Spatial Data Infrastructure Frameworks to Support Decision-Making for Sustainable Development

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ABSTRACT

Sustainable development requires the resolution of many spatial decision problems in regard to managing the rights, restrictions and responsibilities between people and land. Most spatial decision problems are multicriteria in nature, involving economic, social, environmental and political dimensions and competing values. However, the process of multicriteria decision-making is not well established or effectively integrated into contemporary frameworks for spatial analysis or infrastructure.

The need to support decision-making to address the multiple issues concerning sustainable development creates a growing need to organise data across disciplines and organisations through development of spatial data infrastructures (SDI). The principle objective for developing SDI is to achieve better outcomes from spatially related economic, social and environmental decision-making. To this end there has been significant evolution in the approaches taken to implement and support frameworks for spatial data use and access, involving product-based approaches as well as those emphasising the communication process (process-based).

The product-based model for SDI development has been a popular approach for many initiatives. This model has been the domain of managing and automating the availability, access and integration of spatial information. This approach has been advantageous toward the coordination of datasets and standards to support the derivation of information for decision-making. For SDI to evolve to support multicriteria decision-making, process-based approaches to developing SDI frameworks also offer important advantages. Decision-makers face challenges to establishing linkages between data, information and decision-support technologies in many contemporary SDI initiatives. Significant advantage stands to be gained from developing SDIs to support the means for the promotion,

discovery and access to decision-support technologies, facilitated by SDI models emphasising the communication process.

This paper presents the application of product and process-based models as two approaches to SDI development, based on reviews of the concept and nature of these models. Product and process-based models contribute to and help build current understanding about the importance of an infrastructure to support the interactions of the spatial data community. The capacities of current SDI to support decision-making are assessed with respect to SDI development from both product-based and process-based approaches within Australia. SDIs that address support for spatial multicriteria decision problems are investigated for initiatives within State jurisdictions. The frameworks by which product and process-based models can meet the mandates of SDI development for the jurisdiction are proposed, and factors contributing to the success of the models are discussed with regard to the support of multicriteria decision-making for sustainable development.

Introduction

Sustainable development entails the effective incorporation of economic, social, political, conservation and resource management factors into decision-making (Ting and Williamson 2001). It therefore requires the resolution of many spatial decision problems in regard to managing the rights, restrictions and responsibilities between people and land. The need to support decision-making to address the multiple issues concerning sustainable development creates a growing need to organise data across disciplines and organisations through development of spatial data infrastructure (SDI). SDI is fundamentally about facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial data community.

The principal objective for developing SDI for any political/administrative level, as highlighted by Rajabifard *et al.* (1999), is to achieve better outcomes for the level through improved economic, social and environmental decision–making. The role of SDI is to provide an environment in which all stakeholders, both users and producers, of spatial information can cooperate with each other in a cost-efficient and cost-effective way to better achieve organisational goals. SDIs have the potential to promote widespread use of the available spatial data sets, which are essential to optimise spatial technology support for decision-making processes.

Many national, regional, and international programs and projects are working to improve access to available spatial data, promote its reuse, and ensure that additional investment in spatial information collection and management results in an ever-growing, readily available and useable pool of spatial information. To this end there has been significant evolution in the approaches taken to implement and support frameworks for spatial data use and access, especially applications utilising the benefits of product-based approaches, and those emphasising the communication process (process-based).

The focus of product-based approaches to SDI development has been the domain of managing and automating the availability, access and integration of spatial information. An emphasis on harmonising standards for spatial data capture and exchange, the co-ordination of data collection and maintenance activities and the use of common data sets by different agencies, have been to support the derivation of information for decision-making. For SDI to evolve to support multicriteria decision-making, process-based approaches to developing SDI frameworks also offer important advantages.

Decision-makers requiring technological support for complex forms of spatial decision-making face challenges to establishing linkages between data, information and decision support systems (DSS) in many contemporary SDI initiatives (Birk 2000). DSS are geocomputational systems developed to access and utilise domain (discipline-focused or experiential) knowledge bases to support decision-making by the generation of alternative solution scenarios between multiple criteria, and often spatial representations of these through maps and cartographic tools. Significant advantage stands to be gained from developing SDIs to support the means for the promotion, discovery and access to decision support technologies, facilitated by SDI models emphasising the communication process.

In this paper the applications of product-based and process-based models of SDI are investigated, with a look at the positions taken by current SDI initiatives, particularly throughout Australia. The authors analyse the means for these approaches to SDI development to improve decision-making frameworks in different jurisdictions, through facilitating integrated applications of multicriteria DSS. Factors contributing to SDIs successfully supporting DSS for spatial decision making, to support the objectives of sustainable development, will be discussed.

Decision-making for Sustainable Development

Decision-making may be broadly defined to include any choice or selection of alternative course of action (Malczewski 1999), and is therefore of importance to many fields in the social and natural sciences, including the geographical information sciences. Since the 1992 Rio Declaration on Environment and Development' call to develop strategies to guarantee the existence of all life, not just human life, there has been acknowledgement of the need to integrate environmental and developmental aspirations at all levels of decision-making.

