components) – not because the system is not constituted by them, but because too much of the rational information gets lost in the process. In the same way, the SDI assessment strategy must also be complex if it is to represent the system's variability and richness in information important from the assessment perspective. Accordingly, different assessment approaches and methods must be used simultaneously. This is also in line with De Man (2006b), who states that a multifaceted view is needed to understand concrete SDI initiative. The assessment framework should not try to capture and control complexity, but acknowledge multiple SDI realities shaped by heterogeneous and

reflective actors. At the same time, it must be a manageable tool that contributes to a better understanding and assessment of the processes connected with SDI.

If we agree that SDIs are complex systems the discussion above implies the use of rather complex and multiple assessment approaches and methods would be a valid approach to assessing or analysing these complex systems (see Eoyang and Berkas, 1998; Cilliers, 1998; De Man, 2006b). It is interesting then to analyse the experience and practice of evaluation theory and research with multi-approach and multimethod assessment models. In other words: what does evaluation/assessment research says about multimethod assessment?

Scriven (1983) stresses that 'evaluation is a multiplicity of multiplies' in a number of ways: 'Evaluation is *multifield*, concerned with programs, products, proposals, personnel, plans, and potentials; *multidisciplinary*; with *multidimensionality* of criteria of merit; needing *multiple perspectives* before synthesis is done; *multilevel* in the "wide range of levels of validity/cost/credibility among which a choice must be made in order to remain within the resources of time and budget" and in the different levels of analysis, evidential support, and documentation appropriate in different circumstances; using *multiple methodologies, multiple functions, multiple impacts, multiple reporting formats*: "Evaluation is multiplicity of multiples"' (Scriven, 1983).This multiplicity of evaluation is in line with the characteristics of SDI mentioned above: its multifaceted nature, the multiple purposes of evaluation, multiple definitions and multiple objectives.

Assessment of the multiple dimensions of the assessed object is also epistemologically motivated. The more vantage points that are taken, the better the constructed picture of truth will be. For example, the reality might be that one particular SDI has a very well developed clearinghouse, but an inadequate legal framework for access policy. In such cases, assessing only the access network (clearinghouse) of this particular SDI would draw a false picture of reality. Using multiple evaluation models also reduces potential biases in evaluation (Shadish et al., 1991) in case some methods generate considerably different results than others.

The multi-approach and multimethod assessment strategy is well recognized by evaluation practitioners. Datta (1997) confirms moderately high to high acceptance of mixes of methods, analysis and data in evaluation practice, but the difficulty of defining the quality of such multimethod studies should be recognized. Using multiple analyses (descriptive analysis and various statistics within one evaluation) is highly acceptable, although the need to deal with the biases inherent in different techniques is borne in mind. Using multiple data is also highly acceptable, as long as due consideration is given to the weighting of different data sources. Based on Datta's evaluation experience, the benefits of using

multimethod analysis seem to be depth, methodological equity and transparent findings from all methods.

Assessments are made for many specific reasons, for example to measure and account for the results and efficiency of public policies and programmes, or to gain explanatory insights into social and other public problems, or to reform governments through the free flow of evaluative information (Chelimsky, 1997). Chelimsky (1997) distinguishes three general classes of evaluation purposes that cover all of the specific purposes: the accountability purpose of evaluation, the developmental purpose of evaluation, and the knowledge purpose of evaluation. Accountability evaluation measures the results of the programme by asking cause-and-effects questions. The developmental class comprises strategies to measure and recommend changes in organizational activities and to monitor how projects are being implemented across a number of different sites. The purpose of knowledge evaluation is to generate a better explanation of the programme or to acquire a more profound understanding in some specific area or field (Chelimsky, 1997). These three classes of purposes are not mutually exclusive with regard to methods, but they may be needed at different times. For example, evaluation for knowledge or evaluation for development may be needed before evaluation for accountability. Georgiadou et al. (2006) present a different taxonomy of evaluation purposes. They classify existing SDI evaluation approaches through a taxonomical lens from information systems evaluation research and explore four types of evaluation approaches: control, learning, sense-making and exploratory approaches. In principal, Chelimsky's and Georgiadou's classification are comparable. Control evaluation and Chelimsky's accountability approach ask questions about achieving the goals of the programme. Georgiadou's learning and exploratory evaluation and Chelimsky's knowledge approach set out to learn and create knowledge about the assessed phenomena. Both Georgiadou's sense-making evaluation and Chelimsky's developmental evaluation aim to modify and improve the evaluated phenomena.

