

Worldwide Impact Assessment of Spatial Data Clearinghouses

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Abstract: *This paper provides results from a worldwide impact assessment of spatial data clearinghouses. Its aim is to assist policy makers in their task of evaluating whether or not investment in setting up and maintaining these establishments is justified. To achieve this objective a procedure was devised for the comprehensive and systematic evaluation of sustainable development within the worldwide clearinghouse population. The assessment procedure entailed a survey undertaken by clearinghouse coordinators. A range of economic, social, and environmental indicators was chosen to evaluate the relevance, efficiency, and effectiveness of clearinghouses. This paper also presents the results of complementary analyses that were carried out to assess the significance of the impacts recorded. They were also used to assess the objectivity of the responses of the coordinators. The results of these assessments reveal that clearinghouses provide mainly positive impacts. In addition, the results also indicate the significance of clearinghouses as relevant facilities for enhancing spatial data accessibility, providing efficient means of accessing spatial data, and the effective promotion of data use and distribution. Finally, the results could be used to justify present investments and to support future investments in the clearinghouse system.*

INTRODUCTION

Many international regions, countries, states, and counties throughout the world have spent considerable resources over the past few years implementing and managing Spatial Data Clearinghouses (SDCs). These SDCs are prominent features of Spatial Data Infrastructures (SDIs) (Clinton 1994, Federal Geographic Data Committee 1997, Onsrud 1998, Cromptvoets et al. 2004), because they are the facilities for making spatial data accessible to the general public and promoting data sharing. SDCs facilitate the searching, viewing, transferring, ordering, publishing, and/or disseminating of spatial data and services from numerous sources via a Web site (interface) on the Internet, and, as appropriate, providing complementary services. These SDCs contain data catalogs, which are access systems that use metadata (INSPIRE Architecture and Standards working group 2002, Maguire and Longley 2005, Tait 2005).

The access service for spatial data on the Web is known variously within the spatial community as clearinghouse, catalog service, spatial data directory, geportal and geospatial one-stop portal. Although different names are used, obviously the goals of accessing spatial data through the metadata remain the same (Cromptvoets et al. 2004, Beaumont et al. 2005). The enhancement of data/service accessibility and the sharing of spatial data and related services between suppliers and users are the main reasons to build these electronic facilities (Bernard et al. 2005, Beaumont et al. 2005, Maguire and Longley 2005).

Based on an overall assessment, the average cost of an SDC is approximately € 1,500,000 a year (Southern California Association of Governments 1998, INSPIRE Architecture and Standards working group 2002, Pasca et al. 2004). This money is

spent on management and coordination costs, GIS and Internet application development, training, hardware, standardization activities, legal environment creation, and metadata preparation. Currently, about 500 (noncorporate) SDCs have been established and many more SDCs probably will be set up in the future. On a global scale, hundreds of millions of dollars are spent yearly on SDC activities. Up to now this large investment has rarely been audited or evaluated. A study conducted by the Urban and Regional Information Systems Association (Gillespie 2000) cited that while the costs of SDC projects may be relatively easy to assess and highly “front-loaded,” the benefits are often difficult to measure and may not emerge until well into the life of the SDC and depend on other factors coming into play (Federal Geographic Data Committee 2002, Commission of the European Communities 2004).

SDCs could be developed at different administrative levels, ranging from local to state/provincial, national, and international levels to a global level, to better access and share spatial data and related services. There is a need to address politicians and decision makers to demonstrate the benefits of such a system. One of the difficulties of selling the benefits to decision makers has been the paucity of systematic evidence of the full economic, social, and environmental impacts. This was highlighted in the context of Geospatial One-Stop (Federal Geographic Data Committee 2002) and the Extended Impact Assessment of the INSPIRE-initiative (Commission of the European Commission 2004). However, it has been difficult to extrapolate impacts from these individual cases to reach more generalized conclusions. In addition, it is critical to move away from a narrow focus on the technical considerations of SDCs to their potential contribution

to area competitiveness, innovation, productivity, job creation, etc. (Craglia et al. 2003).

The focus of this paper is on the worldwide impact assessment of the current SDCs with the main objective of providing this information to policy makers to assist them in evaluating whether or not investment in setting up and maintaining these SDCs is justified. In this context, the term *impact* is described as the (positive or negative) effect that SDCs could have on society. Few studies exist about the worldwide impact of these facilities. To the best of the authors' knowledge, no comprehensive and systematic impact assessment has taken place. The purpose of the present paper is to fill this gap.

This paper presents and assesses the impacts of current SDCs throughout the world with reference to the economic, social, and environmental dimensions. This impact assessment is based on a survey undertaken among coordinators of known SDCs of the world using indicators to assess the relevance, efficiency, and effectiveness. Complementary analyses are implemented to interpret the significance of the impacts.

