Developing Spatial Data Sharing Strategies for Catchment Management Authorities in Australia

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Key words: Spatial Data Sharing, Mixed Method Research, Catchment Management, Spatial Data Infrastructure, Natural Resource Management

SUMMARY
Spatial data sharing is recognised as one of the important components in spatial data infrastructure design and development. There are many issues that hinder sharing spatial data between organisations. This research develops a roadmap that will be adopted for the implementation of improved spatial data sharing arrangements between regional NRM bodies and state government organisations in Australia. A mixed method research approach was utilised to collect both quantitative and qualitative data from regional Natural Resource Management (NRM) bodies and the embedded design framework was used for the synthesis and interpretation of the results. The national survey conducted across 56 regional NRM bodies provided the current status of spatial data access and sharing for catchment management in Australia and provided a unique nation-wide perspective. Within national survey, there was an embedded case study of Knowledge and Information Network (KIN) project which explored the effectiveness of spatial information and knowledge sharing arrangements between regional NRM bodies and state government organisations. The national survey data and case study data were collected and analysed sequentially using the mixed method design framework. The case study component was the supplementary component of the survey design and the mixing was done at the level of design and interpretation. Within, the case study, social network analysis was introduced for analysing 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 organisations and regional NRM bodies/catchment management authorities 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. A five-point action plan, a mix of institutional consideration and technical consideration was suggested. The study suggests that the adoption and implementation of this road map can assist in overcoming the spatial data sharing issues and hence will contribute to improved spatial data sharing arrangements between regional NRM bodies and state government organisations in Australia.

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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 recognise 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 analysing 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 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 utilise mixed method research and identify key factors that influence spatial data sharing between state government organisations and regional NRM bodies/catchment management authorities. It has formulated roadmaps from the community's perspectives to improve spatial data sharing arrangements between regional NRM bodies and state government organisations 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-organisational relationships (Oliver, 1990), typology based on inter-organisational relations and dynamics (Azad and Wiggins, 1995), an organisational data sharing framework (Nedovic-Budic and Pinto, 1999) a model of willingness based on theory of planned behaviour (Wehn de Montalvo, 2003), interaction between organisational 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 summarised 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) analysed 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) utilised 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) utilised 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 utilises 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 regional NRM bodies/catchment management authorities and the framework of embedded mixed method design framework are explored in sections 3.1 and 3.2.

3.1 Study Area Description

Regional NRM bodies/ catchment management authorities (CMAs) have been established to address complex catchment management issues that involve many community groups and government agencies. There are 56 regional NRM bodies which are responsible for catchment management in Australia. All states/territories have some form of catchment management authorities or natural resource management groups under their jurisdiction. The regional NRM bodies vary in their name, corporate structure, catchment management philosophy, and relationship to the state government organisation. 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, prioritise 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 NRM regions.

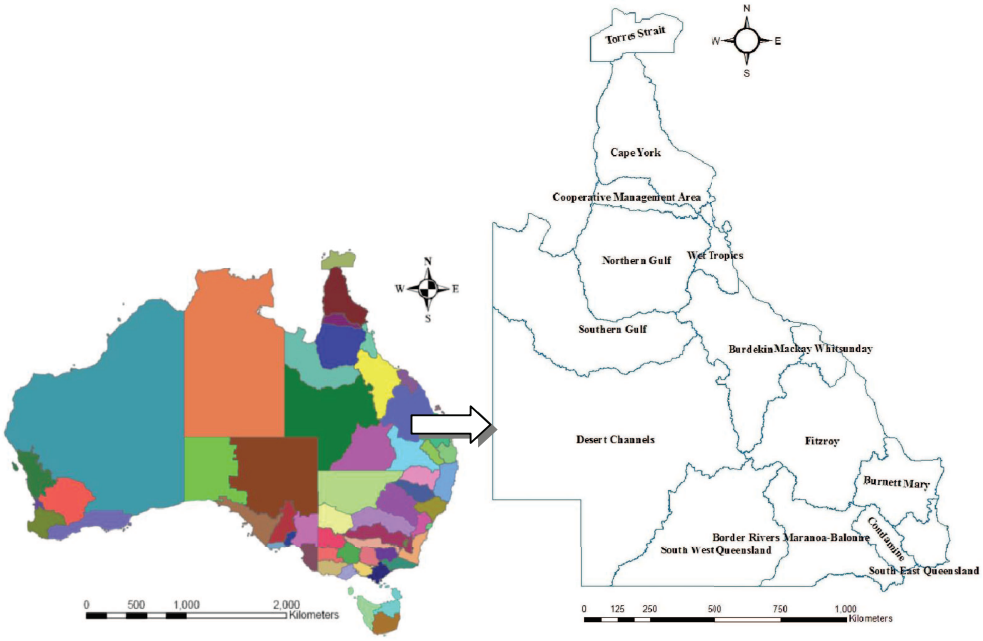

Figure 1: Location map of study areas

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 analysing 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 utilised 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 analysed 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.

