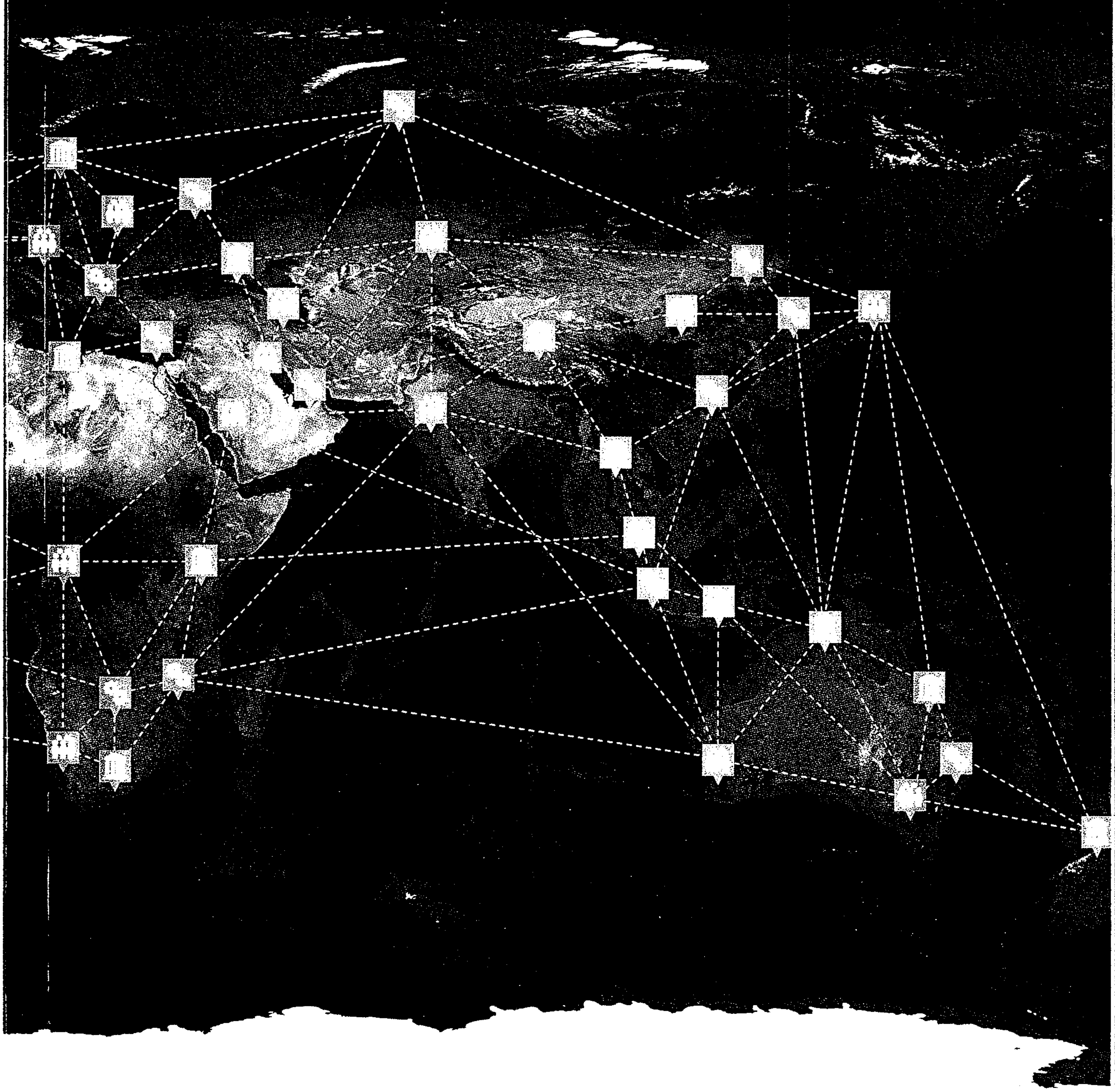
SPATIALLY ENABLING

GOVERNMENT, INDUSTRY AND CITIZENS

RESEARCH AND DEVELOPMENT PERSPECTIVES



EDITORS ABBAS RAJABIFARD & DAVID COLEMAN

GSDI ASSOCIATION PRESS

SPATIALLY ENABLING GOVERNMENT, INDUSTRY AND CITIZENS

RESEARCH AND DEVELOPMENT PERSPECTIVES

EDITED BY
ABBAS RAJABIFARD and DAVID COLEMAN

GSDI ASSOCIATION PRESS

Spatially Enabling Government, Industry and Citizens

Abbas Rajabifard and David Coleman (Editors)

ISBN 978-0-9852444-0-8
D/978-0-9852444-1-5

Cover design by Steven Bunton Design
Printed in Canada

Table of Content

About Editors

Abbas Rajabifard is a Professor and Head of Department of Infrastructure Engineering and Director of the Centre for SDIs and Land Administration at the University of Melbourne. He is President of the Global Spatial Data Infrastructure (GSDI) Association and a member of Victorian Spatial Council (VSC). He was Vice Chair, Spatially Enabled Government Working Group of the UN supported Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP). Abbas has authored/co-authored over 230 publications including 5 books. He has been also consulted widely on spatial data management, SDI, land administration and spatial enablement, to many national government agencies and ministries.

David Coleman is a Dean of Engineering and a Professor of Geomatics Engineering at the University of New Brunswick. Prior to obtaining his PhD, he spent 15 years in the Canadian geomatics industry - first as a project surveyor and engineer, then a general manager and vice-president with one of Canada's largest digital mapping firms, and later as an owner and partner in a GIS and land information management consulting firm. David has authored over 150 publications and reports dealing with land information policy development, geomatics operations management, geographic information standards and spatial data infrastructure. He is a Fellow of the Canadian Academy of Engineering, a member of two Boards of Directors, three federal government advisory boards, and has acted as a consultant on projects in Canada, Australia, the United Kingdom and South America.

Peer Review Board

Foreword

This book is the result of a collaborative initiative of the Global Spatial Data Infrastructure Association (GSDI), the Centre for SDIs and Land Administration (CSDILA) in the Department of Infrastructure Engineering at the University of Melbourne, and the Geographical Engineering Group in the Department of Geodesy and Geomatics Engineering at the University of New Brunswick. In addition to the traditional Call for Papers for the GSDI 13 Global Geospatial Conference: "Spatially Enabling Government, Industry and Citizens", contributions of full articles were solicited for publication in this peer reviewed book.

The authors and reviewers were advised of the conference theme in advance and, in most cases, the addressed this theme in their papers. Even in cases where the theme was not directly referenced, the article reflected the impact and application of the spatial data infrastructures that are now being developed world-wide. The peer-review process resulted in 14 chapters that together reflect how SDIs are enabling us all today. We thank the authors of the chapters and the members of the Peer Review Board.