For the purpose of this paper we will use Chelimsky's three classes: accountability, knowledge and developmental, as they originate from the evaluation theorists and seem to be more generic.

All the purposes of evaluation described above are valid for SDI assessment. There is a demand for accountability evaluation (Lance et al., 2006) to justify and monitor in a systematic way the relations between the investments in SDI initiatives and the results obtained. The assessment approaches that fall into the accountability class may help to answer questions such as did the use of spatial data increase as a result of implementation of a more liberal access policy to spatial data, and what is the impact of implementation of new SDI agenda on stakeholders' activities? Questions about the efficiency and effectiveness of various SDI activities are also valid for accountability approaches. Developmental

evaluation is needed to monitor the transitions of SDI initiatives, such as transition through generations described by Rajabifard et al., (2003a). The analysis of the development, transitions and changes of SDI may help to capture and better understand its dynamic nature, and in monitoring whether SDI is being implemented according to the intended direction and recommend ways of SDI development. The primary functions of the developmental assessment approaches should be to measure and recommend changes in SDI activities and development, to monitor in a continuous way how SDIs are being implemented across many countries, and to find out whether SDI implementation is being realized according to the agenda. Knowledge evaluation is crucial for a better understanding of the mechanisms and forces behind SDI. Better understanding of the mechanisms and rules behind SDI frameworks allows action to be taken to improve them. 'Once one understands the nature of the evaluand (evaluand = object of the assessment), one will often understand rather fully what it takes to be a better and a worse instance of that type of evaluand. To exemplify, understanding what a watch is leads automatically to understanding what the *dimensions of merit* for one are – time-keeping, accuracy, legibility, sturdiness, etc.' (Scriven, 1980). The assessment of SDI could therefore contribute significantly to increasing our knowledge about the key qualities of SDI. The need to better understand the ideas and mechanisms behind SDI is also stressed by Georgiadou et al. (2006), who argue that more attention should be paid to conducting exploratory evaluations of SDI.

The remainder of this paper will focus on the presentation and description of the prototype framework, which acknowledges and deals with the SDI assessment issues discussed above.

