EXPLORING SPATIAL DATA SHARING FACTORS AND STRATEGIES FOR CATCHMENT MANAGEMENT AUTHORITIES IN AUSTRALIA

Dev Raj Paudyal, Kevin Mcdougall, Armando Apan

Keywords: Spatial Data Infrastructure (SDI), Spatial Data Sharing, Catchment Management, Natural Resource Management, Data Sharing Factors

Abstract: *Spatial information plays a significant role in addressing many decision making process including the catchment decisions. Spatial data sharing is recognized as one of the important components in spatial data infrastructure design and development. This research develops spatial data sharing strategies for the implementation of improved spatial data sharing arrangements between catchment management authorities (CMAs) and state government organizations in Australia. A mixed method research approach was utilized to collect both quantitative and qualitative data from 56 CMAs and the embedded design framework was used for the synthesis and interpretation of the results. The national survey data and case study data were collected and analyzed sequentially using the mixed method design framework. Within, the case study, social network analysis was introduced for analyzing data sharing and provides a new perspective on assessing spatial data sharing relationship. The supplemental case study analysis embedded within a larger national survey provided a supportive role and enhanced the findings from the national survey. The key factors which influence spatial data sharing between state government organizations and CMAs were identified and classified into six major classes as governance, economic, policy, legal, cultural and technical. The non-technical factors (governance, policy, economic, legal and cultural) were found to be more significant in comparison with the technical factor. Based on these findings, fourteen data sharing strategies were developed. The study suggests that the adoption and implementation of these strategies can assist in overcoming the spatial data sharing issues and hence will contribute to improved spatial data sharing arrangements between regional CMAs and state government organizations in Australia.*

1 INTRODUCTION

Spatial Data Infrastructure (SDI) is about the facilitation and coordination of the exchange and sharing of spatial data between stakeholders within the spatial community (Feeney et al, 2001; McDougall, 2006). There are many frameworks developed for sharing spatial data (Kevany, 1995; McDougall, 2006; Omran, 2007; Onsrud and Rushton, 1995; Warnest, 2005; Wehn de Montalvo, 2003). However, the frameworks are mainly based on the spatial data provider's point of view and do not recognize the power of users. Readily accessible and available spatial technologies like Google Earth, hand-held navigation systems (including smart phones, GPS, etc), Web 2.0/3.0 technology and social media has created the opportunity for users to contribute towards SDI development. Therefore, it is important to examine the spatial data sharing issues and to formulate roadmaps from the community's perspectives.

Mixed methods strategies are less well known than either the qualitative or quantitative approaches. However, in recent times there has been a growing recognition of collecting and analyzing both qualitative and quantitative data in a research study and mixing them. It has been argued that the overall strength of mixed method in a study is greater than either qualitative or quantitative research (Creswell and Plano Clark, 2007). Blending both qualitative and quantitative research methods can create an optimal design although both single methodology approaches (qualitative only and quantitative only) have strengths and weaknesses. The combination of methodologies can focus on their relevant strengths. Different scholars have used different terms (e g integrative, combined, blended, mixed methods, multi-method, multi-strategy) to identify studies that attempt such mixing (Collins et al, 2007; Creswell and Plano Clark, 2007; Tashakkori and Teddlie, 2007). However, the term mixed methods seems to be accepted by most scholars. It has also been argued that qualitative method often needs to be supplemented with quantitative methods, and vice versa (Baran, 2010), and go hand in hand.

This paper utilize mixed method research and identify key factors that influence spatial data sharing between state government organizations and catchment management authorities (CMAs). It has explored the spatial data sharing factors and developed strategies from the community's perspectives to improve spatial data sharing arrangements between CMAs and state government organizations in Australia.

