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¹What's Special about SDI Related Research?

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Abstract

Four challenging areas for SDI related research are discussed in this paper. These are SDI diffusion, SDI evolution, data sharing in SDIs and the hierarchy of SDIs. What's special about this kind of SDI related research, then, is the insights and understanding of the processes involved in SDI development that can be gained from examining critically with the help of conceptual frameworks and models that have been rigorously tested in other fields

Keywords: Spatial data infrastructures, Geographic information policies, Social science research

1. INTRODUCTION

From my own perspective as a social scientist with a longstanding interest in the political and institutional aspects of spatial data infrastructures I can easily think of four very good reasons why SDI related research needs special attention. Firstly, there is a need to study the processes of SDI diffusion and the social networks that facilitate them both between and within countries. Such studies not only map the spread of the SDI concept but also indicate the ways in which it has to be adapted to meet the demands of the national or local political and institutional context. For this reason there is a strong comparative dimension to SDI diffusion research. Secondly, given that the development of SDIs is a process rather than a product it will also be necessary to closely monitor the evolution of SDIs over time. The outcomes of such research will highlight changes in the political and institutional environment within which SDIs are developed and indicate the long term viability of the SDI concept in different environments. Thirdly, given the importance attached to data sharing for successful SDI development, it will be necessary to explore the motivations of those involved and also explore ways of facilitating the exchange and integration of geospatial information from a variety of sources. Finally, It must be recognised that SDI implementation takes place in a multi level environment and that it will

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be necessary to study hierarchies of SDIs with very large numbers of stakeholders. This research theme also raises important questions about the kind of models that are required for effective SDI governance.

SDI related research in each of these four areas should take advantage of related work in the social sciences. Research on SDI diffusion, for example, can draw upon the conceptual frameworks that have been developed in sociology and communications research. SDI evolution studies make use of the findings of research on management information systems development while the concepts such as actor network theory and of the theory of planned behaviour from social psychology provide useful insights into the circumstances that facilitate or inhibit data sharing. Similarly, hierarchical reasoning is a useful tool for understanding the forces underlying the nature of SDI implementation. What's special about this kind of SDI related research, then, is the insights and understanding of the processes involved in SDI development that can be gained from examining critically with the help of conceptual frameworks and models that have been rigorously tested in other fields

2. SDI DIFFUSION

It has been argued that more than half the world's countries claim that they are involved in some form of SDI development (Crompvoets et al 2004), but these claims need to be treated with some caution until they have been backed up by factual evidence as it is likely that there is an element of wishful thinking in some of them. The findings of the state of play studies carried out the Spatial Applications Division of the University of Leuven for the European Commission (SAD 2005), for example, suggest that only a handful of European countries have anything like a full blown SDI and most of these initiatives can better be described as 'SDI like or SDI supporting initiatives.' Furthermore, the fact that some countries have reported that they are engaged in some aspect of SDI development does not necessarily mean that this will translate into a fully operational SDI over time.

The most obvious SDI success story is in the establishment of clearinghouses and portals to disseminate metadata. The US Federal Geographic Data Committee's Clearinghouse registry, for example, lists nearly 300 registered nodes from the US and other countries (<http://registry.gsdi.org/serverstatus/>). Similarly, David Maguire and Paul Longley (2005) claim that there are on average 5622 user visits per week to the US Geospatial One-Stop portal site in April 2004. However, it is not enough to report that clearinghouses have been established without including some information on their usage and the arrangements that have been made for their continuing upgrading and maintenance. For example, the findings of a number of surveys carried out at different points in time by Joep Crompvoets and his colleagues (2004) suggest

that the use that is being made of some of these metadata services may be declining over time rather than increasing and that this is due to unsatisfactory arrangements for continuing site management.

While considering the extent to which the diffusion of innovations model is an appropriate one for the study of SDI diffusion it is worth noting that SDIs generally fit the definition of an innovation as 'an idea, practice, or object that is perceived as new by an individual or unit of adoption' (Rogers 1995,11). However, while the characteristics of the innovators, early adopters and early majority of SDIs show most of the features described by Everett Rogers, it will be interesting to see whether this is the case for the late majority and laggards.