We are grateful to the GSDI Association Press for its willingness to publish this work under a Creative Common Attribution 3.0 License. It allows all to use the experiences and research presented in this book to their own best advantage.

We especially thank the sponsors of this book. We would also like to thank Dr Sheelan Vaez and Dr Malcolm Park for their editorial assistance in preparation of this publication.

Abbas Rajabifard, *President*
David Coleman, *President-elect*
GSDI Association

Spatially Enablement of NRM Communities through Spatial Knowledge and Information Network Development

Dev Raj Paudyal, Kevin McDougall and Armando Apan

Faculty of Engineering and Surveying
Australian Centre for Sustainable Catchments
University of Southern Queensland, Australia

paudyal@usq.edu.au; mcdougak@usq.edu.au; apana@usq.edu.au

Abstract

A spatially enabled society (SES) is an emerging concept to make spatial information accessible and available for the benefit of society. It is a concept where location, place and other spatial information are available to government, community and citizens. This is an important extension to the generational development and progression of Spatial Data Infrastructure (SDI) as it seeks to contribute to wider societal benefits and sustainable development objectives. This research paper investigates the social dimension of SDI and the theoretical foundation for spatially enablement of catchment communities. Two social science theories, namely, actor network theory (ANT) and social network theory are utilized to better understand the relationships in spatial information sharing and knowledge sharing across catchments. A network perspective of SDI was explored through a case study of the Queensland Knowledge and Information Network (KIN) project. Spatial information sharing processes among regional Natural Resource Management (NRM) bodies were analyzed using an object oriented modelling technique to assess the impact on catchment management outcomes. The relationships among the knowledge network stakeholders and the influence of these relationships to spatial information and knowledge sharing was analyzed using social network analysis. The findings from this study suggest that a network perspective of SDI assists in understanding the spatial information management issues of catchment management and the broader goal of spatially enablement of society.

KEYWORDS: Spatial data infrastructure, spatial information sharing, catchment management, spatially enabled society, social network analysis

1. Introduct

Spatial data infrastructure (SDI) and spatial technologies are now used routinely in decision making to address some of the world's most pressing societal problems. SDI is now recognized by many countries as an essential modern infrastructure such as information communication technology (ICT), electricity or transportation (Ryttersgaard, 2001; Williamson *et al.,* 2003). SDI application areas and custodianship of spatial information are changing with the emerging technologies and the societal needs. However, the overall objective of SDIs is it's economic, social, and environmental benefits to society with the emerging application areas now also becoming part of the solution (Masser, 2011). The creation of economic wealth, social stability and environmental protection can be facilitated through the development of products and services based on spatial information collected by all levels of society including governments, private sector and citizens (Rajabifard *et al.,* 2010). These objectives can be realized through the development of a spatially enabled community, government and society.

Spatial enablement requires data and services to be accessible and accurate, well-maintained and sufficiently reliable for use by the majority of society which may not be spatially aware (Williamson *et al.,* 2010). Traditionally, the mapping and spatial data infrastructure development was accomplished by government agencies, particularly national/state mapping agencies. However, this is now not the case, with all sectors of society increasingly becoming spatially enabled and contributing to the development of SDI. The readily accessible and available spatial products such as Google Earth, hand-held navigation systems (Including smart phones, GPS, etc.), web 2.0 technology, and social media has opened the way for spatial data collection and management and is contributing towards the next generation of SDI development and a spatially enabled society.

Within the SDI community there are differences in the understanding of SDI and its potential benefits (Grus *et al.,* 2007). Current progress of SDI initiatives shows that SDI is viewed, defined and interpreted differently by different practitioners. However, SDI has a common intent; to create an environment in which all stakeholders can cooperate with each other and interact with technology to better achieve their objectives at different political/administrative levels (Rajabifard *et al.,* 2003). SDI is about the facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial data community. Traditionally, SDIs were considered in a hierarchical context in which high levels of SDI (global, regional, national) built upon lower levels (regional, local) (Rajabifard *et al.,* 2003). The concept came with the top-down government approach where the custodians of spatial data were the mapping agencies which led the building of SDI. Now, the concept of more open and inclusive SDIs is emerging, where users play a vital role in spatial information management and SDI development (Budhathoki *et al.,* 2008; Paudyal *et al.,* 2009). The custodianship of spatial data is also no longer totally controlled by mapping agencies.

The hierarchical concept of SDI is now also being challenged and may not be an appropriate model where all sectors of society are contributing for SDI design and development. The social network analysis by Omran and Van Etten (2007) revealed that a hierarchical structure could put serious constraints on spatial data sharing where providers and users are contributing for SDI development. Another approach is to view and examine SDIs from a network perspective. SDI practitioners (Crompvoets *et al.,* 2010; Omran, 2007; van Oort *et al.,* 2010; Vancauwenberghe *et al.*, 2009; Vancauwenberghe *et al.,* 2011) have examined SDI from network perspectives. Table 1 summarizes the main contributors of network perspective of SDI and their findings.

Contributors	**Study focus**	**Strength**	**Limitations**
Omran and van Etten (2007)	Examined motivations for spatial data sharing from network topology perspectives	The collective properties of spatial data sharing in organizations was investigated using social network analysis	Complex interactions that exist between information type, network structure, and individual behaviour, were not explored
van Oort *et al*. (2010)	Examined how the network can be used for sharing of metadata, requests for help, feedback on product quality, innovative ideas, and so on	The findings contributed to methodological research on monitoring SDI programmes	Only three categories of linkages between users were studied
Vancauwen-berghe *et al.* (2011)	Investigated SDI as the collection of arrangements that give shape to a network of spatial data exchanges	Social network analysis was used to explore hierarchical characteristics of the Flemish SDI	Study was only focused on four types of spatial data exchanges in formal arrangements

Table 1. Main contributors of network perspective of SDI

Onsrud (2011) defined SDI as a network-based solution to provide easy, consistent, and effective access to geographic information and services to improve decision making in the real world in which we live and interact. However, the principal objective of SDI has not changed. It is to facilitate access to the geographic information assets that are held by a wide range of stakeholders with a view to maximising their overall usage (Masser, 2011). Existing studies on network perspective of SDI have focussed on the spatially enablement of government agencies have only partially explored the user’s perspective. However, this research examines the spatially enablement of catchment communities with a particular emphasis on the user's perespectives.

The aim of this chapter is to explore the social dimension of spatial data infrastructure and its theoretical foundation from a network perspective in a catchment management context. This concept is examined through a case study of the Queensland Knowledge and Information Network (KIN) project. Two research approaches, namely, business process analysis and social network analysis are utilized to explore the spatially enablement of catchment communities and examine catchment SDI through these network perspectives.