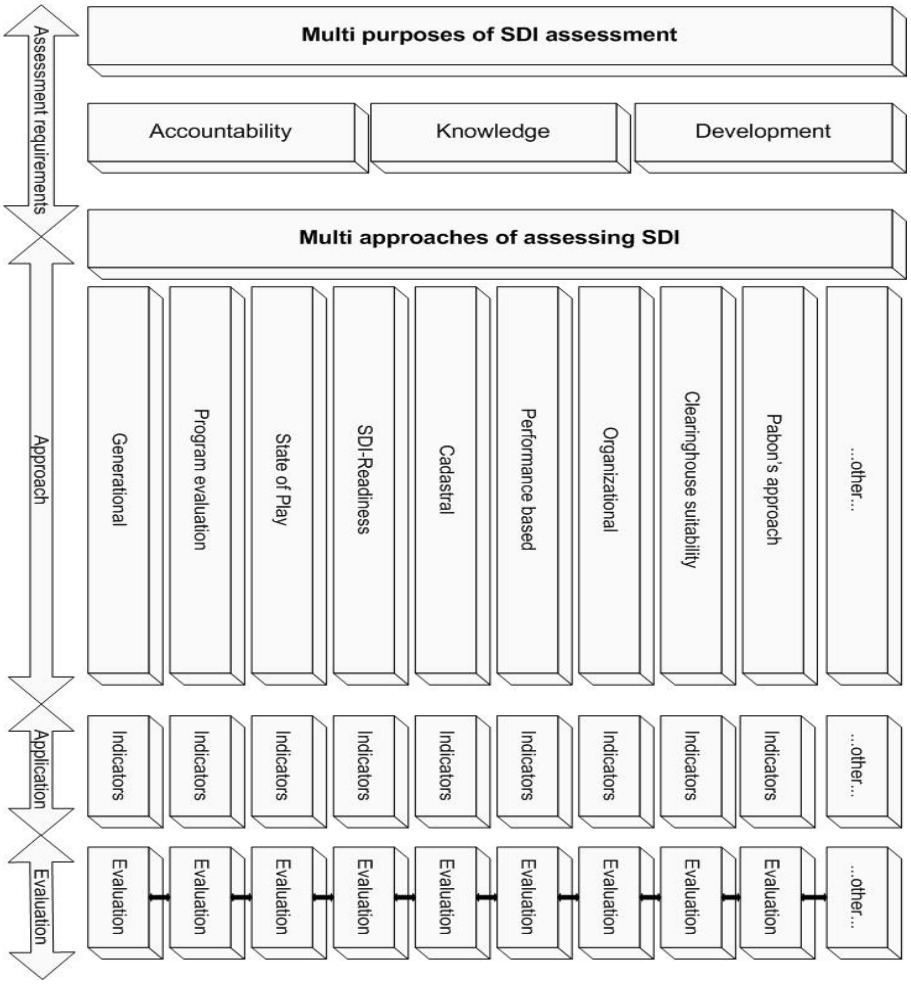
4. MULTI-VIEW SDI ASSESSMENT FRAMEWORK

The previous sections justified the use of multiple assessment approaches, considering the multifaceted and complex nature of SDI. This section presents the assessment framework that potentially fulfils all of the requirements mentioned in the previous paragraphs. A multi-view framework is proposed in order to assess SDI. Figure 1 presents the conceptual model of the framework. The main idea behind the framework is that it covers all three purposes of assessing SDI: accountability, knowledge and development. It also acknowledges the multifaceted character of SDI.

The core of the proposed assessment framework is represented by the multiple assessment approaches that focus on different SDI aspects (facets). To overcome the problem of multiple definitions, SDI is treated here as a complex system with multiple facets. Because we concentrate here on SDI assessment, the facets are related to the assessment approaches included in the framework. Each approach treats SDI from different view. Principally, we concentrate only on the specific

objectives for each approach that SDI should meet in order to be good. For example, the Clearinghouse Approach concentrates only on the SDI's data access facility; for this approach the objectives of good SDI are related only to data access technology. The essence of the multi-view framework is that it accepts multiple views on SDI and thus accepts its complexity in terms of multiple definitions. Moreover, each approach covers at least one of the three purposes of the assessment: accountability, knowledge and development. All approaches use one or more assessment methods, such as case studies, surveys, document analysis, etc., to evaluate SDIs. The proposed assessment methods are both qualitative and quantitative.

Figure 1: Multi-view SDI assessment framework



The Generational Approach is based on the generational development of SDIs described by Rajabifard et al. (2003a). The worldwide development of SDI can be measured according to the identified indicators of first, second and future

generations of SDI development. The results of such an assessment will help the countries concerned to position themselves on the worldwide arena and to indicate directions for future development. Moreover, iterative and longitudinal application of the Generational Approach can measure the dynamics of the worldwide development of SDI initiatives. The measurement of transitions through generations may help to capture the factors that strengthen or weaken the development of SDIs. The generational assessment approach falls into the developmental class of evaluation. It seeks to answer questions about setting a developmental agenda for SDI development, how to measure changes and to monitor SDI implementations across a number of countries. The knowledge purpose is also valid for the Generational Approach. Questions like why one SDI implementation scheme works in Europe but not in Africa may be also answered by this approach. In this approach the worldwide survey and document study may be used to collect data.

The Programme Evaluation approach emerged from the burst of social programmes in 1960s in the USA. The basic function of Programme Evaluation is to check the accountability of social programmes launched in the education, income maintenance, housing, health and criminal justice sectors (Shadish et al., 1991). The Programme Evaluation approach can be defined as a determination of the worth of any enterprise (programme) that aims at solving a particular problem or improving some aspects of the area of interest (Worthen, 1990). This approach treats SDI as a public programme aimed at improving the access to and the sharing and usability of spatial data. Various sub-approaches can be distinguished to conduct a Programme Evaluation. Worthen (1990) identifies a Performance-Objective Congruence Approach, a Decision-Management Approach, a Judgement-oriented Approach, Adversarial Approaches and Pluralist-Intuitionist Approaches. One technique for analysing programmes might be to build a logic model consisting of information on inputs, activities, outputs and outcomes. For each of these components a set of indicators can be found to assess the performance of SDIs. The Programme Evaluation approach falls into the accountability and knowledge purposes of the assessment as it answers the questions of whether the programme works and increases our knowledge about its components. Case studies mixed with surveys are the most common method of conducting a Programme Evaluation.