It should also be noted that the diffusion of innovations model has been criticised for its pro innovation bias (Rogers 1993). This can be seen in the statements that are made in connection with SDI development which constantly stress its positive impacts in terms of promoting economic growth, better government and improved environmental sustainability. These and other similar claims need to be rigorously examined in further research.

In the process more attention should be given identifying possible negative impacts arising out of SDI development. A useful example of this kind of work can be found in the four brave new GIS worlds scenarios that were developed by Michael Wegener and Ian Masser (1996). Their trend, market, big brother and beyond GIS scenarios are easily translatable into the SDI field as can be seen from the Mapping Science Committee's Future of spatial data and society project (National Research Council 1997).

It is not always easy to define with any precision the moment in time when the idea was adopted. In some cases, there is a gradual transition from existing practices into a SDI. This happened, for example, in Australia and Finland where there was a tradition of SDI like thinking before the SDI itself formally came into being. In other cases the position is complicated by differences in the terminology that is used to describe SDI like activities. When, for example, does a national GI system become a SDI?

Some of these problems can be resolved by developing more systematic ways for describing and classifying SDIs. The typology developed by the Leuven group (SAD 2005) as a result of their EU wide state of play study is a step in the right direction, even though, in its current version, it gives rise to some ambiguities and overlaps in practice. However, this typology only takes account of the approach that has been adopted towards coordination and it may be worthwhile extending it to incorporate other variables.

Another matter that needs consideration in future SDI diffusion research is the extent to which cultural factors are likely to influence SDI adoption. An interesting example of this kind of research is Erik de Man's (2006) analysis of the role of culture in SDI development. This draws upon the four dimensional model developed by Geert Hofstede (1997). As a result of extensive empirical research Hofstede found that national cultures varied with respect to four main variables: power distance (from small to large), uncertainty avoidance (from weak to strong), masculinity versus femininity, and collectivism versus individualism. In a SDI environment De Man argues that cultures where there are large power distances are likely to use SDI to reinforce the hand of management whereas those with small power distances will welcome their data sharing and accountability properties. Similarly, masculine cultures will be interested in SDIs because of their capacity to contribute to the visible achievements whereas feminine cultures will welcome their networking and relationship building properties.

3. SDI EVOLUTION

The old adage that Rome wasn't built in a day is equally applicable to SDIs. The creation of SDIs is a long term task that may take years or even decades in some cases before they are fully operational. This process is likely to be an evolving one that will also reflect the extent to which the organisations that are involved reinvent themselves over time. Everett Rogers (1995, 16-7) defines reinvention as 'the degree to which an innovation is changed or modified by a user, in the process of its adoption and implementation.' He also notes that, while some innovations are difficult or impossible to reinvent, others are 'more flexible in nature, and they are reinvented by many adopters who implement them in different ways.' The degree of reinvention involved in GIS implementation in British local government led Heather Campbell and Ian Masser (1995, 109-110) to conclude that 'the meaning of a technology such as GIS was constantly being reinvented at both the organisational and individual scales. This has important implications for studies of diffusion as it would appear that innovations such as GIS embrace a wide range of perceptions. These differences in emphasis are likely to lead to tensions and problems which will complicate the implementation process. It is also likely that such systems will be used to undertake activities not originally anticipated by their inventors.'

There are clear parallels between these findings and SDI evolution. Given that SDI implementation is likely to take place over a long period of time when the technologies are also changing, together with the external political and institutional circumstances that surround a SDI, it may be necessary to distinguish between two levels of reinvention in this case. The first of these concerns the processes needed to initially adapt the notion of a SDI to the local or national context to take account, for example, of the impacts that the allocation

of administrative responsibilities and the style of government will have on the form of SDI development in each case. The second relates to processes that are involved in its evolution over time in response to changing political, institutional and technological circumstances.