INTRODUCTION TO IMPACT ASSESSMENT

Impact assessment is a key tool for improving policy making and implementation, and promoting sustainable development (Long and Alastair 1997, Commission of the European Communities 2002, Bråthen 2003). Many techniques can be used to assess the impacts (Jorgenson 1998, Environmental Protection Agency 2000), but whatever method is used, the results need to be transparent, reproducible, and robust. To make comparisons as accurate as possible, impacts are expressed in quantitative and monetary terms (e.g., cost-benefit analysis) in addition to a qualitative appraisal.

Impact assessment identifies and assesses problems arising from pursuing the objectives and the options available to achieve those objectives. It also highlights the positive and negative impacts with their respective advantages and disadvantages, including synergies and trade-offs (Commission of the European Communities 2002, Bråthen 2003). Any assessment should be based on the following criteria:

- Relevance for solving the problem,
- Efficiency in the use of human and financial resources,
- Effectiveness in achieving the defined objectives.

These assessments of impact are difficult mainly because of the degree of uncertainty in the reliability of the data, the assessments of the proportion of the impacts, the range of affected stakeholders, the short-term and long-term developments, and the efficacy of the assessment method.

Systematic assessment of impacts should also consider sustainable development. Sustainable development is based on the idea that in the longer run, economic growth, social inclusion, and environmental protection should go hand in hand. At this moment, many governments regard these economic, social, and environmental dimensions as the main driving force behind their

policies (Williamson et al. 2003). The economic, social, and environmental impacts should be identified and cover all positive and negative effects, including costs and benefits. Economic, social, and environmental impacts have been identified by the report of the European Communities (2002).

EXISTING IMPACT ASSESSMENT STUDIES

Several studies assess the impact of SDIs including SDCs (Renong Berhad 1995, PriceWaterhouse 1995, Canadian Council of Land Surveyors, Canadian Institute of Geomatics, Geomatics Industry Association of Canada 2000, Berends and Weesie 2001, Fornefeld and Oefinger 2001, Federal Geographic Data Committee 2002, Pasca et al. 2004, Commission of the European Communities 2004). These studies encountered difficulties in estimating the costs, while the estimation of benefits appeared to be even more difficult.

Previous assessment research focused mainly on the impact of one SDC and was neither comprehensive nor systematic (PriceWaterhouse Nederland 1996, Federal Geographic Data Committee 2002, Commission of the European Communities 2004, Pasca et al. 2004, Tait 2005, Walther 2005). As with many SDI initiatives, the majority of impacts were qualitative in terms. The main findings of these six studies are that SDCs:

- Improve the availability, accessibility, usability, and “downloadability” of data supplied.
- Are cost-effective and efficient. For example, the benefit-cost ratio, related only to the reduction of time to access data, ranges from 1.1 to 4.
- Widen the range of users with different levels of education and technical skills.
- Increase the awareness of spatial data among the general public.
- Enhance the performance and productivity of (publicly funded) organizations.
- Improve metadata quality.
- Increase government participation.
- Support better decision making.
- Serve as catalysts to innovation and new ways of working.
- Improve partnerships.

These initial assessment results and literature (e.g., Groot and Sharifi 1994, Askew et al. 2005, Maguire and Longley 2005, Beaumont et al. 2005) suggest that SDCs are a relevant means to enhance data accessibility as well as data sharing, both effective and efficient in the use of human and financial resources.

In contrast with the previous assessment research, this paper focuses on the worldwide clearinghouse population and is comprehensive and systematic.

METHODOLOGY

This paper focuses on the development and implementation of a procedure to assess the impacts of currently existing interna-

tional, national, federal, interstate, state, county, and local SDCs of the world. The “preclearinghouse situation” was considered the baseline against which to assess the current impact of SDC development. The preclearinghouse situation refers to when no electronic facility existed on the Internet to access spatial data using metadata. To undertake the assessment, it was important to take into account developments over time, to use existing knowledge and experience, to consult interested parties and relevant experts, to be transparent, and to compare negative impacts with positive impacts.

Assessment difficulties have circumscribed the very few studies containing quantitative and qualitative information on the impacts of SDCs. Therefore, the approach chosen in the study was to determine impacts by referring to the expert knowledge and experiences of SDC coordinators as their perceptions are sensitive indicators for changes as well as impacts. These coordinators organize activities as management, marketing, technical and legal environment creation, and human resources so that their SDCs operate well. Other reasons to focus on SDC coordinators were their intermediate roles between data/service suppliers and users, their awareness of the historical, institutional, cultural, legal, economic, and technological context, and their ability to provide accurate data about the development, use, management, content, and technology of their SDCs. Moreover, they were relatively easy to contact. This was not the case with the data users as well as the suppliers of SDCs. In addition, the expertise and experiences of a selected number of European SDC practitioners (users and data/service suppliers) were used to evaluate the objectivity of coordinators’ perceptions. The availability of this expertise meant that the impact in terms of economic, social, and environmental context could be described fairly comprehensively.

