

Assessing the Impacts of Spatial Data Infrastructures: Methods and Gaps

Massimo Craglia and Andrew Johnston
University of Sheffield
Sheffield, UK
gisdata@sheffield.ac.uk, A.Johnston@sheffield.ac.uk

SUMMARY

The paper builds on the experience of the authors in preparing an extended impact assessment for the INSPIRE initiative of the European Commission, to discuss the methods deployed and their appropriateness, and reflect then on the gaps in existing knowledge relating to spatial data infrastructures (SDIs), and some of the apparent missing linkages between the development of these infrastructures and the knowledge economy. The value of the paper stems from the growing recognition world-wide of the importance of SDIs to underpin social and economic development, and good governance on the one hand, and the apparent dearth of research substantiating the costs and benefits of such infrastructures on the other. The paper is organized in four sections. The first introduces SDIs, and the lessons learned about their potential role in the knowledge economy during the GINIE project, of which the principal author was the scientific coordinator. The second evaluates the methods used in the extended impact assessment of INSPIRE and the limitations that became apparent during this exercise in our current knowledge about SDIs. The third links the debate about SDIs with the role of institutions in fostering innovation and competitiveness in regional economies, and the fourth puts forward a research agenda to fill the gaps in knowledge and more clearly embed SDIs in regional economic strategies in the Information age.

KEYWORDS: *Spatial Data Infrastructures, cost/benefits, regional innovation systems.*

1. INTRODUCTION

1.1 Spatial Data Infrastructures

Many of the main challenges of contemporary society, such as protecting the environment, increased security, better transport, ‘socially just’ or ‘sustainable’ development, and enhanced services to citizens, require decision-makers to identify where need is greatest. To effectively target intervention, monitor outcomes, and assess impacts access to geographic information is crucial. Ideally it should be easy to identify who owns GI, whether it is fit for the purpose in hand, how it can be accessed and integrated with other information. This requires *a framework of policies, institutional arrangements, technologies, data and people that makes it possible to share and use effectively geographic information.* The term Spatial Data Infrastructure (SDI) encapsulates such a framework.

The importance of an SDI for good governance, economic, and social development, has resulted in many countries developing such information infrastructures at the national level (NSDI). A survey completed in December 2001 (Crompvoerts and Bregt 2003), indicated that 120 of the 192 nations in the world were working on their national spatial data infrastructure, with half having already established catalogues of key data resources searchable on the Web. As noted by Masser, the differences among these endeavours are very considerable with some more focused on “concrete goals such as the completion of the national topographical database. Others are much more process oriented and focus mainly on strategic issues such

as capacity building and the modernisation of government” (Masser 2002, p.5). The ‘national’ dimension of NSDIs also varies but more often than not it refers to central government efforts and rarely includes regional/local government, and the private sector. We use the more generic term SDI to denote both national and regional efforts.

Regardless of these different interpretations of what an SDI is, and the approach adopted for its development, an SDI has significant potential to underpin wider government strategies and initiatives such as e-government which is of particular relevance to this volume. The interest on SDI is also reflected in the number of studies that have recently taken place including the studies by Masser of SDIs in the US, Netherlands, England and Australia (Masser 1998), and the subsequent comparative study of the US, Canada, and Australia (Masser 2002); the review of developments in 14 (mainly) EU countries in 1999 and 2002 (Craglia, Annoni, and Masser 2000; Craglia et al. 2002), and the studies focused on the Accession countries (Pauknerova et al. 2003), and the Mediterranean Basin (Smith, and Dallemand 2003). Further analysis of SDIs in 32 European countries with case-studies in 9 countries has also recently been completed by the University of Leuven under contract to EUROSTAT (see <http://inspire.jrc.it>). At the global level Onsrud undertook a survey of SDIs in 54 countries between 1998 and 2001 in support of the production of the SDI Cookbook (www.gsdi.org), while Williamson et al. (2003) focused particularly on developments in Australasia and the Pacific region. This list is not exhaustive but already gives a sense of the significant interest from academics, and practitioners generated by SDIs.

In practical terms the common denominator in SDIs includes the following: first is *framework data*, being the identification of some of the most important datasets that are of wide use among many communities of users. These often include some of the datasets that enable to reference all other data to specific locations.