2. Theoretical Framework: Social Science Theories

There are many social theories which can contribute to spatial data infrastructure design and development including actor-network theory (Harvey, 2001); the theory of planned behaviour (Wehn de Montalvo, 2003); social learning process (Rodriguez-Pabon, 2005) as cited in (Masser, 2011) and social network theory (Vancauwenberghe *et al.,* 2011). In the following sections, two social theories relevant to the network perspective of SDI development and useful to contributing to spatially enabled society are explored.

2.1 ANT and SDI Networking

Actor-network theory (ANT) is a social theory, also known as the sociology of translation, which emerged during the mid-1980s, primarily with the work of Bruno Latour (1987), Michel Callon (1986), and John Law (1992). ANT is a conceptual framework for investigating society-technology interactions and its primary building blocks which are interactions between actors. It considers the whole world as patterned networks of heterogeneous entities containing both human and non-human elements. Harvey (2001) defined actor networks as "the traces of relationships between people, institutions, and artefacts connected by agreements and exchanges". Shi (2008) has used ANT for analysing and understanding the social and technical nature of the watershed management process and decision tools.

The relevance of ANT theory for SDI development and GIS projects has been explored by a number of authors (Crompvoets *et al.,* 2010; De Man, 2006; Harvey, 2000; Harvey, 2001; Reeve and Petch, 1999). Reeve and Petch (1999) argue that the success of GIS projects depends upon the consideration of socio-organizational contexts i.e. actor-network theory. Harvey (2001) puts the actor-network of the professional GIS-user at the centre of the technology proliferation process. His approach incorporates all network activities, including the technological ones. Based on research in Switzerland, he asserts that actor networks and technology (GIS technology in this case) affect one another. Data exchange stimulates the emergence of effective inter-organizational de facto standards and assists in maintaining actor networks, while prescribed standards do not work and will consequently not have an impact.

De Man (2006) argues that the process of developing networked assemblies is viewed by ANT as interplay between heterogeneous actors-technological and social elements tied together in actor-networks. The actor-network perspective views SDIs as resulting from continuous 'translations' between heterogeneous actors and, hence, as potentially unstable. Alliances may be locked into collaboration but generally only temporarily. He concludes that the actor-network perspective identifies the dilemma of how to navigate between the need for authority and some form of central control, and active involvement (participation) in developing SDI initiatives. Crompvoets (2010) argued that spatial data infrastructure is a complex actor-network and the value of spatial data can be added through complex value added network processes. Their value is added through the translations between the different actors. Therefore, the value of spatial data can be assessed realistically only when the interests, beliefs and values of the individual actors are taken into account. This theory can be useful for spatially enablement of community, government and society.

2.2 Social Network Theory and VGI

The social network theory is a social science concept that discusses the connection and relationship in a social structure (Kadushin, 2004). According to Brass (1992), a social network is a set of nodes or actors that are connected by a set of social relationships. It views social relationships in terms of nodes and ties. Nodes are the individual actors within the networks, and ties are the relationships between the actors. The actors can be all types of social entities, for example, individuals, groups, organizations, or nation-states (Wasserman and Faust, 2008). The outputs from social network analysis can be presented in a graphical or mathematical way (Keast and Brown, 2005). Graphical analyzes concern the map of all of the relevant ties between the nodes and are often displayed in a social network diagram, where nodes are the points and ties are the lines. Mathematical analyzes involve advanced calculations (measure of centrality and density of network or actors) and statistical analysis of the data.

Social network theory is being increasingly utilized for spatial data sharing and SDI related research. Omran (2007) used social network theory and social network analysis to explain spatial data sharing (SDS) behaviour. He used social network analysis to map organizational networks and to determine the actual SDS behaviour. His study was directed at understanding motivations for data sharing and how this was related to network topology. Van Oort *et al.* (2010) utilized social network analysis to study spatial data sharing across organizational boundaries. This study was focused on how the network can be used for the purpose of sharing of metadata, requests for help, feedback on product quality, innovative ideas, and so on. Vancauwenberghe *et al.* (2011) argued that SDI can be viewed from network perspective and social network analysis can be used as a method for SDI research. The case consisted of a sub-national SDI in Flanders and used social network analysis to analyze Flemish spatial data exchange network.

A number of authors (Coleman, 2010; Elwood, 2008b; Goodchild, 2007, 2008; Kuhn 2007; McDougall, 2010) have begun to explore the application of social networking theory to volunteered geographical information (VGI) and spatial information sharing. The term VGI was first used by Michael Goodchild to describe the diverse practices of observing, collecting and producing geographic information by citizens with no formal expertise in the area (Goodchild, 2007). The first research specialist meeting on VGI was organized under the auspices of NCGIA, Los Alamos National Laboratory, the Army Research Office and The Vespucci Initiative and brought researchers around the globe to discuss potential of VGI for spatial information management. Coleman (2010) explored how the concept of VGI fitted within SDI. The utilization of VGI for spatial information collection and updating is now widely used by OpenStreetMap, TeleAtlas, NAVTEQ and Google Maps. Government organizations have now also realized the power of VGI and crowd sourcing and are interested in utilising these technologies for SDI development. The U.S. Geological Survey was an early examiner of this technology. State governments in Victoria (Australia) and North-Rhine Westphalia (Germany) are two exemples of employing volunteered input to their mapping programs in the government sector (Coleman, 2010).

Table 2 summarizes the characteristics, strengths, and limitations of these two social theories and their possible contribution to spatially enabled society.

Social Theory	**Characteristics**	**Strengths**	**Limitations**	**Value for spatial enabled society**
Actor network theory (ANT)	Investigates society-technology interactions	Understanding of the social and technical nature of SDI	Views SDIs as resulting from continuous translations between actors	Useful for spatial enablement development
Social Network Theory	Discusses the connection and relationship in a social structure	Views the network perspectives of SDI	More social bias and sometimes delayed the implementation	Useful for VGI and spatial information sharing

Table 2. Social science theories and their contribution to spatial enabled society

2.3 Social Network Analysis

Social Network Analysis (SNA) is a research methodology that focuses on identification of relationships between and among social entities, and on the patterns and implications of these relationships (Scott, 2000). It is often applied to understand network structures and identify operational efficiencies. There is a body of literature on quantitative methods in social network analysis (Hanneman and Riddle, 2005; Wasserman and Faust, 2008).

Social networks relations can be analyzed for structural patterns that emerge among actors. Thus, an analyst of social networks looks beyond attributes of individuals to also examine the relations among actors, how actors are positioned within a network, and how relations are structured into overall network patterns (Scott, 2000; Wasserman and Faust, 1994). The ties are based on conversation, affection, friendship, kinship, authority, economic exchange, information exchange, or anything else that forms the basis of a relationship. In a network, flows between objects and actors and exchanges, which might contain an advice, information, friendship, career or emotional support, motivation, and cooperation, can lead to very important ties (Kadushin, 2004).