Given the extent to which SDIs can be expected to change over time it will be necessary to set up research procedures to ensure that their progress is systematically monitored. Longitudinal studies will form an important part of this research strategy. To facilitate research of this kind it will also be necessary to ensure that key documents are not lost when they become out of date. This is particularly a problem in SDI research which relies to a great extent on grey literature in the form of unpublished reports and memoranda. As a result it is heavily dependent on materials obtained from web sites that are also changing constantly over time. This is already a matter of concern in some countries and the author's analysis of the UK NGDF experience (Masser 2005, chapter 4) was made more difficult by the fact that many key documents are no longer readily available following the closure of the NGDF website in 2001.

Yola Georgiadou and her colleagues (2005) also argue that more attention needs to be given to the infrastructure dimension of SDIs in future research. Their work on the Indian SDI makes use of three key concepts identified in previous work on information infrastructures: the installed base, reflexive standardisation and a cultivation approach to design. The concept of the installed base and its associated lock in effects describes the extent to which the existing structures influence the design of SDIs. Reflexive standardisation refers to the self reinforcing mechanisms involved in the standardisation process whereby the adoption of standards raises the need for further standards as more users and technologies are incorporated into the network. The cultivation approach to SDI design emphasises the improvisational dimensions of SDI design. In this respect SDI design is not seen as a well defined process with clearly identifiable start and end states but rather as a process of ecological change reflecting the designer's inability to fully anticipate future events.

It is also worth noting that several studies have recently been undertaken to assess SDI readiness and maturity. For example, Tatiana Delgado and her colleagues (2005) proposed a SDI readiness index combines organisational factors, information awareness, and access networks together with human and financial resources. The model used to assess SDI readiness in Cuba is based on fuzzy logic given the qualitative nature of most of the variables. Similarly, the SDI maturity matrices devised by Bastiaan Van Loenen (2006) identify four stages through which organisations develop from a stand alone solution into a networked SDI structure.

4. DATA SHARING IN SDIs

Data sharing featured prominently in the initial discussions about SDIs. The US Mapping Science Committee's landmark report, 'Towards a coordinated spatial data infrastructure for the nation,' devoted a whole chapter to the sharing of spatial data. The rationale for a spatial data sharing programme is 'to increase benefits to society arising from the availability of spatial data. The benefits will accrue through the reduction of duplication of effort in collecting and maintaining of spatial data as well as through the increased use of this potentially valuable information.' (National Research Council, 1993, 89) It also argued that this programme 'must do more than just disseminate spatial data collected by federal agencies. The richness and utility of the program is substantially enhanced by having participation of donors from state and local governments, academic, and the private sector.'(p.104). With this in mind the Committee recommended that the 'FGDC should establish a data sharing committee with the objective of providing the policy making and leadership to launch, maintain, and operate the proposed program' (p.104).

These proposals do not fully take account of the complexity of data sharing in practice. The intricate nature of the relationships involved in organisational and inter organisational data sharing and the legal, economic, cultural and personal privacy related issues associated with these activities were highlighted in the report of an expert meeting convened by the US National Centre for Geographic Information and Analysis. The editors of this report, Harlan Onsrud and Gerard Rushton (1995), define the issues involved in the following terms: 'Sharing of geographic information involves more than a simple data exchange. To facilitate sharing, the GIS research and user communities must deal with both the technical and institutional aspects of collecting, structuring, analysing, presenting, disseminating, integrating and maintaining spatial data.'

Uta Wehn de Montalvo (2003) has subsequently explored spatial data sharing perceptions and practices in South Africa in some depth from a social psychological perspective. This study utilises the theory of planned behaviour. This theory suggests that personal and organisational willingness to share data depends on attitudes to data sharing, social pressures to engage or not engage and perceived control over data sharing activities of key individuals within organisations. The findings of her quantitative analysis generally bear out the relationships postulated in this theory and give valuable insights into the factors that determine the willingness to share spatial data. They also show that there was only a relatively limited commitment amongst those involved to promote data sharing in high profile initiatives such as the South African national SDI whose successful implementation is dependent on a high level of spatial data sharing.