2 RELATED WORK

One of the key motivations for spatial data infrastructure (SDI) development is to provide ready access to spatial data to support decision-making (McDougall, 2006).Various frameworks and models on data sharing are found in the literature. Among them are a generic model of the Mapping Science Committee of the National Research Council (National Research Council, 1993), taxonomy for research into spatial data sharing (Calkins and Weatherbe, 1995), antecedents and consequences of information sharing (Pinto and Onsrud, 1995), factors relevant to GIS data sharing (Kevany, 1995), a typology of six determinants of inter-organizational relationships (Oliver, 1990), typology based on inter-organizational relations and dynamics (Azad and Wiggins, 1995), an organizational data sharing framework (Nedovic-Budic and Pinto, 1999) a model of willingness based on theory of planned behaviour (Wehn de Montalvo, 2003), interaction between organizational behaviour of spatial data sharing and social and cultural aspects (Omran, 2007), a collaboration model for national spatial data infrastructure (Warnest, 2005), local government data sharing (Harvey and Tulloch, 2006; Tulloch and Harvey, 2008), the local-state data sharing partnership model (McDougall, 2006) and geospatial one-stop (Goodchild et al, 2007). McDougall (2006) examined the empirical research on spatial data sharing and SDI and summarized the spatial data sharing models/frameworks into characteristics, strengths and limitations. Most of these frameworks were based on the authors' experiences and have not been proven empirically except for Nedovic-Budic and Pinto's (1999), Wehn de Montalvo's (2003) Harvey and Tulloch's (2006) and McDougall's (2006).

The use of qualitative and quantitative research in land administration and SDI related research is not a new approach. The case study research framework design is the most common research approach on SDI related research. Cagdas and Stubkjar (2009) analyzed ten doctoral dissertations on cadastral development from the methodological point of view and found that case study research was favoured in all the reviewed research. Several doctoral dissertations related to the SDI field (Chan, 1998; Davies, 2003; McDougall, 2006; Mohammadi, 2008; Rajabifard, 2002; Warnest, 2005) used both qualitative and quantitative strands in their studies. However, except for McDougall, all others did not use a mixed method design framework when combined with both qualitative and quantitative strands. Smith et al (2003) utilized the mixed method approach to GIS analysis. They asserted that a mixed-method would provide a more comprehensive analysis of the use of GIS within the National Health Service (NHS). Further, they argued that combining survey results and interview data within mixed method design framework enhanced the research findings. Another significant use of the mixed-method in GIS research was by Nedovic-Budic (Unpublished) who explored the utility of mixed method research in GIS (cited in McDougall, 2006). Wehn de Montalvo (2003) also used the mixed-method in her study, however her design frameworks were based on theoretical grounding (theory of planned behaviour) rather than on a mixed method design framework as suggested by mixed methods researchers (Creswell and Plano Clark, 2011; Tashakkori and Teddlie, 2003; Tashakkori and Teddlie, 2009). McDougall (2006) utilized the mixed method design framework during his SDI research and advocated it as the best of both qualitative and quantitative worlds. His study provided a very structured approach to combine both qualitative and quantitative data. The structure of this study utilizes the embedded research design framework as suggested by Creswell and Plano Clark (2011).

3 METHODOLOGY

In this section, the study area and the research method has been discussed. The institutional arrangements of CMAs (regional NRM bodies) and the framework of embedded mixed method design framework are explored in sections 3.1 and 3.2.

3.1 Study Area Description

Catchment management authorities (CMAs) have been established to address complex catchment management/natural resource management issues that involve many community groups and government agencies. All states/territories have some form of catchment management authorities or natural resource management groups under their jurisdiction and there are 56 CMAs (also called regional NRM bodies) which are responsible for catchment management in Australia. The CMAs vary in their name, corporate structure, catchment management philosophy, and relationship to the state government organization. They are termed catchment management authorities in New South Wales and Victoria, catchment councils in Western Australia, NRM boards in South Australia, regional NRM groups in Queensland and Regional committees in Tasmania. CMAs comprise representatives of the major sectors of the community and government which are involved in, or influenced by, the management of land and water resources in the catchment. Their major role is to provide a forum for community input and discussion, prioritize the issues, and develop and promote the adoption of catchment management strategies. Figure 1 shows the location of case study area and boundary of 56 CMAs (NRM regions).