There are various types of relationships which exist as suggested by Knoke and Kuklinski (1982) including communication relations, boundary penetration relations, instrumental relations, sentiment relations, authority/power relations, kinship and descent relations. In social network analysis, a number of measures have been defined to quantify and classify these relationships. Terms such as centrality, closeness, betweenness and degreeness have been developed to better describe these relationships (Freeman, 1979). These measures can assist in defining where an actor sits within a network, where weak links exist or understanding the level of trust that may be associated with a particular actor. These measures may be used to determine if a user will share or diffuse their information or be willing to grant access to their information (McDougall, 2010). The concept of centrality is widely used in the resource management (Bodin *et al.,* 2006) and network analysis (Vandenbroucke *et al.,* 2009).

3. Methods

In this paper, two analysis techniques have been utilized. First, business process analysis using object-oriented modelling techniques was undertaken on the information sharing process within the knowledge network study. Secondly, social network analysis was used to analyze the network perspectives of various actors within the management of catchment spatial data infrastructure.

3.1 Study Area Description and Institutional Arrangement

The case study location of the Knowledge and Information Network (KIN) project is the State of Queensland, Australia (Figure 1). Queensland has 14 regional natural resource management (NRM) bodies spread from the far-northern region of Torres Strait to the New South Wales (NSW) border at southern end. These groups develop regional NRM plans and deliver sustainable catchment outcomes at grass-roots level.

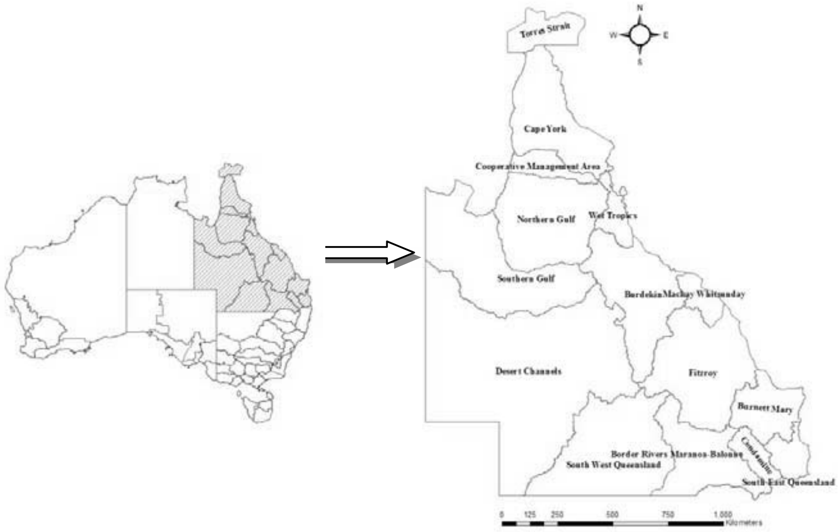


Figure 1. Location Map of KIN Project Areas

The Queensland Regional Groups Collective (RGC) is the lead body for regional NRM bodies in Queensland and represents the interests with the 14 regional natural resource management (NRM) bodies in the state. It is quite a young organization formed in 2002 and is dedicated to improving statewide NRM outcomes. The overall aim of the KIN project was to understand how regional NRM knowledge and spatial information can be better shared across Queensland. The funding for this project was supported by both commonwealth and state governments. The main stakeholders of KIN project were RGC, regional NRM bodies and Department of Environment and Resource Management (DERM) as shown in Figure 2. The project was managed by RGC and four knowledge coordinators. DERM was the state agency responsible for funding support and overall coordination. Apart from these organizations/professionals, there were about 300 landcare groups which were not directly involved in KIN project, however regional NRM bodies also shared spatial information with these groups. The landcare groups often create spatial data for their own use by utilising both government data (authoritative data) and freely accessible spatial products (e.g. Google Map) for grass-root level catchment management activities.

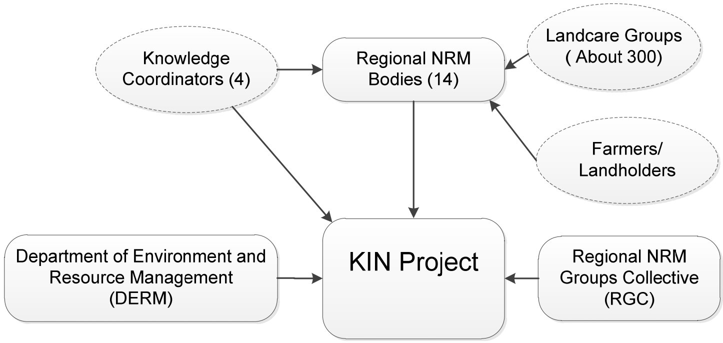


Figure 2. Institutional Settings

3.2 Business Process Analysis of the Spatial Information Sharing in the KIN Project

Both primary as well as secondary data were collected in order to investigate spatial information sharing between regional NRM bodies and state government organization (DERM). Existing project documents/reports, data share agreements and published papers were collected and studied to understand the current spatial information sharing processes. Semi-structured interviews were conducted with all 14 regional NRM bodies, state government representatives and RGC staff. Both telephone and face-to-face interviews were conducted. The staff involved in KIN project who were experienced in spatial and knowledge management activities were interviewed.

The unified modelling language (UML) which is based on the object oriented (OO) concept and standardized by the object management group (OMG) was used to understand the spatial information sharing process. The unified modelling language (UML) is a modelling tool for specifying, visualizing, constructing, and documenting the artefacts of a system-intensive process (Radwan *et al.* 2001). An UML use-case diagram was used to explore and demonstrate the spatial information sharing process. Basically, the use-case identifies the actors and activities which consist of three elements: the actors, use-cases and the system boundaries. In UML, the relationships between actors and use-cases can be shown using the concepts such as generalization, ‘uses’ and ‘extents’. Six main actors and nine use-cases were identified for spatial information sharing process and the use-case analysis of spatial information sharing.

The characteristics and business process analysis of the spatial information sharing in the KIN project is presented in section 4.1.

3.3 Social Network Analysis of KIN Project

The primary reason for undertaking the social network analysis was to measure the variety of relationships between KIN project stakeholders. The targeted population for this network analysis was 18 stakeholders consisting of six categories of organizations/professionals including DERM, RGC, regional NRM bodies, landcare groups, landholders/farmers, and knowledge coordinators. An online questionnaire was constructed and questions were framed in order to specifically target and measure responses regarding other stakeholders. The questionnaires were distributed to a non-random and purposive sample of representatives from regional NRM bodies, DERM and RGC. Three questions were asked to quantify the frequency of interaction, exchange of spatial information, and role of organization to achieve KIN goal.

Data were analyzed using UCINET 6 and NetDraw 2.11 programmes. Initially the data was analyzed using the UCINET programme and visualized through NetDraw programme. The value of InDegree centrality was used to measure the relationships between project participants. Three variables which were used for this analysis were frequency of interaction, rate of flow of spatial information and role of organization (see Table 3).