For this reason there is a pressing need for more research on the nature of data sharing in a multi level SDI environment. The studies that have been carried out by Zorica Nedovic-Budic and Jeffery Pinto (1999) and Nedovic-Budic et al (2004) in the US provide a useful starting point for work in other parts of the world. The earlier study focuses mainly on the motivations for data sharing, the coordination process and the costs of coordination whereas the more recent analysis of the responses of 245 respondents to a survey questionnaire provides some interesting quantitative indicators of the interactions mechanisms involved and the motivations of the respondents. Similarly, the findings of Francis Harvey and David Tulloch's (2004) survey of local governments in the US suggest that many local authorities remain largely unaware of SDI concepts and assess the benefits of sharing information in a limited time frame with an emphasis on supporting existing administrative and political relationships. In an earlier Harvey (2001) also makes use of actor network theory to explore the socio technical context of data sharing. Kevin McDougall and his colleagues' (2005) study of the experiences of local government in three Australian states describes the extent to which the technical and physical capacity of smaller jurisdictions can impact on their ability to participate in with larger and better resourced authorities. In a different vein William Craig (2005) highlights the extent that the motivation of key individuals can influence data sharing. The findings of his research suggest that their efforts are motivated largely by idealism, enlightened self interest and involvement in particular professional cultures.

5. THE HIERARCHY OF SDIs

Some of the most challenging research questions are posed by the scale for multilevel stakeholder participation in SDI implementation. The numbers of stakeholders in large countries such as the US are massive given that more than 100,000 public bodies alone are involved in some way. This task is made even more difficult by a governance model that is based largely on consensus building and the extent to which coordination bodies such as the Federal Geographic Data Committee in the US and the Australia New Zealand Land Information Council in Australia lack the powers to enforce their strategies or to impose sanctions on unwilling participants.

It must also be recognised that the vision of a bottom up SDI associated with multi level stakeholder participation differs markedly from the top down one that is implicit in much of the SDI literature. While the top down vision emphasises the need for standardisation and uniformity the bottom up vision stresses the importance of diversity and heterogeneity given the very different aspirations of the various stakeholders and the resources that are at their disposal. Consequently the challenge to those involved in SDI implementation is to find ways of ensuring some measure of standardisation and uniformity while

recognising the diversity and the heterogeneity of the different stakeholders. This will involve a sustained mutual learning process on the part of all those involved in SDI implementation.

For this reason it may be worthwhile exploring hierarchy theory in greater depth in the context of SDI development. Abbas Rajabifard (2002), for example, has made use of hierarchical reasoning in his work on SDI structures. He has also identified three properties of hierarchies that give some useful insights into these structures:

- the part - whole property which describes the degree to which higher level entities can be subdivided into lower level parts,
- the Janus effect which relates to the relationships that an element has with the levels above and below it, and
- the near decomposability property which describes the nesting of systems within larger systems and the extent to which the interactions between the different systems decrease in strength with the distance between them.

It is also important to bear in mind that different levels of the SDI hierarchy perform different tasks. The role of bodies at the continental and global levels is primarily to foster SDI development by disseminating information about current developments and best practices to the levels below them whereas local SDIs are primarily concerned with the operational needs of day to day decision making. Despite these differences all levels of the hierarchy are involved to some extent in the dissemination of information between the various levels. National level bodies perform a similar task with respect down to sub national and upwards while regional bodies and state level bodies do the same with respect to local ones.

6. CONCLUSIONS

Four challenging areas for SDI related research have been discussed in this paper. These are SDI diffusion, SDI evolution, data sharing in SDIs and the hierarchy of SDIs. The most important conclusion to be drawn from this analysis is that SDIs must be viewed as social phenomena. Consequently there is a continuing need for interaction between those involved in the critical study of SDIs and scholars who are familiar with mainstream social science research.