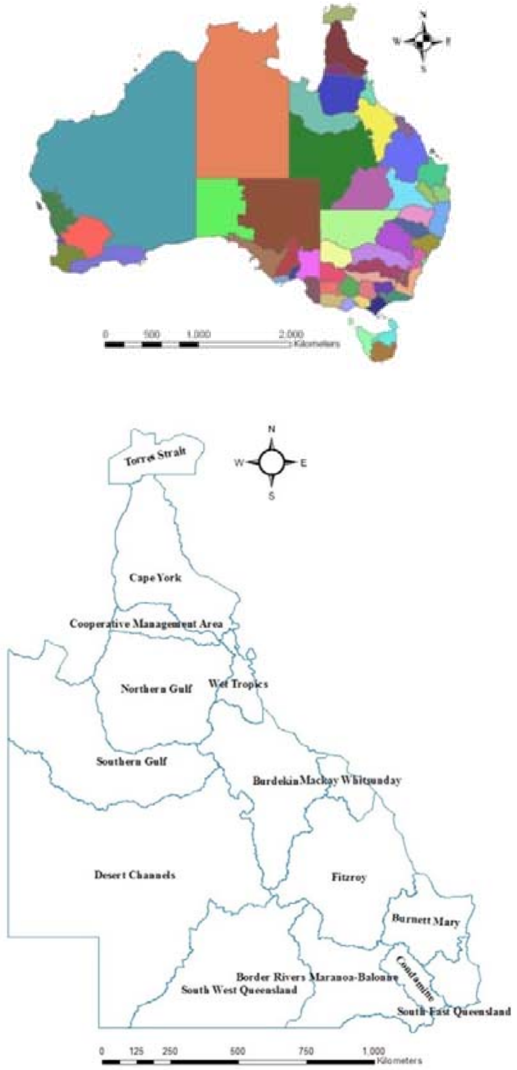

Figure 1: Location map of study areas

3.2 Research Method

It has been argued by a number of researchers that the selection and use of appropriate data collection and analysis techniques are very important to the success of research (de Vaus, 2001; Marshall, 2006; Yin, 2009). The use of qualitative and quantitative strands in SDI related research is a most common approach. However, in recent times, there has been a growing recognition of collecting and analyzing both qualitative and quantitative data in a research study and mixing them. It has been suggested that the overall strength of mixed method in a study is greater than either qualitative or qualitative research (Creswell and Plano Clark, 2007). This study has utilized the mixed method approach and followed the embedded design framework suggested by Creswell and Plano Clark (2011) (Figure 2). The survey and case study data were collected and analyzed sequentially (i.e. in two phases) with the outputs from the two methods integrated. The case study component was the supplementary component of the survey design and different research questions were addressed in the survey and case study design to achieve the main aim of this research. After the integration, the common findings were interpreted. The quality of the output was examined through the validity of the findings.

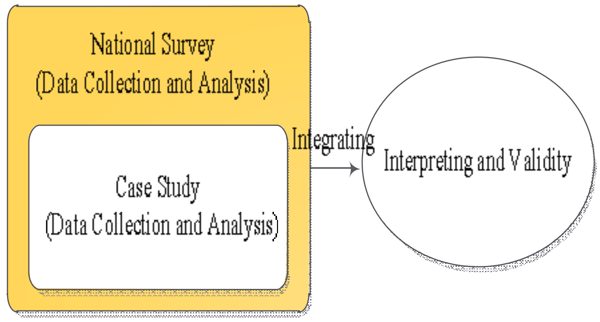

Figure 2: Mixed method: the embedded design

The survey was conducted with all 56 CMAs responsible for catchment management in Australia. The majority of questions were closed and categorical type and were measured on a five point Likert scale. The survey was undertaken from June 2010 to September 2010. A total of 56 valid responses were received to the on-line questionnaire giving an overall response rate of 100%. The online questionnaire was designed such that the data from questionnaire was automatically collected into an Excel spread sheet via a web server. This eliminated the possibility of errors in coding and transaction and accelerated transferring data into the data analysis software. The raw data were reviewed and cleaned up before inputting into the statistical software. The statistical analysis was performed using SPSS statistics package.

The Knowledge and Information Network (KIN) project was selected as a representative or typical case to investigate spatial data sharing process for catchment management. The main stakeholders of KIN project were Queensland Regional Groups Collective (RGC), 14 regional NRM bodies and Department of Natural Resources and Mines (DNRM). 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. Regional NRM bodies are responsible to develop regional NRM plans and deliver sustainable catchment outcomes at grass-root level. DERM was the state agency responsible for funding support and overall coordination. Semi-structured interviews were conducted with all 14 regional NRM bodies, state government representatives and Queensland Regional NRM Groups Collective (RGC) which provided an in-depth understanding about NRM KIN project and its working principles. Both telephone and face-to-face interview methods were used. A brief questionnaire was conducted targeting 18 stakeholders; 14 from regional NRM bodies, two from state government organizations and two from the RGC. It consists of six categories of organizations/professionals including DERM, RGC, regional NRM bodies, Landcare groups, landholders/farmers, and knowledge coordinators. The questionnaire was distributed to a non-random and purposive sample of representatives from project stakeholders to quantify the frequency of interaction, exchange of spatial information, and role of organization in achieving the KIN goal. The data collected through the questionnaire was analyzed using social network analysis software (UCINET and NetDraw). The primary reason for undertaking the social network analysis was to measure the relationships between the KIN project stakeholders.