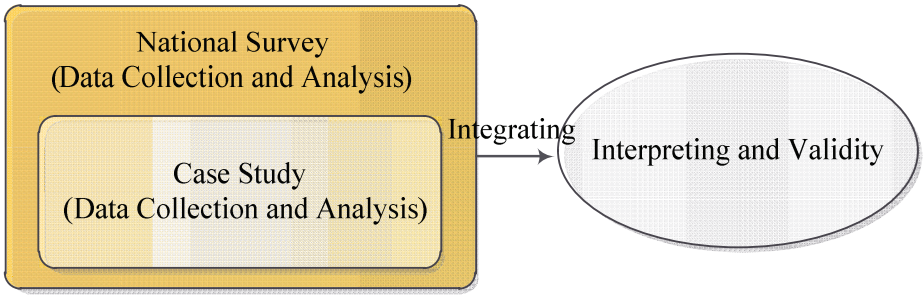

Figure 2: Mixed method: the embedded design

The survey was conducted with all 56 regional NRM bodies/catchment management authorities 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 questionnaire survey was distributed in two stages. Initially, the questionaries were distributed to regional NRM bodies which belong to the Murray Darling Basin Authority (MDBA) and later to the remaining NRM bodies around Australia. The feedback and experience from the first distribution assisted in the second stage of the survey and assisted in achieving the high response rate. 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 organisations and two from the RGC. It consists of six categories of organisations/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 organisation in achieving the KIN goal. The data collected through the questionnaire was analysed 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 organisations 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 and five-point action plan (a mix of institutional consideration and technical consideration) was formulated.

4. RESULTS

4.1 Results from Survey: Descriptive Statistics

Spatial Capacity of Regional NRM Bodies and GIS Activities

The majority (approximately 70%) of regional NRM bodies 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.

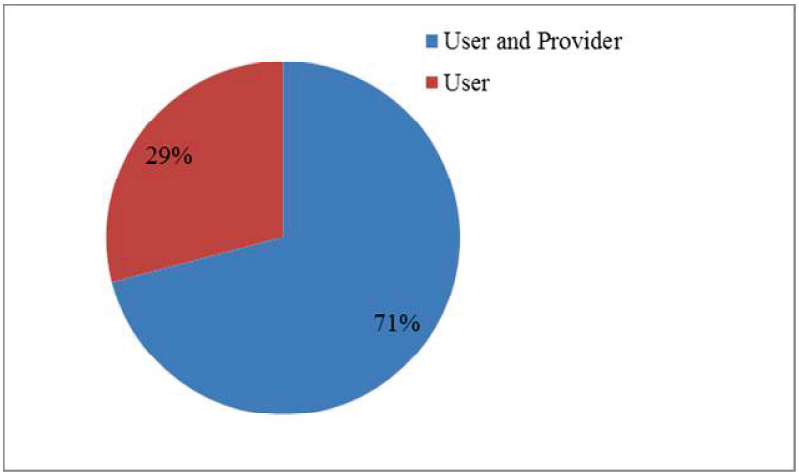

Figure 3: Breakdown of user/provider of spatial information

With respect to the use of spatial information by regional NRM bodies staff, 40 out of 56 regional NRM bodies indicated that over 40% of their staff use spatial information. In contrast, only 7 out of 56 regional NRM bodies indicated that less than 20% of their staff utilise 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 regional NRM bodies 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 regional NRM bodies in Australia are quite mature with respect to using spatial information as part of their catchment decision-making processes.

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 regional NRM bodies responded that spatial information can play a very significant role, with the remaining 40% of the organisations responding that it can play a significant role. Not a single organisation 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).