Second is *metadata*, or ‘information about information resources’, involving the documentation necessary for a user to discover whether an information resource exists, who has it, where it is located, what are the conditions for accessing it, and whether it is fit for the purpose that the user intends¹. Metadata plays an important role in all efforts to develop spatial data infrastructures and e-government initiatives.

Third is the *policy framework*, which includes the set of policies, strategies, initiatives and projects aimed at increasing access, sharing, and effective use of geographic information, in line with the definition of an NSDI given earlier. In theory the policy framework for a SDI should be holistic across all levels of government, well integrated, pro-active, and inclusive. In practice, there is considerable variability as shown in the selected case studies below.

Fourth is *coordination*. This is possibly the most important of the four components because without it all the other ones would either not happen or do so in a very fragmented and inconsistent way. Coordination requires both a *strategic* function necessary to develop and maintain political support, ensure policy integration, and inclusion of different sectors and levels of stakeholders, and an *operational* function needed in the day-to-day initiatives and projects, including capacity building, education and training, and technical implementation.

1.2 Geographic Information Network in Europe (GINIE)

GINIE was a project funded by the Information Society Technologies Programme of the European Union, running from the 1st November 2001 to the 31st January 2004. Its main purpose was to support the development of a cohesive Geographic Information Strategy at the European level. The results of the GINIE project confirm that:

- GI has a major role to play in addressing societal demands and exploiting the opportunities opened up by policy and technology,

¹ For more details see www.ec-gis.org/madame or www.ec-gis.org/etemii, which overview the complex issues that need to be addressed in relation to metadata.

- GI has economic value in its own right as a major component of Public Sector Information, and the basis for the development of new markets and jobs in the value-adding and location-based industries,
- GI has a social and policy value because it provides the basis for integrating policies and targeting intervention where is most needed, thus providing tangible benefits to citizens, business, and governments.
- Governments across the world increasingly understand the value of GI and are taking action to develop and exploit this asset.

Whilst these are some of the general findings, the following have important policy and strategic implications:

- SDIs are not just about having a lot of data. They are about developing a strategic infrastructure to underpin the development of the Information Society and the Knowledge Economy,
- Like any other form of infrastructure (e.g. transport), for an SDI to work effectively it is necessary that:

It operates at all levels: local, regional, national, European, global;

It is well connected with other related infrastructures such as those of e-government, and public administration in general, research, and the private sector;

It is regularly maintained;

There are clear lines of responsibility for its development, operation, maintenance, and regulation.

The evidence gathered by the GINIE project clearly supports these findings. However, it also indicates that whilst enormous progress is being made, there are still major obstacles in the way, including the following:

1. **gaps in spatial data:** spatial data is often missing or incomplete,
2. **lacking documentation:** description of available spatial data is often incomplete,
3. **spatial data sets not compatible:** spatial data sets can often not be combined with other spatial data sets,
4. **incompatible geographic information initiatives:** the infrastructures to find, access and use spatial data often function in isolation only,
5. **barriers to sharing and re-use:** cultural, institutional, financial and legal barriers prevent or delay the use of existing spatial data.
6. **the case for interoperability** in wider Europe (not only of GI) has not been made sufficiently both in private and in public contexts and needs to be developed; many obstacles listed below can be corrected in parallel with building an interoperable Europe;
7. **Lack of coordination and leadership:** these are necessary to the effective development of SDIs. However, at EU level coordination is still weak and insufficient.
8. **Isolation** of the GI communities from e-government developments and poor integration of SDIs and other strategic infrastructures.
9. **Gross underestimation of the cultural and organisational issues** that influence the speed with which progress can be made.
10. **Insufficient evidence of short and medium term benefits of SDIs leading to resistance to change.**
11. **Insufficient consideration given to the crucial need for capacity building (education, training) and targeted research** throughout the wider Europe for the successful deployment of SDIs and the delivery of the wider benefits.

Europe is not of course alone in this situation but it should not be complacent, particularly if it is serious about the commitment expressed by the European Council at the Lisbon Summit in 2000 *“to make the European Union the most competitive and dynamic knowledge-based economy with improved employment and social cohesion by 2010”*.