Using the mixed method design framework as suggested by Creswell and Plano Clark (2011), the key factors which influence spatial information sharing between state government organizations and regional NRM bodies/catchment management authorities were identified and classified into six major classes as governance, economic, policy, legal, cultural and technical. Based on these findings, fourteen data sharing strategies were developed.

4 RESULTS

4.1 Results from Survey: Descriptive Statistics

4.1.1 *Spatial Capacity of CMAs and GIS Activities*

The majority (approximately 70%) of CMAs identified themselves as being both a user and provider of spatial information and the rest as being a user (Figure 3). This response demonstrates that the regional NRM bodies not only use spatial information but also produce spatial information. This provides a strong base for developing spatial data infrastructure (SDI) in the catchment management sector.

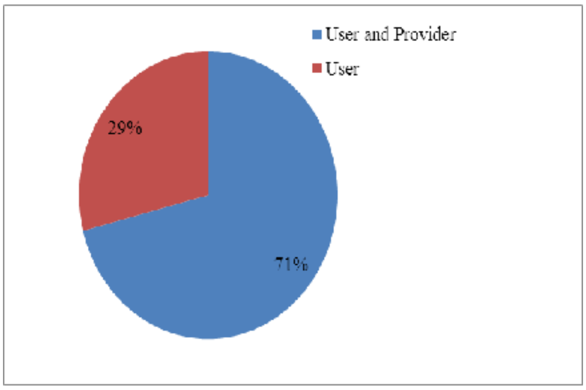

Figure 3: Breakdown of user/provider of spatial information

With respect to the use of spatial information by CMAs staff, 40 out of 56 CMAs indicated that over 40% of their staff use spatial information. In contrast, only 7 out of 56 CMAs indicated that less than 20% of their staff utilize spatial information. This result indicates that there is a strong spatial information awareness and use among regional NRM staff.

The GIS activities are also not new for regional NRM bodies. 26 out of 56 CMAs have been using GIS/spatial information for five or more years and only three NRM bodies have been using spatial information for less than two years. This illustrates that the majority of CMAs in Australia are quite mature with respect to using spatial information as part of their catchment decision-making processes.

4.1.2 *Importance of Spatial Data for Catchment Management*

When asked to identify the role that spatial information can play in addressing the catchment management issues, it was interesting to observe that approximately 60% of the CMAs responded that spatial information can play a very significant role, with the remaining 40% of the organizations responding that it can play a significant role. Not a single organization responded that it was not aware of the role of spatial information in addressing catchment management issues. This response indicates the importance of spatial information in supporting the development of SDI at the regional level (catchment level).

4.1.3 *Information Flow and Data Access*

It examined the effectiveness of access to spatial data from data providers. Approximately half (48%) of the CMAs indicated that access was neither easy or difficult, 18% indicated that it was easily accessible and 11% indicated that it was very accessible. A minority (23%) of CMAs indicated that it was difficult. In regards to the effectiveness of access to spatial data from spatial data providers, the response did not indicate any strong trends or issues for regional NRM bodies in accessing spatial information from spatial data providers.

The majority of organizations (77%) indicated that they also supplied spatial information. The main users of spatial information that was generated or value-added by CMAs were the community organizations such as Landcare, Watercare, Birdwatch, landowners and indigenous groups. Government organizations, the private sector and academic research institutions utilized spatial information managed by CMAs less frequently. It was also evident that there is a two-way information flow between CMAs and government organizations. As a result of this mutual interest, government organizations are interested in collaborating and networking with CMAs via data sharing agreements.

4.1.4 *Spatial Information Sharing Factors*

Spatial information sharing factors were identified and their importance in facilitating information sharing with other organizations was examined. Having a formal agreement, organizational attitude to sharing, individual attitude, ability and willingness to share, and leadership were found most important.

The collaborative arrangements of CMAs with other organizations with respect to the exchange of resources, skills and technology were examined. The majority (83%) of the CMAs advised that they have a collaborative arrangement with other organizations. After investigation, it was found that data sharing and spatial information management were the main areas of collaboration.