Information Flow and Data Access

It examined the effectiveness of access to spatial data from data providers. Approximately half (48%) of the regional NRM bodies 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 regional NRM bodies indicated that it was difficult (Figure 5.6). 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 organisations (77%) indicated that they also supplied spatial information. The main users of spatial information that was generated or value-added by regional NRM bodies were the community organisations such as Landcare, Watercare, Birdwatch, landowners and indigenous groups. Government organisations, the private sector and academic research institutions utilised spatial information managed by regional NRM bodies less frequently. It was also evident that there is a two-way information flow between regional NRM bodies and government organisations. As a result of this mutual interest, government organisations are interested in collaborating and networking with regional NRM bodies via data sharing agreements.

Spatial Information Sharing Factors

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

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

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 organisation in achieving the KIN goal.

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

The Frequency of Interaction

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

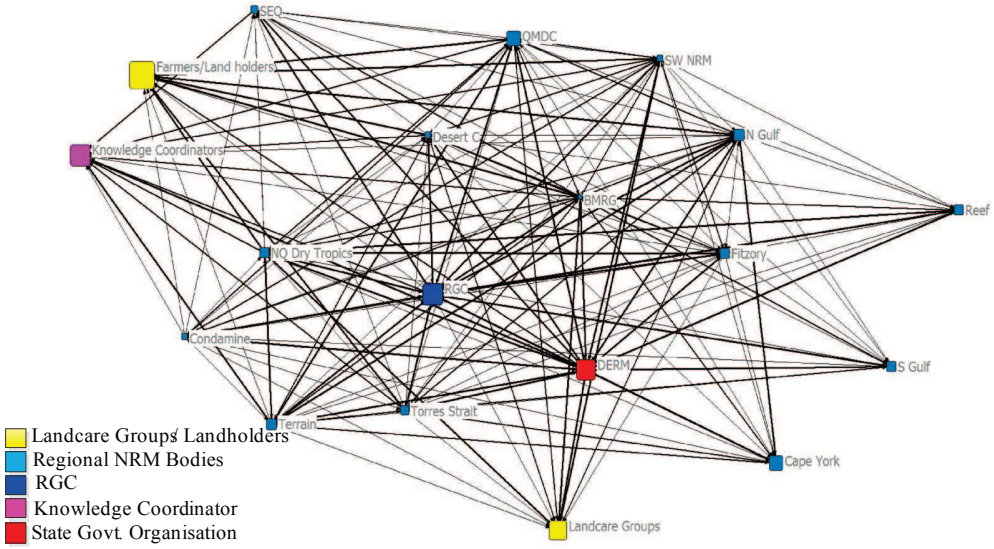

Figure 4: Frequency of interaction

Figure 4 shows the frequency of interaction between regional NRM bodies and other organisations. Five types of organisations directly or indirectly contributed to the KIN project. The different colour nodes represent the organisation type. The size of the node represents the value of InDegree centrality and the rate of frequency of interaction with other organisations. 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 organisation with respect to the communication.

It was observed that regional NRM bodies had frequent interactions with farmers/land holders and landcare groups, though these groups were not directly involved in the KIN project. Regional NRM bodies 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 regional NRM bodies 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 organisations (DERM, Landcare groups, etc) in comparison with internal regional NRM bodies. RGC and DERM both appear at the centre of the network. The organisations which appear at the centre of the network diagram indicate the importance of their role to maintaining communication relationships.

Rate of Flow of Spatial Information

The flow of spatial information was used as a unit to measure transactional relationships between organisations. Participants were asked to rate the flow of spatial information between

their organisation and other organisations. 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 regional NRM bodies and other organisations. There were four different categories of organisations involved in spatial information sharing and the organisations are differentiated by node colours. The variations in line weights represent the rate of flow of spatial information between organisations. 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 regional NRM bodies is higher than with those that are more distant.