To start addressing in a coherent way the issues identified above, a major potential contribution, particularly for issues 1 to 5, could be provided by the INSPIRE initiative of the European Commission which is summarised below.

2. ASSESSING THE IMPACTS OF SDI: THE INSPIRE CASE-STUDY

2.1 Introduction on INSPIRE

The Infrastructure for Spatial Information in Europe initiative (www.ec-gis.org/inspire) was launched at the end of 2001 with the aims of making available relevant, harmonised and quality geographic information for the purpose of formulation, implementation, monitoring and evaluation of Community policy-making. To achieve its aim, INSPIRE has been addressing a broad set of issues including common reference data and metadata, architecture and standards, legal aspects and data policy, funding and implementation structures, and impact analysis. The objective is to arrive at an agreed European legal framework that whilst focusing first on the needs of environmental policy, will subsequently be extended to other areas of Community concern such as agriculture, regional policy, and transport. INSPIRE is governed by the following principles:

1. that spatial data should be collected once and maintained at the level where this can be done most effectively;
2. that it must be possible to combine seamlessly spatial data from different sources across the EU and share it between many users and applications;
3. that it must be possible for spatial data collected at one level of government to be shared between all the different levels of government;
4. that spatial data needed for good governance should be available on conditions that are not restricting its extensive use; and
5. that it should be easy to discover which spatial data is available, to evaluate its fitness for purpose and to know which conditions apply for its use.

The importance of INSPIRE rests on a series of considerations. Firstly, it marks the recognition that policy formulation, implementation, and evaluation requires good information, which is up to date and at a territorial scale congruent with the focus of the policy being considered. As argued earlier, there is an increasing recognition that sub-national and regional levels are the most appropriate levels to assess policy requirements and impacts. Hence, it is information that is referred to these geographical scales that is becoming increasingly important for European policy. Secondly, it also recognizes that to maintain local/regional information up to date, it is important to involve providers at these levels, and leave it to them to manage their information resources rather than attempt to centralize information at the European level. As a consequence, this decentralized model of information management, requires agreed rules to harmonise data collection and management methods, and to access the information so that it can be shared and integrated. Thirdly, although the first focus of INSPIRE is on environmental information, much of this information and the core geographic themes that underpin it are extremely relevant for policy and research across many other sectors including agriculture, transport, regional policy, and public health. In recognition of the importance of this initiative, the European Commission included INSPIRE among the major policy measures for which an Extended Impact Assessment was required.

2.2 INSPIRE Extended Impact Assessment

The EC's Communication COM 2002/276 on Impact Assessment introduces this new instrument with two objectives:

- First, to consider the effects of policy proposals in their economic, social and environmental dimensions.
- Second, to simplify and improve the regulatory environment.

The Guidelines issued by the EC for the Impact Assessment argue that:

Impact assessment helps structure the process of policy making. It identifies and assesses the problem at stake and the objectives pursued. It identifies the main options for achieving the objective and analyses their likely impacts. It outlines the advantages and disadvantages of each option as well as synergies and trade-offs. Impact Assessment is an **aid** to political decision, not a substitute for it.

Impact assessment is applied to all major proposals adopted by the Commission, i.e. those listed in its Annual Policy Strategy or its Work Programme, be they either **regulatory** proposals or other proposals having an **economic, social and environmental** impact. The impact assessment process has two stages:

- firstly a filtering exercise based on a **short preliminary assessment** of all proposals presented in the context of the Annual Policy Strategy or the Work Programme of the Commission; and
- secondly an **extended assessment** of selected proposals.

As indicated earlier INSPIRE was one of the earlier initiatives subject to a full extended impact assessment (XIA), the general structure of which is indicated by the EC as requiring consideration of the sets of issues outlined below:

- What issue/problem is the policy/proposal expected to tackle?
- What main objective is the policy/proposal expected to reach?
- What are the main policy options available to reach the objective?
- What are the impacts – positive and negative – expected from the different options identified?
- How to monitor and evaluate the results and impacts of the proposal after implementation?
- Results of the Stakeholder consultation
- Draft proposal and justification based on the above.