Table 1 lists the spatial information sharing factors and their importance as rated by regional NRM bodies.

Table 1: Spatial information sharing factors and their importance

Spatial Information Sharing Factors	Importance
Formal agreement	Very High
Organizational attitude to sharing	Very high
Individual attitude, ability and willingness	Very High
Leadership	Very High
Networking and contacts	High
IT system and technical tools	High

4.2 Results from Case Study: Social Network Analysis

The primary reason for undertaking the social network analysis was to measure the relationships between the KIN project stakeholders. This research measured three types of relationships namely: transactional relations, communication relations and authority-power relations. The reasons for measuring relationships were to quantify the frequency of interaction, exchange of spatial information and the role of organization in achieving the KIN goal.

The organizations were differentiated in the diagram by different node colours, node position, and node size and line width to show the interaction between organizations in network. The results from social network analysis of the KIN project are described in the following sections.

4.2.1 *The Frequency of Interaction*

The frequency of interaction was used to measure the communication relationship between catchment communities and state government organizations. The organizations were asked to rate the frequency of interaction with other organizations and their responses were measured on a five point Likert scale (from very frequently to rarely).

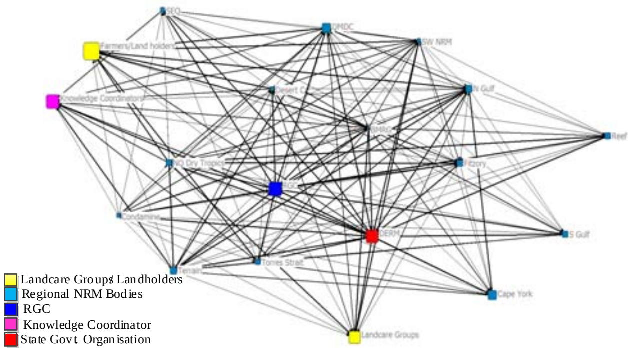

Figure 4: Frequency of interaction

Figure 4 shows the frequency of interaction between CMAs and other organizations. Five types of organizations directly or indirectly contributed to the KIN project. The different colour nodes represent the organization type. The size of the node represents the value of InDegree centrality and the rate of frequency of interaction with other organizations. The thickness of lines depicts the frequency of communication. The larger the node size, the greater the frequency of interaction and the value of InDegree centrality. The network position shows the importance of each organization with respect to the communication.

It was observed that regional NRM bodies/CMAs had frequent interactions with farmers/land holders and landcare groups, though these groups were not directly involved in the KIN project. CMAs also communicated frequently with knowledge coordinators, 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 the Landcare groups/farmers. The communication between CMAs also varied. There were greater levels of communication between adjacent regional NRM bodies compared with geographically distant bodies. However, it was found that if groups had common environmental concerns and good professional relationships they had a greater number of interactions. Further, the regional NRM groups had more frequent communication with external organizations (DERM, Landcare groups, etc) in comparison with internal regional NRM bodies. RGC and DERM both appear at the centre of the network. The organizations which appear at the centre of the network diagram indicate the importance of their role to maintaining communication relationships.

4.2.2 *Rate of Flow of Spatial Information*

The flow of spatial information was used as a unit to measure transactional relationships between organizations. Participants were asked to rate the flow of spatial information between their organization and other organizations. Their responses were measured on a five point Likert scale (from more to less).

Figure 5 shows the flow of spatial information and spatial information exchange between CMAs and other organizations. There were four different categories of organizations involved in spatial information sharing and the organizations are differentiated by node colours. The variations in line weights represent the rate of flow of spatial information between organizations. The thicker the line weight the greater the flow of information. The size of the node represents the value of InDegree centrality. 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 like 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 that the flow of spatial information with adjacent CMAs is higher than with those that are more distant.