Level of Analysis	Measure	Relationship	Variable used
Network Analysis	InDegree Centrality	Communication relationship	Frequency of Interaction
	InDegree Centrality	Transactional relationship	Rate of flow of spatial information
	InDegree Centrality	Authority-power relationships	Role of organization

Table 3. Measures, relationship and variables used for social network analysis

The organizations were differentiated by different node shapes and node position, node size and line width was used to show the interaction between organizations in the network analysis. The results from social network analysis of KIN project is described in section 4.2

4. Results

4.1 Characteristics and Business Process Analysis of the Spatial Information Sharing in the KIN Project

Prior to the KIN project, the NRM data hub scoping project was conducted for Queensland's NRM science panel to identify the characteristics of data sharing between regional NRM bodies and state government organizations (Jones and Norman, 2008). These characteristics were also confirmed during the interview process. It was confirmed that the key characteristics of spatial information sharing with respect to NRM community were:

- **Current data sharing is not an organizational priority**: In the current NRM business environment, it was not in the interest of individual organizations to share data and information, even though it was in the collective interest.

- **Sharing led by dedicated sections**: Data sharing was mostly led by organizations with dedicated sections funded and resourced to share information.

- **Lack of metadata**: People do not know what information and data exists including within their own organization. Significant amounts of unpublished or uncatalogued spatial data exist with regional NRM bodies.

- **Willing to share but lack of trust**: People were willing to share data/information when asked, but didn't promote the fact that they have information available. They fear that if they put landholder's information in the public domain that it might be misused.

- **Data sharing through personal contact**: Where sharing occurred it was done on a person-to-person and immediate need basis. Much sharing was conducted via personal contacts rather than organizational processes.

- **Institutional issues are more complex than technical ones**: Many IT solutions have been developed to solve data sharing problems; however, most have not demonstrated long-term success or realized their potential. These normally require or assume that people will willingly format and package data sets for sharing with others, and then maintain those data or information sets in a suitable format.

- **No incentive for sharing**: The cost of data sharing is being rationally avoided by publishers of information.

- **Data sharing benefits are known:** The benefits of data sharing and its reduction of costs are desired by all NRM organizations.

The spatial information sharing characteristics demonstrated that the main concerns were related to the institutional and cultural areas of data sharing and not the technical areas such as the actual data hub portal. The study identified the importance of improving the institutional and cultural part of the data sharing mechanism. The KIN project was initiated to improve access and sharing of NRM information between regional NRM bodies and DERM. A single licensing agreement was made between RGC and DERM which covered the interest of all 14 regional NRM bodies. A framework was endorsed by RGC and the project is in the implementation phase. Six main actors and nine use-cases were identified for spatial information sharing process and spatially enablement of catchment communities via the modelling using object oriented use-case process. As shown in Figure 3, six actors are interacting with nine use-cases in a system whose system boundary is defined by the 'Spatial Information Sharing Process'.

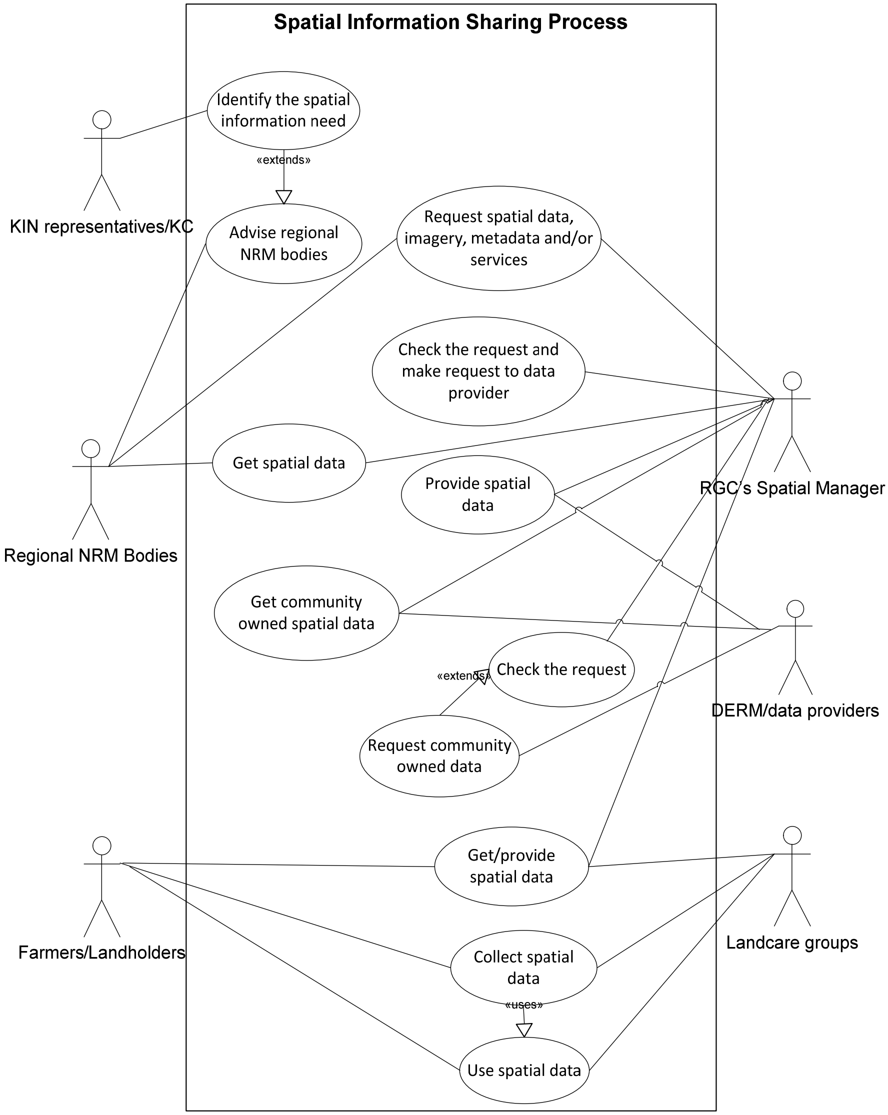


Figure 3. Use-case diagram of spatial information sharing process

The six main actors and spatial information sharing process include:

- **KIN representative/knowledge coordinators**: The KIN representative or knowledge coordinators (KC) identify the spatial information needs for catchment management and advise regional NRM bodies to make requests for the particular spatial information.

- **Regional NRM Bodies:** Regional NRM Bodies request spatial information, imagery, metadata and/or any spatial information services to RGC's spatial manager.

- **Spatial Manager (RGC):** RGC's spatial manager checks the request from regional NRM bodies and makes requests to a spatial information provider. They know how and who to approach to access and obtain spatial information.

- **DERM/Spatial Information Provider:** DERM provides spatial information to the RGC's spatial manager. If DERM or other government agencies need community owned spatial data, they request the data through RGC's spatial manager.