The procedure used in this assessment study consisted of the following steps:

- Undertaking extensive literature research (see the previous section on existing impact assessment studies);
- Determining assessment indicators to evaluate the relevance, efficiency, and effectiveness;
- Designing and conducting the survey to collect information about the perceptions of coordinators;
- Analyzing results by categorization of the SDCs to facilitate the interpretation of these results; and
- Assessing the objectivity of coordinators’ responses.

DETERMINING ASSESSMENT INDICATORS

The assessment was confined to using a number of economic, social, and environmental impact assessment indicators, because a full implementation of a quantitative assessment study was proscribed by cost considerations. These indicators were measurable and illustrative (Taylor et al. 1990). They could measure the relevance, efficiency, and effectiveness of SDCs and provide insight into how economic and social structure and environment alter when SDCs are implemented. The selection of indicators

was based on expert knowledge, literature, and direct relevance for SDCs.

The economic indicators used were:

- Consumption of data/services,
- Data market transparency,
- Duplication of data collection.

The social indicators were:

- Spatial data/service awareness and
- Social cohesion between citizens.

The only environmental indicator was:

- Data delivery for environmental policy formulation.

DESIGNING AND CONDUCTING SURVEY

The survey was undertaken (November 2004 to April 2005) to collect information about the perceptions of coordinators. A questionnaire was distributed to all known coordinators of SDCs. This survey was strongly supported by the INSPIRE expert group (a group composed of representatives of the European Commission and environmental and GI communities of member states) and the Executive Board of the Permanent Committee of GIS Infrastructure for Asia and Pacific (PCGIAP).

As many SDC coordinators as possible completed the survey to provide a full and reliable impact assessment. For this reason an inventory of identified SDCs was compiled by extensive browsing on the Internet (using several search engines), reading literature, contacting experts and SDC coordinators. Where possible, the e-mail address (and name) of the SDC coordinator was collected.

A questionnaire was used to collect the relevant information. The questions were based on current literature as well as on expert knowledge, so that the coordinators’ perceptions of their SDCs could be analyzed. Most questions could be answered by selecting the appropriate option boxes; none of the questions were open. The questions were framed in a way that they described the impacts of SDCs as well as the future developments. The questions were:

- 1) On which administrative level listed is your SDC mainly operating? (In the next section, the administrative levels listed are presented).
- 2) For which of the countries listed does your SDC cover (partly) metadata (193 countries were listed)?
- 3) Which of the options listed are the main benefits of your SDC? (Figure 3 presents the benefits listed.)
- 4) Which of the options listed are the main drawbacks of your SDC? (Figure 4 presents the drawbacks listed.)
- 5) Which of the options listed is likely to take place with your SDC within the next five years? (In the following “Future Developments” section, the future options are partially presented.)