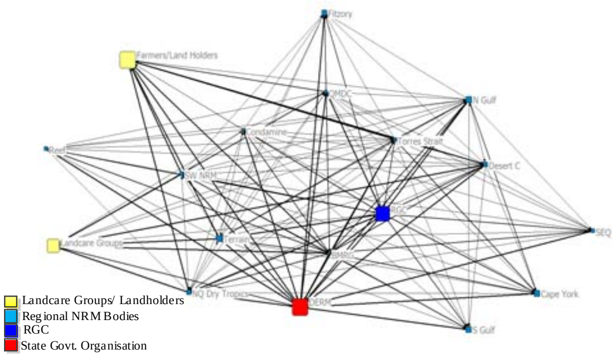

Figure 5: Flow of spatial information

4.2.3 *Role of Organizations in Achieving the KIN Goal*

The value of InDegree centrality was used to measure the role of an organization in achieving the KIN goal. Participants were asked to rate the importance of the role of organizations/professionals in achieving the KIN goal. Participants rated each of the organizations on a five point Likert scale (from highest to lowest) and their responses were recorded and used for social network analysis.

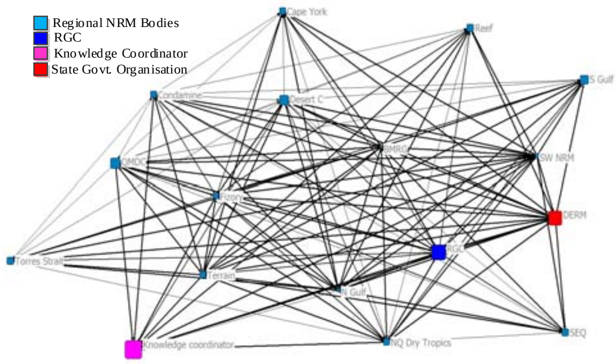

Figure 6: Role of organizations in achieving the KIN goal

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 and the size of the node represents the value of InDegree centrality. The larger the node size, the greater the importance of the role of organization. The organizations which appear at the centre of the network diagram indicate the importance of their role in achieving the KIN goal. Three organizations were identified as having important roles in achieving the KIN goal. As RGC is at the centre of the network, it has one of the strongest roles. Knowledge coordinators also have very important roles. The role of CMAs varies, however, RGC could be seen as having a coordination role in bringing all the CMAs together. This is a state-wide project and DERM has provided the funding, so it also has an important role in the network. This network analysis demonstrated that intermediary organizations and professionals play a very important role in achieving the KIN's goal.

5 SYNTHESIS

This research followed the embedded mixed method design. In the embedded mixed method design, different datasets are connected within the methodology framed by other datasets at design phase to help in interpretation of the results (Creswell and Plano Clark, 2011). The case study results provided a supportive role and enhanced the findings from the national survey.

Following the national survey of CMAs and the case study, this list of factors has been classified into six major classes which are influencing, or contributing to spatial data sharing. These classes of factors are: governance (sharing environment), policy (rules for sharing), economic (value of sharing), legal, cultural (will to share) and technical (capacity to enable sharing). The first five classes of factors are non-technical factors and the last is a technical factor (Figure 7).