- **Farmers/Landholders:** Farmers/landholders receive spatial information through RGC's spatial manager. They also collect large scale spatial information and provide this to regional NRM bodies through RGC's spatial manager. RGC's spatial manager checks the request and facilitates the access of community owned spatial information to government agencies and other external bodies.

- **Landcare groups:** Landcare groups also receive spatial information through RGC's spatial manager from spatial information providers. They also collect large scale spatial information and make this data available to regional NRM bodies through the RGC's spatial manager. The RGC spatial manager makes this community owned spatial information available to government agencies and other external bodies.

4.2 Results from Social Network Analysis of KIN Project

4.2.1 Frequency of interaction

The frequency of interaction was used to measure communication relationship between catchment communities and state government organization. The value of InDegree Centrality was used as a measure.

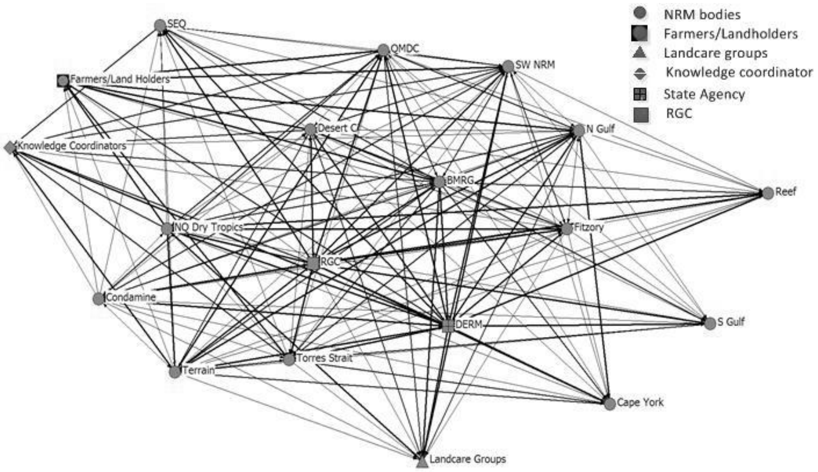


Figure 4. Frequency of interaction

Figure 4 shows the frequency of interaction between regional NRM bodies and other organizations. Six types of organizations were directly or indirectly contributing to the KIN project. The different shape node represents the organization type. The thickness of lines and node size depict the frequency of communication. The network position shows the importance of each organization with respect to the communication.

It was observed that regional NRM bodies had the most frequent interactions with farmers/land holders and landcare groups though these groups were not directly involved in the KIN project. Regional NRM bodies also had frequent communication with knowledge co-ordinators, RGC, and DERM. RGC appeared at the centre of the network with a high InDegree centrality value in communication and could be viewed as a good mediator in the process of spatial information sharing. There was little communication between DERM and landcare groups/farmers. The communication between regional NRM bodies also varied. There were greater levels of communication among adjacent regional NRM bodies compared to geographically distant bodies. However, it was found that if groups had common environmental concerns (common interest) and good professional relationships they had more communication. Further, the regional NRM groups had more communication with external organizations (DERM, landcare groups, etc.) in comparison to internal regional NRM bodies). RGC and DERM both appear at the centre of the network which shows their importance to maintaining communication relationships.

4.2.2 Flow of spatial information

The value of InDegree centrality was used to measure the flow of spatial information between organizations. The amount of flow of spatial information was used as a unit to measure transactional relationships between organizations.

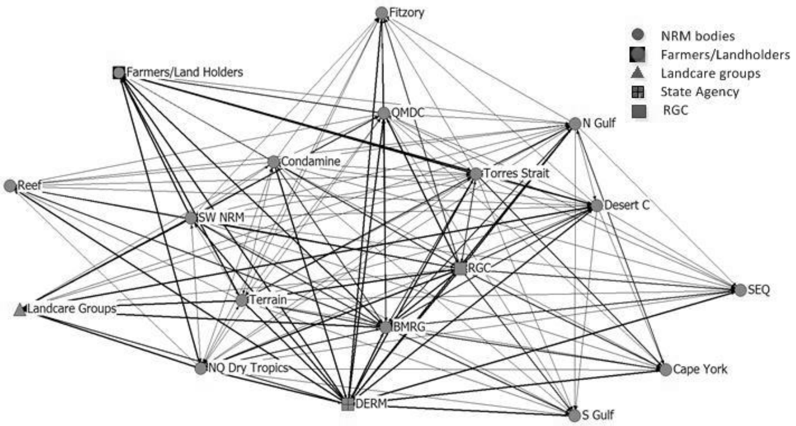


Figure 5. Flow of spatial information

Figure 5 shows the amount of flow of spatial information and spatial information exchange between regional NRM bodies and other organizations. There are five different categories of organizations involved in spatial information sharing and the organizations are differentiated by different node shapes. As discussed earlier, there were both spatial information providers and users in the network and they had varying capacities for spatial information collection and management. NRM bodies provide spatial information to community groups such as Landcare groups and farmers/land holders. The community owned spatial information is also provided to government (namely DERM). RGC is at the centre of the network so again it could be perceived that RGC is a key mediator and facilitator of the spatial information sharing process. Further, it was found the amount of flow of spatial information with adjacent regional NRM bodies is higher than those that are more distant.

4.2.3 Role of organizations in achieving the KIN goal

The value of InDegree centrality was used to measure the role of organization in achieving the KIN goal. Participants were asked to rate the importance of the role of organizations/professionals in achieving the KIN goal.

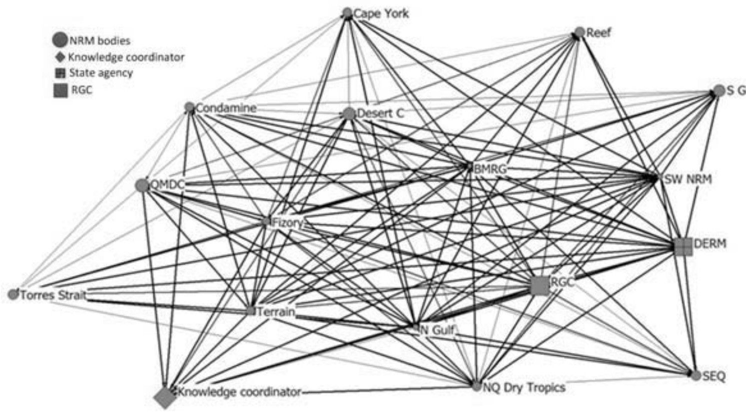


Figure 6. Role of organization in achieving the KIN goal

Figure 6 shows the role of organizations in achieving the KIN goal. The importance of the role is demonstrated by the size of the node. Three organizations are identified as having important roles in achieving the KIN goal. As RGC is at the centre of the network, it has the greatest role. Knowledge coordinators also have a very important role. The role of regional NRM bodies vary, however, RGC could be seen as having a coordination role in bringing all the regional NRM bodies together. This is a statewide project and DERM has provided the funding, so it has also an important role in the network. This network analysis demonstrated that intermediary organizations and professionals have very important roles in achieving the KIN's goal.