In practical terms, the process of assessing the XIA of INSPIRE involved the following:

- Establishment of a Framework Definition Support (FDS) Group with experts in environmental and geographic information from all the Member States and Accession Countries
- Appointment of a Contractor (Univ of Sheffield and OXERA Consulting) to lead the assessment
- Review of the literature on cost-benefits of SDIs
- Preparation of Impact matrices, as suggested by the EC, for each of the proposed policy measures of INSPIRE,
- Preparation of a framework for the analysis of impacts by OXERA Consulting focusing on incremental costs and benefits, and possible ways of identifying them from key stakeholders
- Preparation/Collection of 39 case-studies of SDI-related projects with a view to provide qualitative and sometime quantitative indications of costs and benefits
- Questionnaire to 50 organisations involved in the preparation of Environmental Impact Assessment (EIA) and Strategic Environmental Assessments (SEA) to estimate the costs incurred that related to the proposed INSPIRE measures;
- Input from the GINIE project, particularly in relation to current experiences of SDIs in Europe and beyond, and Data Policies.
- Input from the SDI State of Play project commissioned by EUROSTAT to the Univ. of Leuven,
- Preparation of a do-nothing Scenario and an INSPIRE scenario as input for the Internet public consultation (April-June 2003)
- Public hearing on the draft XIA held in Rome in July 2003.

The time frame for the XIA was of eight months, from January to August 2003. A further revision of the XIA took place in January-February 2004 to take into account concerns expressed at the political level about the high investment costs of the initiative at the local level.

2.3 Evaluation of the XIA

Limitations

The XIA of INSPIRE suffered from a number of limitations including:

- Lack of research and hence evidence of cost-benefits of SDIs with few exceptions,

- Voluntary nature of the FDS group composed by very busy individuals. This led inevitably to a large degree of variability in the input provided,
- Limited value provided by the impact matrices, which turned out to be almost wholly qualitative in nature, often unsubstantiated beyond the expert's "hunch" and often double counting effects or driven by organisational agendas.
- Limited value of case-studies in providing quantitative assessments of costs and benefits
- Very lengthy process to turn the broad principles of INSPIRE into measurable activities
- Lack of adequate time and resources to put in place a structured process for the identification of costs and benefits once the measurable activities had been agreed upon.

Positive features

- The most positive feature of the XIA was the collective and iterative process of moving from broad principles to agreed measurable activities. Although identified above as also one of the limitations, it was indeed a clear contribution to all the organisations involved including the European Commission, and helped to crystallize the thinking on what exactly INSPIRE had to deal with.
- Once the process above had been sufficiently completed, the measurement of the costs of INSPIRE was also possible at least in broad terms. What was then not possible was to assess the individual costs that each country would incur, since that would have required much greater information on the stage of SDI development in each country and repartition of costs between different institutional and private sector actors at all levels, from national down to local.
- The measurement of benefits was inevitably much more difficult, in line with all the experiences reviewed of SDI or indeed even GIS implementation. Given the limitations highlighted above, the method that became more useful was to use the individual expertise of the members of the FDS Group and technical staff in the EC to arrive at plausible estimates which were then validated from peer review and public consultation. It was therefore appropriate to focus primarily on the environmental sector from which the FDS expertise was drawn, on the basis that if the case for INSPIRE was proven for this sector, other sectors would benefit more than the additional costs. The feedback received has validated this strategy.
- Specifically conducted surveys (EIA and SEA) and case-studies particularly within the EC and the JRC yielded precious information backing up the evidence collected on a more qualitative basis.
- The transparency of all the assumptions made in respect to both costs and benefits, made it possible to revise the XIA very quickly in early 2004 to take into account the comments received and new evidence from the State of Play project and the experience of SDI developments in Italy.

In the light of the above the following statements summarize the experience of the XIA of INSPIRE:

- XIA are useful tools, and the process is as important as the outcomes
- Given the number of SDI developments taking place worldwide, much more research needs to be conducted to document the costs and benefits of these initiatives as they are deployed.

Given that most of the costs (and potential benefits) of INSPIRE were identified at the local/regional level because of the need to build operational capacity, and develop the necessary organisational and technical skills, a research agenda on cost-benefits of SDIs requires first a discussion of the potential roles of SDIs in local/regional development.