The SDI-Readiness Approach is an existing model that assesses whether a country is ready to embrace SDI development (Delegado-Fernandez et al., 2005; Delgado-Fernandez and Crompvoets, 2007). When building an SDI readiness index, various factors like organization, information, access network, people and financial resources are taken into account. Each of these factors consists of a number of indicators that can be quantitatively measured. This model falls within the knowledge and developmental evaluation purposes. The results can be used to answer questions about comparing the progress made with implementing SDIs by

different countries. It also helps to identify obstacles in SDI programmes implementations. SDI-readiness is measured by collecting and analysing predefined indicators based on surveys.

The Cadastral Assessment Approach was originally developed as a land administration evaluation framework by Steudler et al. (2004). It presents a number of indicators for five areas in evaluating Land Administration Systems (LAS): the policy level, the management level, the operational level, influencing factors and assessment of performance. The reason for including this approach in the SDI assessment framework is that there are significant similarities between efficient and effective SDIs and Land Administration Systems and therefore there is a strong ground for using LAS evaluation and performance indicators for SDIs (Steudler 2003). However, this approach is still a conceptual one and has not even been used for evaluating LASs. It still needs to be developed and operationalized for application in practice. If applied it may give us answers about the performance of SDIs, as it contains a number of performance assessment indicators (accountability purpose of evaluation), and increase our knowledge about the policy, management and operational levels of SDIs (knowledge purpose of evaluation). The survey method will be used to measure predefined indicators on a worldwide scale.

The Organizational (Institutional) Approach is based on Kok and van Loenen's (2004) research into the assessment of the different stages of development of geographic information infrastructures, when viewed from the institutional (organizational) perspective. This approach focuses on measuring the development of the following GII (SDI) aspects: vision, leadership, communication, self-organising ability, awareness, financial sustainability and status of delivery mechanism. This approach falls into the developmental perspective of evaluation as it measures SDI development from an organizational (institutional) perspective. So far, the authors of this approach have measured and analysed the development of five SDIs using the case study method (van Loenen, 2006).

The Performance-Based approach uses the Performance-Based Management (PBM) technique to evaluate, demonstrate and improve the performance of SDI (Giff, 2006). This approach is based on the assumption that SDI is an infrastructure and that methods like PBM normally used for assessing the performance of infrastructure can be used for assessing SDI. This method aims at developing performance indicators based on specific SDI objectives, which are used to measure the effectiveness, efficiency and reliability of SDIs. This approach is still in the conceptual stage and specific indicators and methods to measure them have yet to be developed. It falls under the accountability evaluation purpose as it mainly seeks to answers questions about SDI efficiency and results.

The Clearinghouse Suitability Approach is based on research by Crompvoets et al. (2004) into measuring and assessing the development of National Spatial Data Clearinghouses worldwide. A method for measuring a specific set of quantitative indicators of clearinghouse portals can be applied as a continuation of longitudinal studies started in 2000. This developmental assessment aims at showing the advances and trends in the development of clearinghouses (and web portals). This assessment approach uses survey (website visit) and contacting key informants to measure indicators of the development of clearinghouse and web portals.

The State of Play Approach is a study covering the period from mid 2002 to 2007 to describe, monitor and analyse activities related to National Spatial Data Infrastructures in 32 European countries: 25 EU member states, 3 Candidate Countries and 4 EFTA countries. The major activity of this study is to collect and structure all the relevant information on the status of the six building blocks that together, according to this approach, constitute an SDI: the legal framework and funding, reference data and core thematic data, metadata, access and other services, standards, and thematic environment (SADL, 2005). The same approach and methods can be used as a component of the multi-approach framework, also in regions of the world outside Europe. Document studies (country reports), surveys (website visits) and contacting key informants (national SDI experts) are the methods used in this approach.