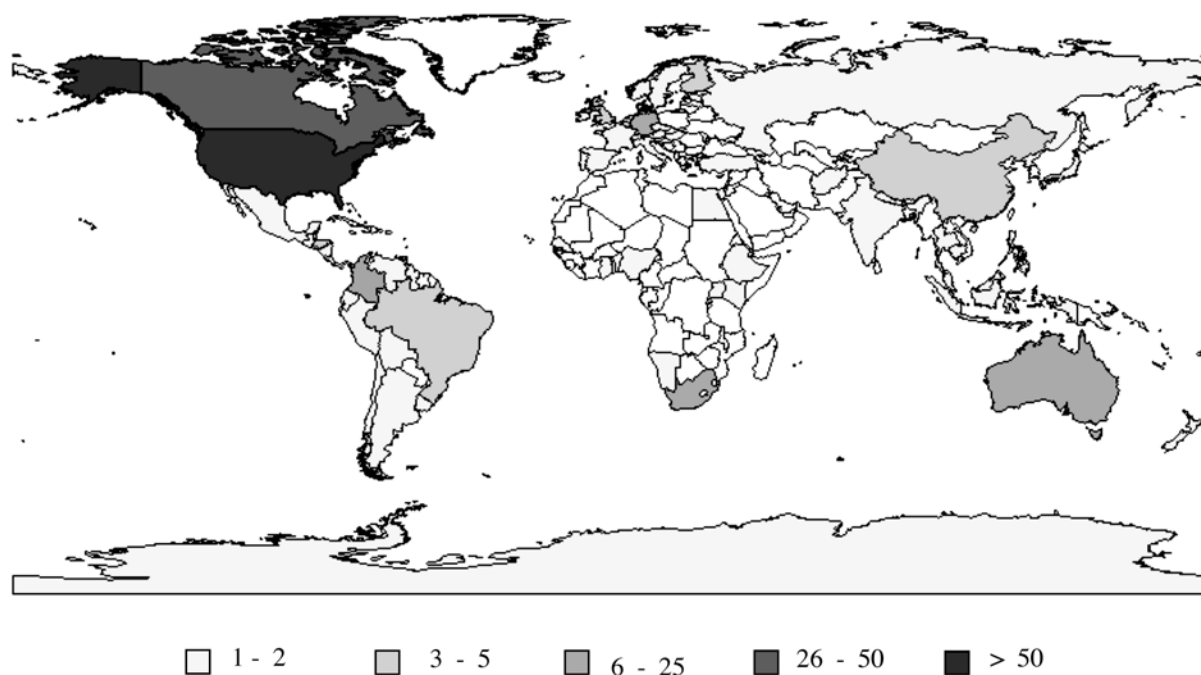


Figure 1. Worldwide distribution of spatial data clearinghouses (456) by country

Moreover, 14 statements were formulated to assess what SDC coordinators considered the impacts of their SDCs on a scale from strongly agree to strongly disagree. Examples of these statements include:

- Your SDC increases the consumption of spatial data and services.
- Your SDC improves data market transparency.
- Your SDC reduces data duplication.
- Your SDC improves the awareness of spatial data.
- Your SDC strengthens the social cohesion among citizens. This statement refers to the solidarity and social bonding between people within state, country, or international region.
- Your SDC improves the appropriate data delivery for environmental policy formulation.
- Establishment and maintenance of your SDC is economically beneficial.

In addition, supplementary statements were included to check the face validity of the responses.

The questionnaire was distributed via e-mail and was addressed personally to the coordinators. The main advantages of using e-mail are that it is fast, easy, and inexpensive for distribution. In total, 428 coordinators were contacted.

ANALYZING RESULTS

The worldwide answers were aggregated. However, because the world is so diverse in historical, institutional, legal, cultural, technological, and economic respects, and different geographical

information (GI) processes take place at various administrative levels, the variability of the answers between regions and administrative levels was categorically analyzed. The classification by region was based on the division of Dorling Kindersley (2002). Eight administrative levels were identified: worldwide, continental, international, national (federal), interstate, state, county, and local. The chi-square and Fisher exact tests (Agresti 1990) were used to test whether respondents at different regional areas and administrative levels reacted differently to the questions and statements of the questionnaire. Throughout, test results with a (one-sided) P value of less than 0.1 were considered significant.

ASSESSING THE OBJECTIVITY OF COORDINATORS' RESPONSES

Because the results of the questionnaire were based on the responses from the SDC coordinators, it was expected that their views could be biased. To mitigate this, a comparison of responses from the European SDC coordinators with those of the European user community was made, assuming that the objectivity of European coordinators' responses represent well the objectivity of all SDC coordinators' responses. To facilitate this procedure, a short version of the questionnaire was distributed to 75 European representatives of the GI user community (June to August 2005). These practitioners were members of the INSPIRE Expert Group and were considered important stakeholders who could use SDCs to access or supply spatial data (e.g., ministries, municipalities, mapping agencies, cadastres, universities, public/private institutions, utilities, etc.). The chi-square and Fisher exact tests were