5. Discussion

Although technical solutions (spatial information portals) for spatial information access and sharing between regional NRM bodies and government agencies exist, the government led knowledge information network requires further development in order to be effective for catchment communities. The traditional concept of SDI has been conceived with government organizations as the primary custodians of spatial information. In this model, the catchment decisions rely on public sector data and regional NRM bodies are just the users of spatial information. Now, this concept has changed and the regional NRM bodies are also becoming spatially enabled and collecting a significant amount of large-scale spatial information which has social and environmental value. A recent national survey with 56 regional NRM bodies demonstrated that about 80% of regional NRM bodies were both spatial data providers and users. In Queensland, 13 out of 14 organizations identified themselves as both spatial information providers and users. This work also identified the main users of spatial information generated or value-added by regional NRM bodies were the community organizations such as Landcare groups and landholders/farmers. Spatial technology and products like Google Earth, hand-held navigation systems, web 2.0 technologies, and social media are not only spatially enabling regional NRM bodies, but also empowering grass-root level communities and citizens.

Budhathoki *et al.* (2008) argue that it is increasingly difficult to differentiate data 'producers' and 'users' in an environment where many participants function in both capacities. The so-called users are now becoming more important and powerful for spatial data infrastructure design and development. The spatial information sharing between government agencies and natural resource management bodies is now also reflecting this trend. The significant amounts of unpublished or uncatalogued spatial data that exist with regional NRM bodies could be more effectively utilized as a resource for the sector. Additionally, the study found that regional NRM bodies are not willing to publicize their spatial information because they do not believe that it is a current organizational priority and will attract additional time and effort. However, most of the interviewees indicated that they were willing to share spatial information if they were asked. However, they were suspicious of government agencies and thought that their data may be misused.

Mostly, the sharing of spatial information occurs through a data sharing agreement or ad hoc process (informally) rather than organizational process. Some form of collaboration with respect to spatial information and knowledge sharing was desired by regional NRM bodies as a form of knowledge and information transfer. As with many similar organizational arrangements, the data sharing culture is not well practised among regional NRM bodies. The single licensed agreement between RGC and DERM was a useful process to facilitate the spatial information sharing. Although the RGC is a quite young organization, it has gained the trust of government organizations and community groups. It has also achieved a good level of co-ordination and promoted spatial knowledge and information sharing across the various catchments.

The social network analysis proved to be a useful tool to measure transactional relationships, communication relationships and authority-power relationships between project partners. Regional NRM bodies had their most frequent communication with farmers/land holders and land care groups, although these groups were not a formal part of KIN project. Regional NRM bodies also had frequent communication through knowledge coordinators, RGC, and DERM. With respect to spatial information exchange, the analysis indicated that RGC played an important role. There was also a positive two-way flow of spatial information between regional NRM bodies and the state government organizations. The analysis also highlighted the fact that NRM bodies generally work within their defined catchment boundaries so there was little need for sharing spatial information with other NRM bodies.

SDI practitioners (Budhathoki *et al.,* 2008; Elwood, 2008b; Goodchild, 2007) have recognized the power of user and grass-root citizens for the next generation of spatial data infrastructures and the spatial enablement of society. Elwood (2008a) illustrates how these citizens and grass-root groups may also be generating spatial data that is useful to government officials. This research identified the role of regional NRM bodies and grass-root level community groups for spatially enablement through spatial knowledge and information sharing. Social network analysis and business process analysis demonstrated and qualified the spatial information sharing processes and relationship between stakeholders. It was also evident that there was an increasing utilization of web 2.0 technology and open source models for catchment SDI development activities. Volunteered contributions of spatial information prompted by environmental concerns will continue to grow.

6. Conclusions

This chapter has contributed to the current body of knowledge by exploring the social science theoretical framework for the next generation of SDI development particularly the network perspective of SDI. The two theories, namely, the actor network theory and social network theory were found useful in understanding or describing the spatial enablement of community and society. The case study on the spatial knowledge and information network project provided some insights into the spatial information sharing arrangements between catchment communities and the state government organization. The business process analysis of spatial information sharing revealed the role of some intermediary organizations/professionals such as the RGC and knowledge coordinators can assist or facilitate community spatial enablement and spatial information sharing.

The social network analysis was found to provide some useful measures to understand and visualize the various relationships including the communication relationship (frequency of interaction), transactional relationship (spatial information exchange), and authority-power relationships (role of organization) in collaboration and networking. It was clear there is growing utilization of open models and social media for spatial information management and knowledge sharing at the community level. Spatial knowledge sharing is also emerging as an important process for achieving better catchment outcomes and SDI will be a critical underlying infrastructure. There is no doubt that spatial knowledge and information network development can contribute towards spatially enablement of catchment communities. The findings from this study suggest that the network perspective of SDI is useful to understanding the spatial information management issues for NRM bodies and to achieve the broader goal of spatially enabled society (SES).

References

Bodin, O., Crona, B., and Ernstson, H., (2006), WHAT you know is WHO you know? Communication patterns Ecology and Society Ecology and Society 11(2).

Brass, D.J. (1992), Power in Organization: A Social Network Perspective" in G Moore and JA Whitt (Eds) *Research in Politics and Society,* JAI Press, Greenwich, 295-323.

Budhathoki, N., Bruce B., and Nedovic-Budic, Z., (2008), Reconceptualizing the role of the user of spatial data infrastructure, GeoJournal 72(3): 149-60.

Callon, M., (1986), Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay, in J Law (Ed) *I*n Power, Action, and Belief: A New Sociology of Knowledge?, London, Routledge & Kegan Paul.

Coleman, D.,(2010), Volunteered geographic information in spatial data infrastructure: An early look at opportunities and constraints, in A Rajabifard, J Crompvoets, M Kanantari and B Kok (Eds) Spatially Enabling Society: Research, Emerging Trends and Critical Assessment, Leuven University Press, Leuven, Belgium, Leuven.

Crompvoets, J., De Man, W.H.E. and Macharis, C., (2010), Value of Spatial Data: Networked Performance beyond Economic Rhetoric. International Journal of Spatial Data Infrastructures Research 5(96-119).

De Man, W.H.E., (2006),Understanding SDI : complexity and institutionalization. International journal of geographical information science (IJGIS) 20 (3): 329-43.

Elwood, S., (2008a), Grassroots groups as stakeholders in spatial data infrastructures: challenges and opportunities for local data development and sharing. International Journal of Geographical Information Science 22(1): 71-90.