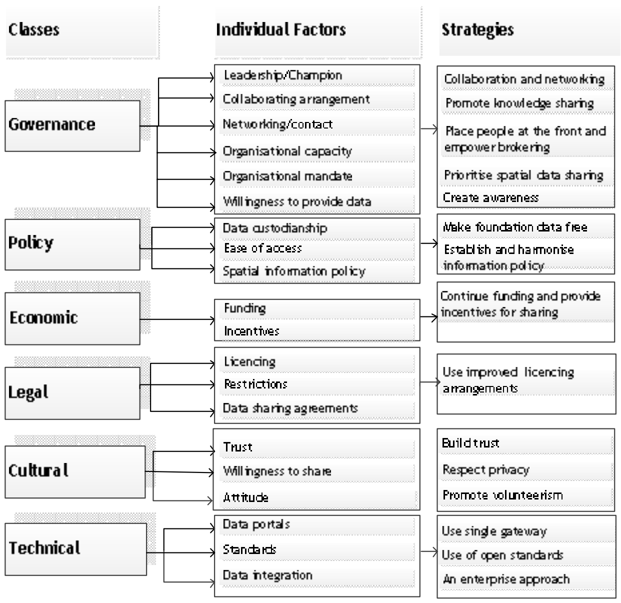

Figure 7: Spatial data sharing factors and strategies

The six main governance factors that influence the spatial information sharing between CMAs and state government organizations include leadership/champion, collaboration arrangement, organizational capacity, networking/contact, organizational mandate and willingness to provide spatial data. Spatial information policy, data custodianship and ease of access were the three main policy factors. There were no or limited policies/guidelines in CMAs to manage spatial information. Specifically, there was no policy to return the spatial information collected by CMAs to the state repositories or to utilize that spatial information for updating state-wide NRM databases. Spatial information sharing was not considered a part of the organizational mandate and was always considered a lower priority. The continuity of funding and incentives for spatial information sharing activities were the two main economic factors, whilst the data sharing agreements, licensing and restrictions were identified as the legal factors. CMAs (Regional NRM Bodies) were used to multiple licensing arrangements with state government organizations and showed interest in sharing data under the Creative Commons Framework. Trust, willingness to share and attitude were cultural factors. The landholders' data contained information that was considered private and they feared that their information could be used against them by government. The data portal, standards and data integration and the lack of a single gateway to access NRM related spatial information were identified as technical factors.

The strategies were developed to address the spatial data sharing factors. The adoption and implementation of these strategies can assist to improve spatial data sharing. Further, these strategies can accelerate the progress in the development of catchment SDI initiatives.

6 CONCLUSION

This paper has contributed to the current body of knowledge by exploring the spatial data sharing arrangements in catchment management areas and developing spatial data sharing strategies utilising mixed method research approach to facilitate spatial data sharing between catchment management communities and government agencies. The national survey provides a unique nation-wide perspective on the spatial data access and sharing for catchment management. The outputs from the survey will help to identify priority catchment management issues, national NRM datasets and information infrastructure in Australia. Spatial information plays a significant role in addressing the catchment management issues and majority of regional NRM bodies agreed this statement. 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 utilisation of open models and social media for spatial information management and knowledge sharing at the community level.
The critical factors for improving data sharing across catchment management authorities were identified through triangulating the findings from the literature review, the results of the national survey of CMAs and the KIN project case study. Eighteen issues were identified as being highly significant and classified into the six major classes of organizational, policy, economic, legal, cultural and technical. The non-technical factors (organizational, policy, economic, legal and cultural) were found to be more significant in comparison with the technical factor. Based on these findings, spatial data sharing strategies were developed. The strategies from this research have the potential to improve spatial information sharing between CMAs and government organizations to support better catchment management decisions.

References:

Azad, B and Wiggins, LL 1995, *'Dynamics of Inter-organizational Data Sharing: A Conceptual Framework for Research'* In Sharing Geographic Information (Eds, Onsrud, HJ and Rushton, G), Centre for Urban Policy Research, New Brunswick, pp. 22-43.

Baran, M 2010, *'Teaching Multi-methodology Research Courses to Doctoral Students'*, International Journal of Multiple Research Approaches, vol 4, no 1, pp 19-27.

Cagdas, V and Stubkjar, E 2009, *'Doctoral Research on Cadastral Development'*, Land Use Policy, vol 26, no 4, pp 869-889.

Calkins, HW and Weatherbe, R 1995, *'Taxonomy of Spatial Data Sharing'* In Sharing Geographic Information (Eds, Onsrud, HJ and Rushton, G), Center for Urban Policy Research, New Brunswick, New Jersey, pp. 65-100.

Chan, TO 1998, *'The Dynamics of Diffusion of Corporate GIS '*, Doctor of Philosophy, The University of Melbourne, Australia.

Collins, KM, Onwuegbuzie, AJ and Jiao, QG 2007, *'A Mixed Methods Investigation of Mixed Methods Sampling Designs in Social and Health Science Research'*, Journal of Mixed Methods Research, vol 1, no 3, pp 267-294.

Creswell, JW and Plano Clark, VL 2007, *Designing and Conducting Mixed Methods Research*, Sage Publications, Thousand Oaks, CA.

Creswell, JW and Plano Clark, VL 2011, *Designing and Conducting Mixed Methods Research*, 2nd edn, Sage Publications, LA.

Davies, J 2003, *'Expanding the Spatial Data Infrastructure Model to Support Spatial Wireless Applications'*, Doctor of Philosophy, The University of Melbourne, Australia.

Feeney, M-EF, Rajabifard, A and Williamson, IP 2001 In *5th Global Spatial Data Infrastructure Conference Cartagena de Indias*, Columbia, pp. 14.

Goodchild, MF, Fu, P and Rich, P 2007, *'Sharing Geographic Information: An Assessment of the Geospatial One-Stop'*, Annals of the Association of American Geographers, vol 97, no 2, pp 249–265.

Harvey, F and Tulloch, D 2006, *'Local lgovernment data sharing: Evaluating the foundations of spatial data infrastructures'*, International Journal of Geographical Information Science, vol 20, no 7, pp 743-768.