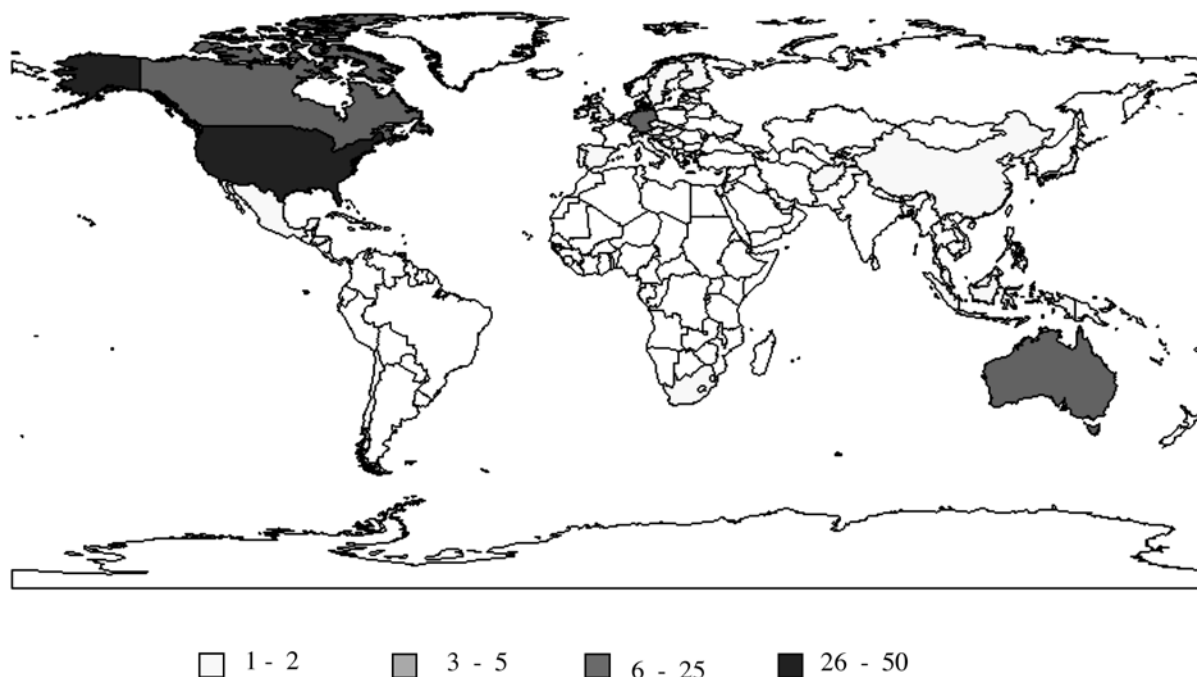


Figure 2. Worldwide distribution of survey responses (105) by country

also used to test the differences of the views between the European SDC coordinators and these practitioners.

RESULTS AND DISCUSSION

The inventory resulted in a list of 456 SDCs (of 80 countries) of which 428 had personal e-mail addresses of their SDC coordinators. Figure 1 indicates the worldwide distribution of all identified SDCs by country. Apparently, the establishment of SDCs has become a global activity as recorded by Cromptvoets and Bregt (2003) and Cromptvoets et al. (2004). Most SDCs are established in Europe, Southeast Asia, North America and South America. The countries with the highest number of SDCs are the United States and Canada. The areas with few implementations are Africa and the Middle East.

A total of 105 coordinators from 31 countries completed the survey (25 percent of the population of coordinators). This percentage is in line with the responses to similar types of surveys (Hamilton 2003). This sample size was adequate in respect to the SDC population in the developed world for the respondents were mainly coordinating SDCs in North America (the United States/Canada) (41 percent), Europe (32 percent), and Australia (8 percent) (only 19 percent in total were African, South American, and Asian (see Figure 2)). To obtain reliable results, the regional analysis included only the North American, European, and Australian coordinators. The other regions were excluded from the regional analysis because of the limited number of responses.

As mentioned previously, the survey identified eight administrative levels (question 1). To achieve reliable statistical analysis,

several levels were reclassified. Finally, three classes were considered: (inter)state, national (including federal), and international. Interstate and state classes were reclassified into (inter)state (41 percent); national class was unchanged (31 percent); worldwide, continental, and international classes were reclassified into international (20 percent); county and local classes were excluded from the administrative level analysis (8 percent).

BENEFITS AND DRAWBACKS

The enhanced access to spatial data and the improved data sharing and distribution are regarded as the main benefits (question 3) of the current SDCs (see Figure 3). This confirms the results derived from the previous studies and literature (see the previous section on existing impact assessment studies). On the basis of this result, overall SDCs are relevant facilities to access data/services and to promote sharing. However, many SDCs still lack integration among suppliers and users. This could result in inefficient use of resources, potential duplication, inconsistency, incompatibility, and the inability to maximize the value of data and services. The main benefits appear to be economic in nature. Minor benefits are the more effective use of available data, the improved spatial data awareness, and the reduction of spatial data duplication. Cost savings are not really seen as a benefit, which could indicate that SDC coordinators are not very cost-conscious.

Coordinators of North American SDCs regard the reduction of data duplication and the improved data sharing and distribution significantly more as benefits (this is in contrast with European SDCs).