3. SDIs AND REGIONAL INNOVATION

Within the literature on SDIs, there is a clear recognition that governments play a critical role in developing and maintaining this type of infrastructure as they are at the same time the largest producers, users, and regulators of GI (e.g. Masser 1998). The focus tends to be by and large on the national level and emphasise National SDIs, rather than sub-national or regional ones, although their existence is recognized (Craglia et al. 2000, 2002)

A parallel, i.e. often disconnected from the SDI debates, literature and policy initiatives argues that the future of economic development in Europe lies in the development of the Information Society and Knowledge Economy. This is the sense of the 1993 White paper on Growth, Competitiveness, and Employment (CEC, 1993), the e-Europe political declaration (CEC 1999) and the subsequent eEurope Action Plans for 2002 (CEC 2001) and 2005 (CEC 2002a) which have massively promoted the development of initiatives such as e-government, e-health, and so on. Similarly, the contested debate on the re-use of Public Sector Information (PSI) starts from the assumption that “liberating” this major source of information will underpin the creation of knowledge workers, achieve international competitiveness, and create a diverse and profitable content business sector (CEC 2002b). Again a clear role here for (national) governments as originators of PSI, re-users in the context of e-services, and regulators.

A third set of literature even less well linked to those above, but much more established and recognized in policy circles focuses on the role of governments and institutions in supporting economic development, particularly at the regional level, and fostering innovation. The acceptance of the region as a unit of analysis is crucial to the focus on institutions. The rise of regional economics has led to an interest in what they contain, especially their institutional structures. The rise of the region as a unit of analysis can be attributed to the recognition of the economic success of regions like the Silicon Valley, Baden-Württemberg and the industrial districts of the ‘Third Italy’.

Amin (1999) argues there are two conceptual strands regarding the competitive advantage of regions; the advantages associated with spatial clusters and the local social cultural and institutional arrangements (pp. 368-369), i.e. one that looks at the organisation of firms and one that examines the support mechanisms.

In respect to clusters of firms, Porter (1998) provides one of the more useful definition because it focuses not only on the firms but also on the associated institutions:

“geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate.”

Economic clusters or industrial districts has received much attention in academia and policy and hinge on the notion that through their geographical and functional concentration, firms, especially if SMEs, take advantage of external economies such as pooled labour and knowledge spillovers, which make them more competitive (Krugman, 1991, 1998; Porter 1990 and 1998). In relation to the role of institutions, we can identify three very closely related strands in the literature:

New institutionalism, including the concept of institutional thickness (e.g. Amin and Thrift 1994, Powell and Dimaggio 1991) which focuses on the presence of institutions in a given geographical area supporting the innovative processes of firms through their interactions, power relations and shared agendas.

Learning Regions, which argues that as knowledge has become an important factor in the production process, regions must “learn” in order to be competitive, i.e. “provide(s) a series of related infrastructures which can facilitate the flow of knowledge” (Florida, 1995, pg. 532).

Regional Innovation Systems, i.e. *“Localised network of actors and institutions in the public and private sectors whose activities and interactions generate, import, modify and diffuse new technologies”* (Evangelista et al. 2002 Pg. 174). This strand builds on the work of many authors from Schumpeter onwards but typically Lundvall (1992) argues “the most fundamental resource in the modern economy is knowledge and, accordingly, the most important process is learning” (pg. 1). Therefore competitiveness is dependent on the institutions present being able to generate and disseminate knowledge and the level of interaction that determines access to this knowledge, i.e. a system.

What these three sets of theories have in common is:

1. A recognition of the importance of knowledge spillovers, which describes the dissemination of knowledge among firms located in the same geographic proximity, to innovation and competitiveness;
2. The importance of geographical concentration of firms in clusters
3. The role of government and other institutions (trade associations, universities, R&D establishments) to facilitate the dissemination and exchange of knowledge.