A preliminary step toward achieving decision-making for sustainable development has been increasing recognition of the role of geographic information to generate knowledge, provide added value to identify problems, assist in proposing alternatives and defining a course of action, geographic information discovery, access and use. The importance of geographic information to support decision-making and management of growing national, regional, and global issues, such as deforestation and pollution, was specifically cited in the Rio Declaration (Ting and Williamson 2000) and has been made one of the key themes to the meeting of the 2001 Commission on Sustainable Development (CSD 2001).

Decision problems that involve geographical data and information are referred to as spatial decision problems. Spatial decision problems often require that a large number of feasible alternatives be evaluated on the basis of multiple criteria, thus spatial decisions are multicriteria in nature (Massam 1980).

Multicriteria decision-making is more complex than that based on a single criterion, because of the difficulty finding an alternative that dominates all others with respect to all criteria. The number of people involved in the decision-making process influences the complexity of spatial decision problems (Massam 1988; Malczewski 1996). They may be characterised by different preferences with respect to the decision consequences and the relative importance of the evaluation criteria. The incorporation of values and preferences into decision-making models is an important function of multicriteria analysis in complex decision problems.

The need for sustainable development to link social, economic and environmental issues, and examine the use of land in an integrated manner to minimise conflicts, as recommended by UNDSD (2001), requires multicriteria decision-making. With this is mind, the multiple criteria involved in mediating sustainable use of land-based resources in an integrated manner was the focus of the 1999 UN-FIG International Workshop on Land Tenure and Cadastral Infrastructures for Sustainable Development, which resulted in the Bathurst Declaration (UNFIG 1999). The Bathurst Declaration identified the need for reliable information infrastructures to record environmental, social and economic rights, restrictions and responsibilities as well as provide spatial data to facilitate appropriate decision-making (figure 1) and support conflict resolution (UNFIG 1999). These drivers in turn affect the resulting spatial data industry environment and SDI vision, in particular partnership concepts.

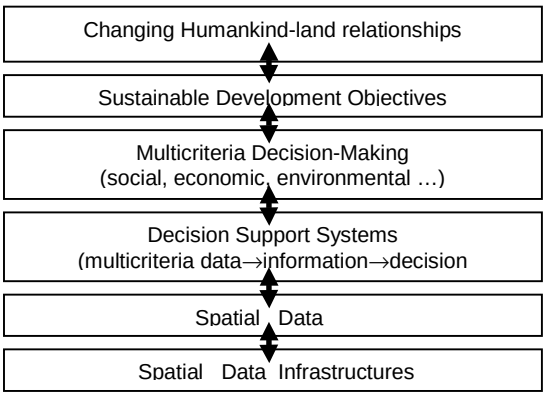

Figure 1: The need for Spatial Data Infrastructures to provide spatial data to facilitate appropriate decision-making for sustainable development

SDI Development

The design of any SDI requires understanding the nature of the concept, the contributing components, the impact of global drivers and the needs of the user community. The interaction of the spatial data users and suppliers and any value-adding agents in between, drive the development of any SDI. These present significant influences on the changing spatial data relationships within the context of SDI jurisdictions. For this reason the formation of cross-jurisdictional (both intra- and inter-jurisdictional) partnerships has been the foundation of SDI development initiatives supported to date.

There has been a trend for countries to expand their effort in developing SDIs through partnerships. In the 1990s different countries' national SDI development took a broad-base approach to encourage cooperation among stakeholders to pool data assets. Based on this approach, an ideal SDI should have all data sets in the corporate SDI fully integrated. Constrained by existing technical and institutional arrangements, SDI developing agencies have focused on promoting adoption of common standards, as well as fast-tracking integration among certain strategic data sets through partnership arrangements (ANZLIC 1996, Jacoby *et al.* 2001). Partnerships are formed to create business consortia to develop specific data products or services for strategic users, by adopting a focussed approach to SDI development.

From this popular approach to SDI development in the 1990s, focused on defined data and partnership *objectives*, there has emerged the idea that the approaches to SDI development in future need also to facilitate more defined *interactions* between people, data and emerging technologies (Ting and Williamson 2000, Chan *et al.* 2001), in order to achieve the flexibility to meet user decision-making requirements and to support sustainable development objectives.

All decisions require data yet the rights, restrictions and responsibilities influencing the relationship of people to data become increasingly complex, through compelling and often competing issues of social, environmental and economic management. Human issues of

data sharing, security, accuracy and access encourage the need for more defined relationships between people and data. In a SDI people (data users through producers) cannot access data without the framework of the access network, policy and standards – the main technological components of interactions within a SDI (figure 2). Therefore, facilitating the role of people and data in governance that appropriately supports decision-making and sustainable development objectives is central to the concept of SDI.

On this basis the identification of competing factors in SDI development have given rise to the idea that approaches designed around defined interactions, rather than defined outcomes and objectives alone, hold great potential for the development of initiatives established to support the on going use of enabling technologies, like DSS, and decision-making environments adaptable to the complexity of sustainable development.