Pabon (2005) present a theoretical framework to assess SDI initiatives by identifying and describing common success criteria across different contextual backgrounds. According to this framework, SDI initiatives must be evaluated in their two major dimensions: the quality dimension and virtue dimension. The quality dimension covers the efficiency and effectiveness of technical and organizational aspects of SDI projects. The virtue dimension consists of political, human and social aspects, which are measured against predefined qualitative criteria.

Table 1 summarizes the attributes of all the evaluation approaches proposed for the multi-view framework. Some of the approaches presented exist only as theoretical constructs and need to be elaborated further to develop application methods. These include the Generational, Cadastral, Performance-Based and Organizational approaches. The SDI-Readiness, Clearinghouse Suitability and State of play approaches can be applied in the framework in a straightforward manner because the methodologies and application practices already exist. The Programme Evaluation approach still needs to be developed and methods of measurement and assessment need conceptualization. This variety of assessment methods guarantees that a wide range of data on SDIs can be collected. The set of approaches constituting the framework also covers all three classes of evaluation purposes presented by Chelimsky (1997): accountability, knowledge and developmental purposes.

Table 1: Summary of evaluation approaches proposed for the multi-approach assessment framework

Approach	Goal Description	Method	Status	Assessment purpose class
Generational	To measure the development of SDIs worldwide	Survey, document study	Not developed	Developmental Knowledge
Programme Evaluation	To determine the worth and accomplishment of the objectives of SDIs	Case study and survey	Not developed	Developmental Knowledge Accountability
SDI-Readiness	To assess if the country is ready to embrace the SDI development	Survey	Applicable	Developmental Knowledge
Cadastral	To measure five evaluation areas of LAS	Survey	Needs improvement	Knowledge Accountability
Organizational	To measure SDI development from the institutional perspective	Case study	Applicable	Developmental
Performance-Based	To measure SDI effectiveness, efficiency and reliability	Not available	Needs improvement	Accountability
Clearinghouse Suitability	To measure the development and impact of SDI clearinghouses worldwide	Survey, key informants	Applicable	Developmental
State of Play	To measure the status and development of SDIs	Document study, survey, key informants	Applicable	Developmental Accountability
Pabon's	To measure quality and virtue dimensions of SDI	Case studies, Web survey	Needs improvement	Developmental, Knowledge

The *application* part of the assessment framework focuses on measuring the indicators for each assessment approach. The selection criteria for the indicators

are the criteria of merit: the descriptors of an evaluand that reflect its capacity to meet needs (Shadish et al., 1991). For example, if *interoperability* is the criteria of merit of SDI it should be measured with an indicator that best reflects the level of interoperability. The scale of the measure should be defined to allow comparison and ranking of the measured values. The result of the measurement of selected data forms the basis for the assessment of a particular SDI. The best approach and method can be chosen according to the purpose of the evaluation of the SDI (accountability, development or knowledge).

The *evaluation* part of the framework has two functions: (1) evaluation of the SDI and (2) evaluation of each approach and the whole assessment framework. The first function is the primary one as the main purpose of the research is to assess SDIs. The evaluator makes a judgement on SDI, taking into account the standard of merit determined for each criterion of merit for the particular assessment approach. For example, if interoperability is being measured, each measured value should be placed on a defined scale to make it possible to assess (evaluate) and compare the value of interoperability, either between countries or as a reference to some standard value (benchmarking). A more holistic and bias free picture of specific SDI initiatives can be obtained by interpreting the assessment results for those SDIs from different viewpoints. This will enhance our understanding and assessment of the SDIs.

The second function of the evaluation part is the evaluation of the assessment approaches and the whole framework itself, or meta-evaluation, to ensure that they are acceptable to the stakeholders. Meta-evaluation refers to a variety of activities intended to evaluate the technical quality of evaluations and the conclusions drawn from them. Its purpose is to identify any potential bias that there might be in an evaluation and, using a variety of methods, to estimate their importance (Straw and Cook, 1990). Meta-evaluation can also provide information about the impacts of evaluation activities. Several models of meta-evaluation exist (Cook and Gruder, 1978), but at this early stage in the development of the multi-approach assessment model it is difficult to choose the most suitable one. Nevertheless the meta-evaluation must be performed, especially by the users of the framework, and must follow the application of the multi-approach framework. However, given that the principal feature of the proposed framework is the use of multiple approaches, the same indicators can be used for different assessment approaches and methods. Coming to similar conclusions about the value of one particular SDI using multiple assessment approaches would therefore confirm the validity of the whole assessment framework. This design is in fact a kind of built-in self-evaluation mechanism: the use of multiple, independent approaches and methods used by a number of evaluators guarantees SDI assessment results that accurate reflect reality and have a low bias. The potential overlap between the methods used for different assessment approaches may help to validate the approaches themselves. Moreover, this assessment framework design is related to *triangulation* research