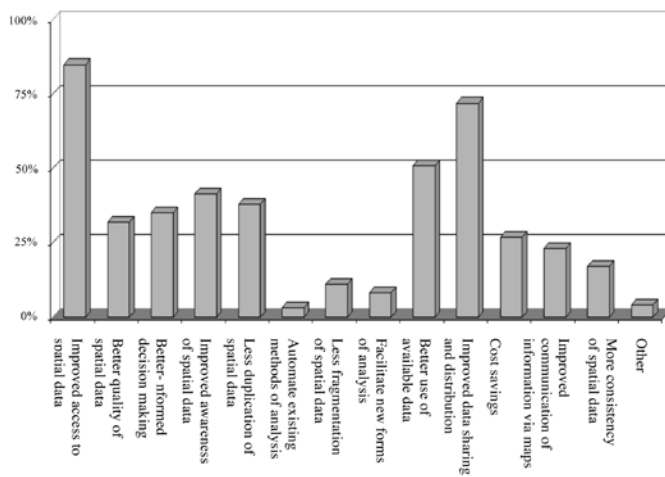


Figure 3. Worldwide distribution of SDC coordinators' responses (percentage) relating to the benefits of spatial data clearinghouses

In addition, coordinators of international SDCs see the reduction of data duplication significantly less as a benefit. This is in contrast with (inter)state coordinators who also look on cost savings significantly more as a benefit.

Besides costs and funding (80 percent), not one single drawback (question 4) could be identified as another important obstacle for SDC implementations and maintenance (see Figure 4). Institutional problems (33 percent), lack of specialized data managers (25 percent), and data standardization (23 percent) can be considered as significant drawbacks. The lack of harmonized reference systems (3 percent), liability problems (12 percent) and inadequate Internet bandwidth (16 percent) are less significant as drawbacks for SDC implementation. This result is in line with literature (INSPIRE Architecture and Standards working group 2002, Federal Geographic Data Committee 2002, Wehn de Montalvo 2004, Askew et al. 2005). None of the main obstacles are directly technology-related. It seems that the challenges are more likely to be organizational than technical.

North American coordinators consider lack of specialized managers significantly more as a drawback and problems with data pricing as less. On the other hand, the European SDC coordinators look on problems with data pricing and commercialization of data significantly more as drawbacks.

The high degree of correspondence in coordinators' views with respect to the perceived benefits and drawbacks is significant insofar as it gives a clear indication that SDCs worldwide function within a broadly similar operating environment.

ECONOMIC, SOCIAL, AND ENVIRONMENTAL IMPACTS

Economic Impact. The economic impact is primarily assessed by using economic indicators. Several statements in the questionnaire refer to these economic indicators. The survey results show the likelihood of higher consumption of spatial data and services as well as the reduction of data duplication as the main

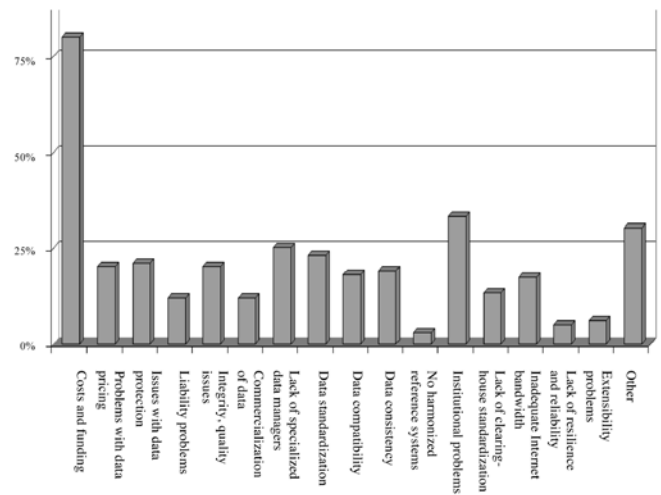


Figure 4. Worldwide distribution of SDC coordinators' responses (percentage) relating to the drawbacks of spatial data clearinghouses

economic impacts. This impact result is illustrated in Figure 5, which presents the responses of SDC coordinators to three economic indicators: consumption of data and services (statement a), data market transparency (statement b), and duplication of data collection (statement c). On the basis of these results, it is apparent that the vast majority of respondents agree with the statement that their SDCs increase the consumption of spatial data and services. This implies that this increase of consumption could be regarded as the most important economic impact. Additionally, a majority also agrees with the statement that their SDCs reduce duplication of spatial data. The result related to the statement that an SDC improves data market transparency is not clear (the majority neither agrees nor disagrees). On the basis of the responses related to these three economic indicators, it could be deduced that SDCs have a significant (positive) impact on the economic dimension.

From a regional perspective, evidence can be found that more North American coordinators agree with the statements that their SDCs increase the consumption of spatial data and services and reduce duplication of spatial data.

Evidence exists that national SDCs agree less that their SDCs increase the consumption of spatial data and services while (inter)state SDCs agree more that their SDCs reduce duplication of data.

Besides the statements directly related to the indicators, the coordinators could also respond to the statement that establishment and maintenance of their SDCs are economically beneficial (statement g). Some 70 percent of the coordinators agree and only 11 percent disagree with this statement. Because the main benefits and drawbacks are likely to be economic in nature, this result indicates that SDC coordinators perceive that the positive impacts more than counterbalance the negative impacts.