Elwood, S., (2008b), Volunteered geographic information: key questions, concepts and methods to guide emerging research and practice, GeoJournal 72(3): 133-5.

Freeman, L.C., (1979), Centrality in social networks. Conceptual clarifications, Social Networks 1(3): 215-39.

Goodchild, M.F. (2007), Citizens as voluntary sensors: Spatial data infrastructures in the world of Web 2.0, International Journal of Spatial Data Infrastructure Research 2(24–32).

Goodchild, M.F. (2008), Commentary: whither VGI? *GeoJournal* 72(239–44).

Grus, L., J. Crompvoets and A. Bregt. 2007. Multi-view SDI Assessment Framework. International Journal of SDI Research 2(33-53).

Hanneman, R.A. and Riddle, M. (2005), Introduction to social network methods. University of California, Riverside, Riverside, CA.

Harvey, F., (2000),The social construction of geographic information systems. International Journal of GIS 14(8): 711-3.

Harvey, F.,(2001), Constructing GIS: Actor Networks of Collaboration. 4 October 2011, <http://www.urisa.org/files/HarveyVol13no1-3.pdf>.

Jones, A. and Norman, P. (2008), NRM Data Hub Scoping Project, Queenslands NRM Science Panel, Queensland.

Kadushin, C. (2004), Chapter 2: Some basic network concepts and propositions, Introduction to social network theory.

Keast, R. and Brown, K. ,(2005),The network approach to evaluation: Uncovering patterns, possibilities and pitfalls South Bank, Brisbane, 10-12 October 2005.

Knoke, D. and Kuklinski, J.H., (1982), Network Analysis. Sage Publications, Inc.

Kuhn, W., (2007), Volunteered Geographic Information and GIScience, Proceedings of Position Paper for the NCGIA and Vespucci Workshop on Volunteered Geographic Information, Santa Barbara, CA, December 13-14, 2007.

Latour, B., (1987), Science in Action: How to Follow Scientists and Engineers through Society. Harvard University Press, Cambridge, MA.

Law, J., (1992), Notes on the Theory of Actor-Network: Ordering, Strategy and Heterogeneity. Systems Practice 5:379–93.

Masser, I.,(2011), Emerging Frameworks in the Information Age: The Spatial Data Infrastructure Phenomenon, in TL Nyerges, H Couclelis and R McMaster (Eds) The SAGE handbook of GIS and society, SAGE, London.

McDougall, K.,(2010), From Silos to Networks – Will Users Drive Spatial Data Infrastructures in the Future?, Proceedings of FIG Congress 2010: Facing the Challenges – Building the Capacity, Sydney, Australia, 11-16 April 2010

Omran, E.E., (2007), Spatial Data Sharing: From Theory to Practice. Wageningen University.

Omran, E.E. and van Etten J.,(2007), Spatial Data Sharing: Applying social network analysis to study individual and collective behaviour. International Journal of Geographical Information Science 21(6): 699-714.

Onsrud, H.,(2011), Afterword in N-B Zorica, J Crompvoets and Y Georgiadou (Eds) Spatial Data Infrastructure in Context: North and South, Taylor & Francis, CRC Press, London.

Paudyal, D.R., McDougall, K. and Apan, A. (2009), Building SDI Bridges for Catchment Management, in B van Loenen, JWJ Besemer and JA Zevenbergen (Eds) Spatial Data Infrastructure Convergence: Research, Emerging Trends, and Critical Assessment, Netherland Geodetic Commission (NGC), Delft, The Netherlands, 265-79.

Radwan, M.M., Onchaga, R. and Morales, J., (2001), A Structural Approach to the Management and Optimization of Geoinformation Processes, European Organization for Experimental Photogrammetric Research (OEEPE).

Rajabifard, A., Feeney M.-E.F. and Williamson, I., (2003), Spatial Data Infrastructures: Concept, Nature and SDI Hierarchy, in I Williamson, A Rajabifard and M-EF Feeney (Eds) Developing Spatial Data Infrastructures: From Concept to Reality, Taylor & Francis, London, UK. 17-40.

Rajabifard, A., Crompvoets, J., Kalantari, M. and Kok B., (2010), Spatially Enabled Societies in A Rajabifard, J Crompvoets, M Kalantari and B Kok (Eds) Spatially Enabling Society Research, Emerging Trends and Critical Assessment, GSDI Association and Leuven University Press, Belgium, Leuven.

Reeve, D.E. and Petch, J.R.,(1999), GIS organizations and people: a socio-technical approach. Taylor and Francis, London,

Rodriguez-Pabon, O., (2005), Cadre theoretique pourl'evaluation des infrastructures d'information geospatiale Canada. Laval University.

Ryttersgaard, J.,(2001), Spatial Data Infrastructure-Developing Trends and Challenges, Proceedings of CODI-2, Addis Ababa, 4–7 September

Scott, J., (2000), Social Network Analysis: A handbook. Sage, London.

Shi, Y., (2008), Virtual organization based distributed environmetal decision support systems: Applications in watershed management. Michigan State University.

van Oort, P., Hazeu, G., Kramer, H., Bregt A., and Rip, F., (2010), Social networks in spatial data infrastructures. GeoJournal 75(1): 105-18.

Vancauwenberghe, G., Crompvoets, J., Bouckaert, G. and Vandenbroucke , D.,(2009), A network perspective on Spatial Data Infrastructures: SDI as support to e-government", Proceedings of GSDI11, Rotterdam, The Netherlands

Vancauwenberghe, G., Crompvoets, J., Bouckaert G., and Vandenbroucke D., (2011), Social Network Analysis of the SDI in Flanders in Z Nedovic-Budic, J Crompvoets and Y Georgiadou (Eds) Spatial Data Infrastructures in Context: North and South CRC Press, Taylor and Francis Group, Boca Raton, London, New York.

Vandenbroucke, D., Crompvoets, J. , Vancauwenberghe, G., Dessers, E. and Van Orshoven, J., (2009), A Network Perspective on Spatial Data Infrastructures: Application to the Sub-national SDI of Flanders (Belgium). Transactions in GIS 13(105-22).

Wasserman, S. and Faust, K., (1994), Social Network Analysis: Methods and Applications Cambridge University Press, Cambridge, England.

Wasserman, S. and Faust, K., (2008), Social Network Analysis: Methods and Applications Cambridge University Press, Cambridge, England.

Wehn de Montalvo, U., (2003), Mapping the determinants of spatial data sharing. Ashgate Publishing Ltd, Aldershot, England.

Williamson, I., Holland, P. and Rajabifard, A., (2010), Spatially Enabled Society, *P*roceedings of FIG Congress 2010, Facing the Challenges - Building the Capacity, Sydney, Australia, 11-16 April 2010

Williamson, I.P., Rajabifard, A. and Feeney, M.-E.F., (2003), Developing spatial data infrastructures: from concept to reality. Taylor & Francis, New York.