methodology which applies and combines several research methodologies in the study of the same phenomenon. Triangulation is the preferred line of research in the social sciences because combining multiple observers, theories, methods and data sources can overcome the intrinsic bias inevitable in single-method, single observer and single-theory investigation (Denzin, 1990). Evaluation of the assessment framework and its approaches is crucial for their future usability because stakeholders will only use its results to improve SDI's performance if they accept the framework.

5. DISCUSSION

The core element of this paper is the presentation of the conceptual model of the SDI assessment framework. The authors intend to apply the assessment framework in their future research to assess SDIs at the national level (NSDIs). The multi-view assessment strategy was based on the principles of assessing Complex Adaptive Systems and general evaluation research. A combination of multiple approaches and methods generates more complete, more realistic and less biased assessment results. Multiple assessment methods – case studies, surveys, key informants and document studies – capture the multifaceted and complex character of SDI. They guarantee a diversity of SDI data, which in turn can reflect the complexity of the SDI. The framework is flexible because it permits evaluation approaches and indicators to be added, removed or corrected – an especially important feature when the framework is applied iteratively and refined successively. The relative complexity of the assessment framework presented here also meets the requirement that truly complex systems should be explored and understood with complex methods to properly reflect reality. The aim of the proposed framework is not only to assess SDI performance, but also to deepen our knowledge about SDI mechanisms and support SDI development.

Some obstacles and difficulties may be encountered when applying the assessment framework. The issue of timing is the first important consideration, especially in such a dynamic and constantly evolving environment like SDI. The simultaneous use of several assessment approaches will generate more realistic results than if they are conducted sequentially. Therefore the intervals between data collections for various approaches should be as short as possible to allow application of the multiple approaches to be synchronized. The next consideration is the difference in data availability between various assessment approaches and methods. Because the SDI concept is still very young, some countries may not produce reports or any other data that could be used in the assessment analysis. For some assessment approaches and their methods it may be impossible to collect reliable and complete data, such as reports on SDI finances, expenditure or revenues figures, and there may be no internal self-assessment reports available. The last consideration concerns the integration of multiple approaches. The intended outcome of the integration of all the assessment approaches included in

the framework is to give tangible information on the merits of the SDIs. It is possible, though, that the findings of several assessment approaches will present different pictures of SDI. These differences must be reported so that future investigators can build on such observations (Denzin, 1990).

An important aspect of applying the assessment framework in practice is promoting the use of the evaluation results, and so evaluators must take active steps to increase the use of their results. Shadish et al. (1991) state that evaluators can facilitate the use of evaluations by choosing the right communication channels to disseminate the results and by taking the appropriate stance when dealing with potential users. The appropriate role for the evaluator to adopt is as a servant. The preferred communication channels are writing and presenting evaluation reports, making recommendations for action, publicizing evaluation findings and maintaining close contacts with users to stimulate the use of the results of the assessment.

6. CONCLUSIONS

In this paper we have highlighted four characteristics of SDI that make its assessment specific: its complexity, its many definitions, the often vague objectives and its dynamic nature. To deal with these issues we suggested that the framework should be based on the principles of assessing Complex Adaptive Systems: using multiple assessment strategies, a flexible framework and a multi-perspective view of the assessed object. We argued that the application of the proposed framework would lead to a more complete, realistic and less biased assessment of SDI. We proposed a number of existing and non-existing SDI assessment approaches as building blocks for the framework. We also discussed issues related to the application of the framework in future research. Despite the fact that the multi-approach assessment framework is strongly supported in complexity theory and evaluation practice, and its application results are promising for evaluating SDIs worldwide, we also suggest that the issues of harmonizing the different approaches at one point in time, the difficulties of collecting data for all approaches for all countries and the integration of the results should be examined critically during future application of the assessment framework.

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