Both data users and suppliers could gain economically by the implementation of SDCs. Data users benefit from the improved efficiency to access spatial data, and data suppliers from the in-

creased effectiveness to distribute their spatial data and the improved efficiency to collect data by reducing data duplication. It seems that the establishment and maintenance costs of these facilities are economically justified, although the cost savings for the SDC coordination organizations appear to be a less important impact.

Social Impact. The social impact is primarily assessed by using social indicators. Two statements in the questionnaire refer to these indicators: spatial data/service awareness (statement d) and social cohesion between citizens (statement e). These impact results are illustrated in Figure 6. From the responses of SDC coordinators, the vast majority agrees that their SDCs improve spatial data awareness. Thus, this improvement of spatial data awareness could be regarded as the most important social impact. It appears that SDCs could change the way society is using this spatial data. In many decision-making processes, the role of spatial data is increasing. SDCs improve (indirectly) these processes in a way that enables stakeholders to become better informed. Additionally, a majority also agrees that their SDCs strengthen the social cohesion. It appears that SDCs are, for example, able to provide equal spatial information access to rural, urban, and remote communities, which will support local decision-making capacity development and new socioeconomic activities in these communities. In view of these social results, it is reasonable to deduce that SDCs exert a significant impact on the social dimension.

From a regional perspective, evidence exists that North American coordinators agree more with the statement that their SDCs improve the awareness of spatial data. From an administrative-level perspective, no differences in agreement exist.

Environmental Impact. The environmental impact is assessed by using one environmental indicator: data delivery for environmental policy formulation (statement f). The coordinators expect little impact on the environment. From the response it appears that the majority of the coordinators neither agree nor disagree (60 percent) with statement f. SDCs do not seem to deliver the data appropriately for environmental policy formula-

tion. Nevertheless, some environmental policy makers make use of SDCs to access needed spatial data and services (Williamson 2004).

From a regional perspective, the evidence indicates that North American coordinators do not consider this impact as important. From an administrative-level perspective, no differences in agreement exist.

Examining assessment indicators in combination with the benefits, it appears that the main positive impact of implementing SDCs is economic. The high degree of correspondence in coordinators' views with respect to the economic, social, and environmental impacts is significant, confirming that SDCs worldwide function within broadly similar operating environments

FUTURE DEVELOPMENTS

The coordinators were asked to select what they expect will happen with their SDCs in the next five years (question 5). A subset of their response was that:

- The use of spatial data will increase (89 percent).
- More (new) services will be provided (55 percent).
- The data quality will improve (50 percent).
- The use by governments will increase (49 percent).
- More datasets will be provided (35 percent).
- More specific datasets will be needed (34 percent).
- The metadata standards applied will be changed (31 percent).
- New expertise will be needed (26 percent).

The coordinators expect mainly that the spatial data consumption as well as the range of service provision of their SDCs will increase. These developments are in line with literature (Maguire and Longley 2005, Beaumont et al. 2005) and link strongly to the gradual shift in focus of SDC development: from data-centric to user-centric. In the 1990s, data and technology were the main driving forces for SDCs. At the present moment,

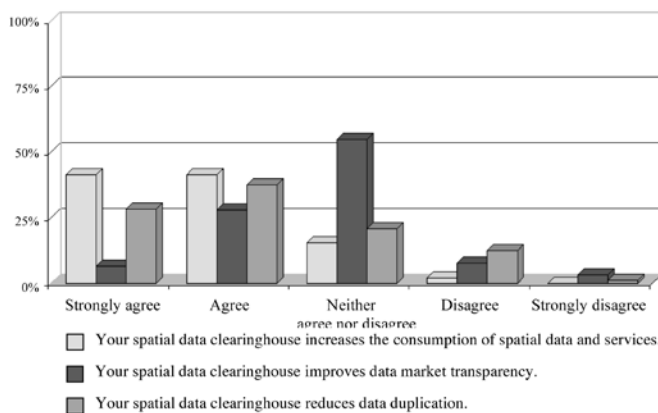


Figure 5. Worldwide distribution of SDC coordinators' responses (percentage) to statements relating to economic indicators

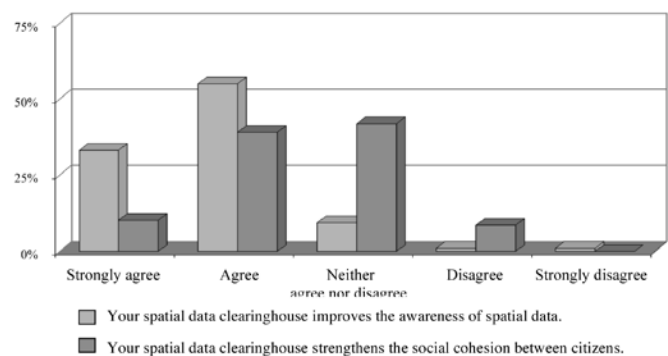


Figure 6. Worldwide distribution of SDC coordinators' responses (percentage) to statements relating to social indicators

the use of data (and services) and the needs of the users are becoming the main forces for SDC development (Reeve and Petch 1999, Williamson et al. 2003, Crompvoets et al. 2004).