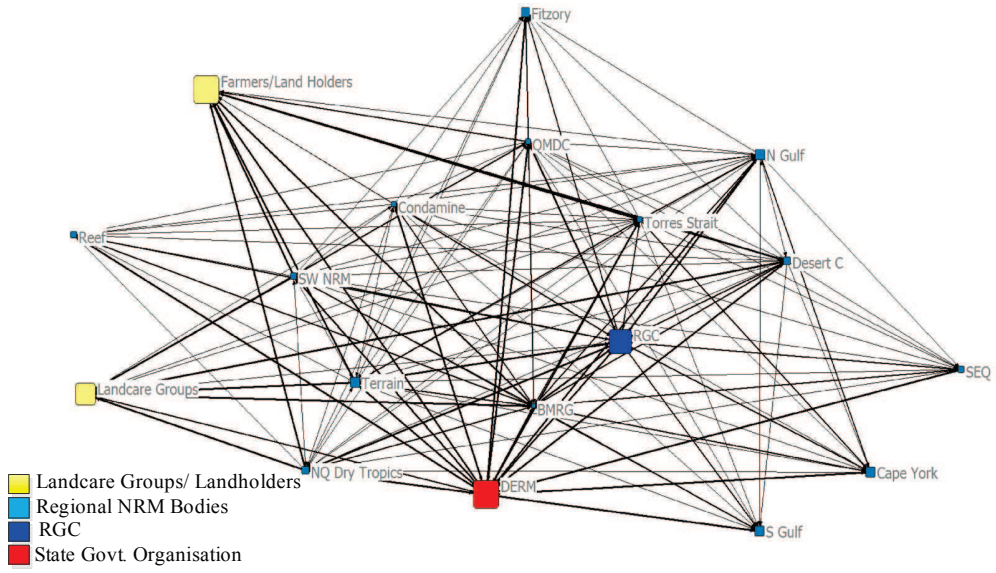

Figure 5: Flow of spatial information

Role of Organisations in Achieving the KIN Goal

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

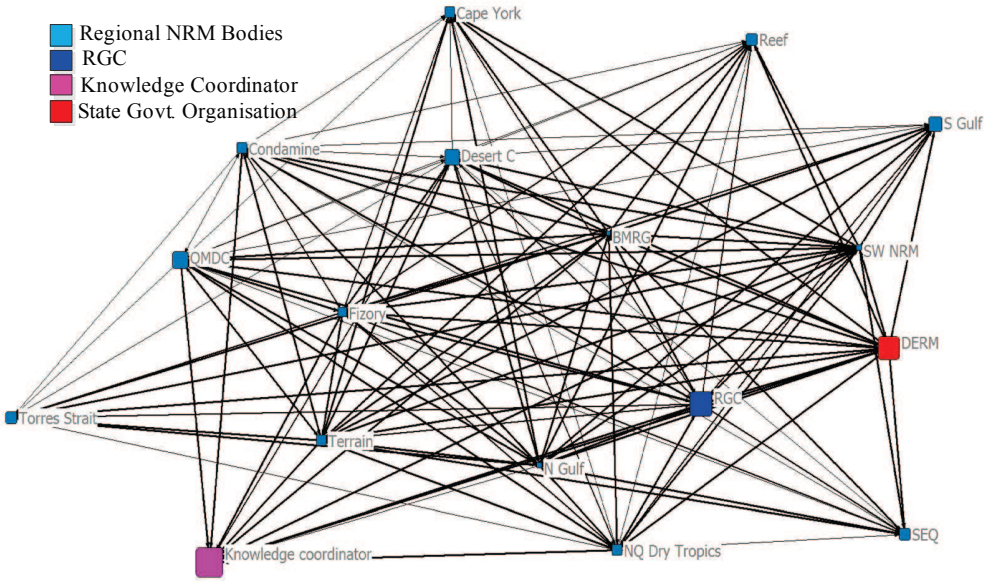

Figure 6: Role of organisations in achieving the KIN goal

Figure 6 shows the role of organisations 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 organisation. The organisations which appear at the centre of the network diagram indicate the importance of their role in achieving the KIN goal. Three organisations 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 regional NRM bodies varies, however, RGC could be seen as having a coordination role in bringing all the regional NRM bodies 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 organisations 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 regional NRM bodies 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).