Given the emphasis on knowledge creation, dissemination, and exploitation, one would expect a close link between these sets of theories and the debates on the “knowledge economy” and the Information Society. This is unfortunately not the case. Most of the theories above have been formulated and tested in the context of the manufacturing industries (see for example the most recent work by Porter 2003). Policy is similarly lagging behind. For example, the recent report by the Department for Trade and Industry *UK Competitiveness: Moving to the next stage* (DTI 2003) whilst advocating a continued emphasis on geographical clustering of industries does not contain the words “internet” or “e” once. We see therefore a schism between the rhetoric of the Information Society which seems largely driven by a technologically-deterministic viewpoint that if more information is made available it will be used, and industrial policy which focuses on geographical clustering and institutions as a way to increase knowledge spillovers and competitiveness, and yet ignores the emerging e-economy. Somewhere in between these two, stand a large group of government-led initiatives to develop SDIs that have failed as yet to articulate the extent of SDI contribution to economic and social well-being, particularly at the regional/local level where most of the costs (and potential benefits) are likely to accrue as argued by the INSPIRE XIA.

4. TOWARDS A REGIONAL SDI RESEARCH AGENDA.

The experience of the XIA of INSPIRE has shown the difficulty in assessing the full economic impact of SDIs, and the dearth of research substantiating the claims of their proponents. In the absence of rigorous studies and real evidence, all too easily such initiatives then are either built on untested assumptions, with the risk of falling from political grace as quickly as they arose, or, as the current experience of INSPIRE demonstrates, to become easy prey of particular interests that fear any change in the status quo.

It is therefore extremely important that a much greater research effort is devoted to assessing the costs and benefits of SDIs, and we argue that regions (i.e. the sub-national level) are an appropriate level at which to focus because:

- National SDIs are unlikely to be sustainable, and relevant unless they are articulated also at the regional and local level, responding to the needs of citizens and firms in localities (see GINIE findings)
- The regional/local level is likely to be the more costly to develop and sustain because of the lack of organisational capacity and technical skills. It is however, also where most of the benefits may accrue (see INSPIRE XIA)
- Regions are currently being the focus of much of the economic literature as the most crucial intersection between new localisms and globalisation processes (e.g. Wood and Valler, 2001)

In addition to a regional focus, we argue that the discussion and analysis of SDIs needs to be much more closely embedded into the literature on regional economics, clustering, and the role of institutions. We need therefore to move away from faith-based arguments that “SDI are good for you, trust me”, and technocratic models that assume blindly that if the technology (and information) are there they *will* be used thus ignoring twenty years of studies of the social shaping of technology (e.g. Bijker 1995). This however opens a rich and complex research agenda that includes:

1. How do we conceptualise and measure the “knowledge economy”? Attempts by OECD statisticians to measure e-content (Aufrant, 2001) have resulted in a very narrow focus on the publishing industry, which fails to include major information producers, and value-added integrators, who may or may not

ultimately publish the new product. Moreover it fails to capture the emerging grey zones of quasi-public agencies acting as private sector undertakings. More work is clearly needed here.

2. To what extent is the geographic cluster model of innovation dissemination still relevant in the e-economy based on digital information flows taking potentially place anytime anywhere? To address this question requires also a much better understanding of the value chains in the e-economy. The emergence of competing but interoperable web-services, i.e. self-contained, self-describing, modular applications that can be published, located, invoked and chained across the Web to provide user services, are a new development requiring critical evaluation. Are there nodes of intersection between different value chains that benefit from clustering? If so, what are their characteristics and how sensitive are they to policy instruments?
3. The levers available to governments to foster innovation and growth in this sector. In particular there is a need to explore the policy space between the traditional actions promoting clustering through physical infrastructures, which may apply to manufacturing, and the normative model that assumes that it is sufficient to make more public sector information (PSI) available for re-use to foster new e-industries. Between these two extremes, there is likely to be scope for actions that build capacity and organisational thickness.
4. Are SDIs the appropriate infrastructural framework to support innovation, growth, and competitiveness in the e-economy? What are their costs and benefits? How to measure them?

Addressing the issues above requires a multi-national and multi-disciplinary research effort built around common methodologies and research paradigms to succeed. This needs time and joint effort as well as resources, but it is high time to start the discussion if we want to ground the e-economy and SDIs hype into measurable economic and social progress, and develop the evidence necessary to convince politicians, the markets, and society at large of the value of SDIs.

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