The similarity in development views of the coordinators is significant, showing that the coordinators possess the same future objectives probably created by such external developments as expanding technologies, market demand, changing business models, sustainable development, e-government, and participatory democracy. The few differences are that more North American coordinators expect that additional datasets will be provided and new expertise will be needed.

ASSESSMENT OF THE OBJECTIVITY OF COORDINATORS' RESPONSES

A total of 41 European practitioners completed a short version of the questionnaire. The high degree of correspondence between the responses of these European practitioners and the European SDC coordinators (34) with respect to the questions and statements is significant. This result implies that the coordinators' perceptions are not unduly biased (at least the European coordinators' perceptions) and justifies the choice to focus on SDC coordinators as reliable sources of information to assess the impacts. Furthermore, the practitioners look on cost savings as a more significant benefit and consider the improved awareness of spatial data as a less important impact. This indicates that the coordinators underestimate the efficiency of SDCs and overestimate the improved awareness.

METHODOLOGY USED

The implementation of the assessment procedure was appropriate to measure the impact of SDCs on a worldwide scale to assist policy makers to decide whether investments in the establishment and maintenance of SDCs are justified. When compared to previous studies, the strength of this impact assessment was that it was comprehensive and systematic, reproducible, robust, based on expert knowledge, and that it identified significant economic and social impacts. Through the survey it was possible to gather the perceptions of the coordinators in a fast, inexpensive, and easy way. The complementary analyses were needed to interpret the results of the survey. The main limitation of this study was that only qualitative impacts could be assessed and it was not possible to determine quantitative measures such as financial impacts. The current experiences of the SDC operations are limited by the fact that they are still at an early stage of their development. There is a need to refine methodology so that more precise records of numerical and financial data can be recorded. In this way, a better and more accurate grasp of financial and operational impacts could be delivered. Nevertheless, the usage of indicators gave some insight into how economic, social structure, and environment alter when SDCs are implemented.

CONCLUSIONS

The main conclusions of this comprehensive and systematic impact assessment referring primarily to SDCs of the developed world are:

- SDCs are likely to exert a positive impact on society. The main (positive) impacts are of an economic nature, but social impacts are obviously important as well. On the other hand, SDCs likely have little impact on the environment.
- SDCs could be considered as relevant facilities to enhance spatial data/service accessibility and to promote the sharing of these resources.
- SDCs could be considered as efficient facilities to enhance data/service accessibility and to reduce data duplication.
- SDCs could be considered as effective facilities to increase the use and distribution of spatial data/services, to improve the awareness of spatial data/services, to strengthen social cohesion between citizens, and to improve potentially better-informed decision making.
- Costs and funding could be regarded as the main obstacle for SDC implementation.
- In the near future, the use of spatial data resources of SDCs will increase as well as the range of service provisions.
- Coordinators have similar views toward the benefits, drawbacks, and impacts as well as the future developments of SDCs. These similarities could form a perfect basis to ensure interoperability between datasets and access mechanisms, and to create a culture of sharing as well as a shared language among coordinators.

North American SDCs are considered the most efficient and effective facilities, and are substantially accepted within the community. This is in line with Maguire and Longley (2005), who mention that many American as well as Canadian SDCs already in the 1990s were able to promote awareness of spatial data, create community involvement, and build capacity to access this data (Maguire and Longley 2005). The Australian SDCs form the intermediate in efficiency and effectiveness between North American and European SDCs.

The diversity in benefits, drawbacks, impacts, and future developments between the different administrative levels appear to be low. This could imply that the GI processes relating to spatial data/service accessibility do not vary much at different administrative levels.

The results obtained could be used to justify present investments and to support future investments in SDCs. However, the authors observe that despite these positive results in terms of relevance, efficiency, and effectiveness, the SDC concept to share resources continues to be resisted, which leads to unnecessary inefficiencies, resulting in duplication of data collection and storage and consequent costs (Nedovic-Budic and Pinto 2000, Federal Geographic Data Committee 2002, Askew et al. 2005). To utilize these SDCs effectively, there must be a clear understanding of how they influence and justify their costs, and overcome

institutional problems. It appears that more impact assessment research is needed (e.g., case studies).

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