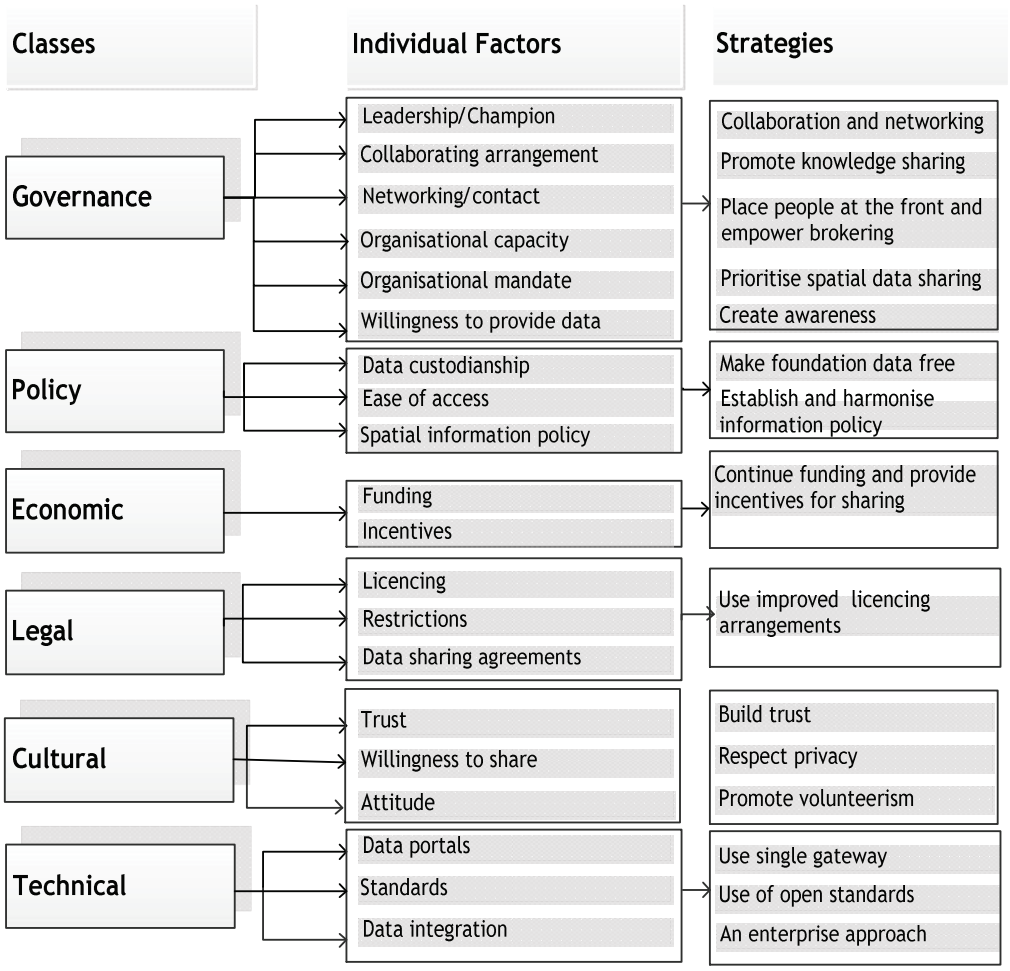

Figure 7: Spatial data sharing factors and strategies

The six main governance factors that influence the spatial information sharing between regional NRM bodies and state government organisations include leadership/champion, collaboration arrangement, organisational capacity, networking/contact, organisational 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 regional NRM bodies to manage spatial information. Specifically, there was no policy to return the spatial information collected by regional NRM bodies to the state repositories or to utilise that spatial information for updating state-wide NRM databases. Spatial information sharing was not considered a part of the organisational 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. Regional NRM bodies were used to multiple licensing arrangements with state government organisations 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. DEVELOPING A ROAD MAP FOR IMPLEMENTING SPATIAL DATA SHARING STRATEGIES

A roadmap can serve as a starting point for implementation of comprehensive SDI program (The National Academy of Sciences, 2012). In this study, the roadmap sets out the approach that will be adopted for the implementation of improved spatial information sharing arrangements between regional NRM bodies and state government organisations in Australia. Specifically, it provides specific guidelines on how spatial information sharing strategies can be adopted and used in practice, provides support to address spatial information sharing issues, and improves spatial information sharing arrangements in catchment management sector. A five-point action plan is suggested for the implementation of these strategies. The first four are institutional considerations and the last one is a technical consideration.

6.1 Establish a formal knowledge and information network (KIN) between state government organisations and regional NRM bodies

Collaboration and networking was identified as an important strategy to improve spatial information and knowledge sharing between regional NRM bodies and government organisations. It is proposed that a formal knowledge and information network (KIN) be established throughout the states, similar to Queensland KIN. The institutional arrangements of this network should include spatial data managers, knowledge coordinators, communication officers and representatives from community volunteer organisations and government agencies. The knowledge coordinator and spatial data manager should be a focal position to promote spatial information and knowledge sharing. The communication officer should establish communication channels and improve the communication between regional NRM bodies, community volunteer organisations and government agencies. This will also help to build trust for collaboration. The communication officer should also create awareness for the prioritisation of spatial information sharing as part of each organisation's goal. The collaboration arrangements will bring all stakeholders together to pursue an appropriate data licensing agreement with government and community partner agencies. This arrangement should support the preparation of an appropriate information policy.