Kevany, MJ 1995, *'A Proposed Structure for Observing Data Sharing'* In Sharing Geographic Information (Eds, Onsrud, HJ and Rushton, G), Center for Urban Policy Research, New Brunswick, pp. 76-100

McDougall, K 2006, *'A Local-State Government Spatial Data Sharing Partnership Model to Facilitate SDI Development'*, Doctor of Philosophy, The University of Melbourne, Australia.

Mohammadi, H 2008, *'The Integration of Multi-source Spatial Datasets in the Context of SDI Initiatives'*, Doctor of Philosophy, The University of Melbourne, Australia.

National Research Council 1993, *'Toward a Coordinated Spatial Data Infrastructure for the Nation'*, Mapping Science Committee, National Academy Press, Washington DC.

Nedovic-Budic, Z Unpublished, *'Exploring the Utility of Mixed Method Research in GIS'*,

Nedovic-Budic, Z and Pinto, JK 1999, *'Understanding Interorganizational GIS Activities: A Conceptual Framework'*, Journal of Urban and Regional Information Systems Association, vol 11, no 1, pp 53-64.

Oliver, C 1990, *'Determinants of Inter-organizational Relationships: Integration and Future Directions'*, Academy of Management Review, vol 15, no 2, pp 241-65.

Omran, EE 2007, *'Spatial Data Sharing: From Theory to Practice'*, Doctor of Philosophy, Wageningen University, The Netherlands.

Onsrud, HJ and Rushton, G 1995, *Sharing Geographic Information, Centre for Urban Policy Research, Urban Policy Research*, New Brunswick, New Jersey.

Pinto, JK and Onsrud, HJ 1995, *'Sharing Geographic Information Across Organizational Boundaries: A Research Framework'* In Sharing Geographic Information (Eds, Onsrud, HJ and Rushton, G), Centre for Urban Policy Research, New Brunswick, New Jersey, pp. 45-64.

Rajabifard, A 2002, *'Diffusion of Regional Spatial Data Infrastructures: with particular reference to Asia and the Pacific'*, Doctor of Philosophy, The University of Melbourne, Australia.

Smith, DP, Higgs, G and Gould, MI 2003, *'Using a Mixed Method Approach to Investigate the Use of GIS Within the UK National Health Service'* In Socio-economic Applications of Geographic Information Science (Eds, Kidner, DB, Higgs, G and White, S), Taylor and Francis, London.

Tashakkori, A and Teddlie, C 2003, *Handbook of Mixed Methods in Social and Behavioral Research*, Sage Publications, Thousand Oaks, CA.

Tashakkori, A and Teddlie, C 2007, *Foundations of Mixed Methods Research : Integrating quantitative and qualitative techniques in the social and behavioral sciences*, Sage Publications, Thousand Oaks, CA.

Tashakkori, A and Teddlie, C 2009, *'Mixed Methods'* In The SAGE Handbook of Applied Social Research

Methods (Eds, Bickman, L and Rog, DJ), Sage Publications, LA, pp. 283-317.

The National Academy of Sciences 2012, '*Advancing Strategic Science: A Spatial Data Infrastructure Roadmap for the U.S. Geological Survey*', Committee on Spatial Data Enabling USG Strategic Science in the 21st Century, Mapping Science Committee, Board on Earth Sciences and Resources, Division on Earth and Life Studies, National Research Council, National Research Council, the National Academy of Sciences, Washington.

Tulloch, DL and Harvey, F 2008, '*When Data Sharing Becomes Institutionalized: Best Practices in Local Government Geographic Information Relationships*', URISA Journal, vol 19, no 2, pp 51-59.

Warnest, M 2005, '*A Collaboration Model for National Spatial Data Infrastructure in Federated Countries*', Doctor of Philosophy, The University of Melbourne, Australia.

Wehn de Montalvo, U 2003, *Mapping the Determinants of Spatial Data Sharing*, Ashgate Publishing Ltd, Aldershot, UK.

Author's Information

Name:	Dev Raj Paudyal
Academic Qualification:	Doctor of Philosophy (PhD)
Organization:	School of Civil Engineering and Surveying, University of Southern Queensland
Current Designation:	Lecturer/Academic
Work Experience:	20 years
Published Papers/Articles:	40
e-mail:	paudyal@usq.edu.au