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REFERENCES

- Campbell, H. and I. Masser (1995). *GIS and organisations: how effective are GIS in practice?* London: Taylor & Francis.
- Craig, W. (2006) White knights of spatial data infrastructures: the role and motivation of key individuals, *URISA Journal*, 16(2): 5-12.
- Crompvoets, J., A. Rajabifard, A. Bregt and I. Williamson (2004). Assessing the worldwide developments of national spatial data clearinghouses, *International Journal of Geographical Information Sciences*, 18: 1-25.
- De Man, E. (2006). Understanding SDI: complexity and institutionalisation, *International Journal of Geographical Information Sciences*, 20: 329-340.
- Delgado, T., K. Lance, M. Buck and H. J. Onsrud (2005). "Assessing an SDI readiness index", *Proceedings GSDI 8*, Cairo, Egypt, http://gsdidocs.org/gsdiconf/GSDI-8/papers/ts_36/ts36_03_delgado_etal.pdf [accessed 5/8/2006].
- Georgiadou, Y., S. Puri and S. Sahay (2005). Towards a research agenda to guide the implementation of spatial data infrastructures: a case study from India, *International Journal of Geographical Information Sciences*, 19: 1113-1130.
- Harvey, F and D. Tulloch (2004). "How do governments share and coordinate geographic information issues in the United States", *Proceedings 10th EC & GIS workshop*, Warsaw, Poland, http://www.ec-gis.org/Workshops/10ec-gis/papers/25june_harvey.pdf [accessed 5/8/2006].
- Harvey, F. (2001). Constructing GIS: actor networks of collaboration, *URISA Journal*, 13(1): 29-37.
- Hofstede, G. (1997). *Cultures and organisations: software of the mind*, Beverley Hills: Sage Publications.
- Maguire, D. and P. A. Longley (2005). The emergence of geoportals and their role in spatial data infrastructures, *Computers Environment and Urban Systems*, 29: 3-14.
- Masser, I. (2005). *GIS worlds: creating spatial data infrastructures*, Redlands: ESRI Press.
- McDougall, K., A. Rajabifard and I. Williamson (2005). "Understanding the motivations and capacity for SDI development from the local level", *Proceedings GSDI 8*, Cairo, Egypt. http://gsdidocs.org/gsdiconf/GSDI-8/papers/ts_50/ts50_04_mcdougall_etal.pdf [accessed 5/8/2006].

- National Research Council (1993). *Towards a spatial data infrastructure for the nation*, Mapping Science Committee, National Research Council, Washington D.C: National Academy Press.
- National Research Council (1997). *The future of spatial data and society*, Mapping Science Committee, National Research Council, Washington D.C: National Academy Press.
- Nedovic-Budic, Z. and J. K. Pinto (1999). Understanding interorganisational GIS activities: a conceptual framework, *URISA Journal*, 11(1), 53-64.
- Nedovic-Budic, Z., J. K. Pinto and L. Warnecke (2004). GIS database development and exchange: interaction mechanisms and motivations, *URISA Journal*, 16(1): 15-29.
- Rajabifard, A., M.E. Feeney, I. Williamson and I. Masser (2003). "National spatial data infrastructures", in Williamson I., Rajabifard A., and M. E. Feeney, (Eds.), *Development of Spatial Data Infrastructures: from Concept to Reality*, London: Taylor & Francis. pp.95-109.
- Rogers, E. (1993). "The diffusion of innovations model", in Masser I. and H. J. Onsrud (Eds.) *Diffusion and use of geographic information technologies*, Dordrecht: Kluwer. pp. 9-24.
- Rogers, E. (1995). *Diffusion of innovations*, Fourth edition, New York: Free Press.
- Spatial Applications Division, Catholic University of Leuven (2005). *Spatial data infrastructures in Europe: state of play spring 2005*. http://inspire.jrc.it/state_of_play.cfm [last accessed 24/5/2006].
- Van Loenen, B. (2006). *Developing geographic information infrastructures: the role of information policies*, Delft: Delft University Press.
- Wegener, M. and I. Masser (1996). "Brave new GIS worlds", in Masser I., Craglia M. and H. Campbell (Eds.) *GIS diffusion: the adoption and use of geographical information systems in local government in Europe*, London: Taylor and Francis. pp. 9-21.
- Wehn de Montalvo, U. (2003). *Mapping the determinants of spatial data sharing*, Aldershot: Ashgate.