6.2 Ensure an effective governance arrangement for catchment management

The Australia New Zealand Land Information Council (ANZLIC) is Australia's peak spatial information council, responsible for developing "best practice" guidelines for the use and sharing of spatial information in Australia and New Zealand. In most of the states there are spatial councils which are responsible for spatial policy and strategic direction for the use of spatial information. The NSW Spatial Council (NSC), Victorian Spatial Council (VSC), Queensland Spatial Information Council (QSIC) and Western Australian Land Information

System (WALIS) are examples of formal state spatial information councils. It is important to formalise some formal spatial council in each of the states to support ANZLIC and to promote spatial information within their state jurisdictions. Similarly, an effective governance arrangement should be established to ensure that NRM bodies are represented on the state spatial information council. This will ensure a strong stakeholder voice in the development of spatial information policy and improve the access and availability of public sector information (PSI). The Commonwealth Government and the Victorian Government have already recognised the benefits of improved access and availability of PSI and other states should follow. With this arrangement, the regional NRM bodies will have an opportunity to be the member of the Open Geospatial Consortium (OGC) and the issue of data interoperability can be addressed using open standards. This effective governance arrangement will bind together technology, organisations and information. This will constitute the enabling platform for effective spatial information sharing.

6.3 Communicate the work of regional NRM bodies for a strong voice to government

Adequate resources, time and effort are needed to develop catchment SDI and facilitate spatial information sharing. Regional NRM bodies need to influence and lobby government agencies to support their activities by utilising their collective energy or power. Regional NRM bodies need to align their business with government priority areas to obtain funding as state and federal government funding is highly competitive. They need to convince government agencies about the importance of their work so that their collective voice will be accepted and their program will be prioritised. For example, the Murray Darling Basin Authority (MDBA) was able to convince federal government to provide funding by demonstrating their achievements on the ground. The federal government has provided funding to develop the basin plan knowledge and information directory (BPKID) as part of their information sharing strategy. The MDBA has been pursuing appropriate data-licensing agreements with state and federal partner agencies to improve spatial information access and sharing. Likewise, regional NRM bodies should highlight the critical catchment management issues and identify how improved spatial information sharing arrangements will help to address these issues.

6.4 Continue to encourage the community volunteer activities

There is a need to create a formal mechanism to continue and encourage community volunteer initiatives such as landcare, birdwatch, water watch, coastcare and bushcare and to utilise these volunteer inputs for spatial information collection and management. These groups are not a formal part of the knowledge and information network. The involvement of grass-root level community groups for natural resource management has a long tradition in Australia. These community volunteer activities have been very successful in achieving better environmental outcomes and their volunteer inputs are widely acknowledged by government agencies. Recent developments in ICT tools and spatial technology have provided these groups with a new opportunity to manage the natural resource data utilising their volunteer synergy. Mechanisms should be established to systematically collect and validate data that is collected locally so that it can be utilised as a regional resource. These groups are also key users of spatial information collected by regional NRM bodies and therefore the access to spatial data should be facilitated to support their volunteer initiatives. These actions will ensure that the local environmental and spatial knowledge of these groups can be utilised to achieve better natural resource management outcomes.

6.5 Develop appropriate spatial and ICT tools spatial information management

The development of appropriate spatial technology and ICT tools and existing infrastructure to enable volunteers to submit data via smart phones and other mobile devices should be a priority. This should be coordinated through a KIN type model or by creating a representative body similar to regional groups collective (RGC) in Queensland. It was found that some form of collective or representative organisation is desirable in each of the states to provide a single, strong voice for regional NRM bodies to improve the state-wide delivery of regional NRM outcomes. This organisation should be funded by regional NRM bodies and the state and federal governments. The website of the representative organisation should be utilised as a single gateway for access and use of spatial information. The OGC open standard should be used to address the issues of interoperability. This will assist in integrating authoritative spatial data and volunteered geographic information (VGI).

7. CONCLUSION

This paper has contributed to the current body of knowledge by exploring the spatial data sharing arrangements in catchment management areas and developing a road map for implementing spatial data sharing strategies utilising mixed method research approach to facilitate spatial data sharing between NRM 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 organisation) 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.

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 regional NRM bodies and the KIN project case study. Eighteen issues were identified as being highly significant and classified into the six major classes of organisational, policy, economic, legal, cultural and technical. The non-technical factors (organisational, 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 road map and strategies from this research have the potential to improve spatial information sharing between regional NRM bodies and government organisations to support better catchment management decisions.

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