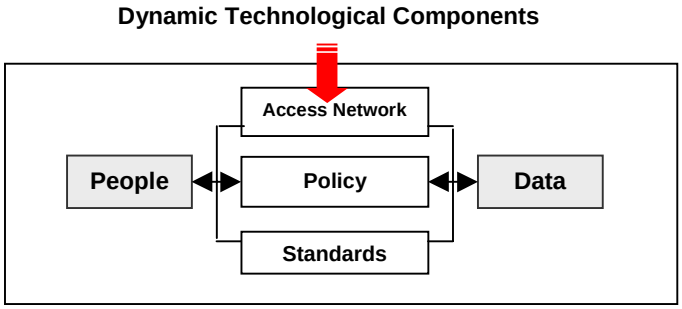

Figure 2: Nature and relations between SDI components (from Rajabifard *et al*. 2001)

The Product-based and Process-based Approaches to SDI Development

The competing importance of 'content' and 'conduit' development in infrastructure has been acknowledged from the origins of early infrastructure definitions in the telecommunications sector (Coleman and McLaughlin 1998). Whilst the competing foci are of relative importance to each other, as mentioned earlier, the balance of SDI development to date has been on *content* formation and preliminary access agreements, evolving within short-term frameworks or on a project-by-project basis and thus taking on *product-based* characteristics.

The deliverables expected from SDI initiatives have frequently had more to do with aligning the access networks, policies and standards for particular stakeholders or databases, than establishing *conduits* or long-term *process-based* spatial data-people networks. Rajabifard *et al.* (2001) propose that the future of SDI lies in addressing the balance between the competing foci in SDI development to encourage process-based facilitation for participant initiatives for spatial data sharing. Whilst ongoing *content* development, a product-based approach, is essential to complement process-based facilitation, the differing roles of each in the development of SDIs is becoming more important for longer-termed commitments to and investments in SDIs. Masser (2000) identified similar approaches when discussing the implications for access within National SDI initiatives.

Rajabifard *et al.* (2001) highlighted that both product-based and process-based approaches can be identified from the strategies, aims, objectives and status of contemporary SDI initiatives in different political and administrative levels. The product-based model represents a popular and familiar approach with the main aim of an SDI initiative being to link existing and potential databases of the respective political/administrative levels of the community. The process-based model presents a less widely adopted approach with the main aim of an SDI initiative as defining a framework to

facilitate the management of information assets, that is to provide better communication channels for the community for sharing and using data assets.

The process-based model emphasises facilitation through development of a communication channel of knowledge infrastructure and capacity building (Rajabifard *et al.* 2001). This facilitation can be supported by creating a clearinghouse system, metadata directory or other facility for collecting and storing information about datasets and databases within a community. By creating such systems the coordinating agency is able to increase the knowledge infrastructure for that community by enabling them to better identify appropriate datasets and communication links with custodial agencies.

Both approaches have value, but they provide different frameworks for dealing with intra-jurisdictional mandates for the objectives of spatial data access and sharing. Appropriately adopting either the product-based or process-based models for SDI development will provide a framework in which to meet the mandates of the relevant SDI jurisdictions. Alternatively, the approaches may be able to be combined, whence SDI development initiatives taking composite product-process approaches are able to balance the advantages drawn from both, enabling the SDI initiatives to be more versatile. Therefore, an initiative predominantly adopting a process-based approach may fast-track development by establishing working-groups addressing particular *content* issues or responsible for the establishment of specific SDI components, which adopt a product-based approach.

Approaches to SDI Development in Australia

Australia, whilst predominantly displaying product-based approaches to SDI development (also noted by McLaughlin and Coleman 1998) has recently recognised the value in taking a facilitation role for SDI development rather than that of implementation of a specific data product by itself. Australia has started to incorporate more process-oriented models to address some of the challenges faced by SDI development, particularly at a national level, under the influence of a federated political system.

The initial aims for Australian SDI development (ANZLIC 1996) faced the difficulties of coordinating many individual efforts (the differently-staged achievement by Australian states, as well as awareness of the value and vision of SDI development), which made the objective of alignment difficult to achieve. Whilst product-based approaches to data set assembly and sharing were the focus of SDI development from 1991-1996 (ANZLIC 1996) a transition toward process-based development has been initiated through a clearinghouse initiative - the focus of an ANZLIC workshop in March 2000 (ANZLIC 2000). More recent efforts toward ANZLIC pursuing a role of coordination have resulted in ANZLIC delegating the task of integrating and sharing different jurisdictional data sets to the Public Sector Mapping Agency (PSMA) in cooperation with the private sector. This is emphasised by the reported vision of the PMSA as " the coordination, assembly and delivery of…national data sets from fundamental databases held by member agencies" (PSMA 2000). The PSMA plays an important role as champion and coordinating body for the development of initiatives progressing objectives of SDI developments in Australia.

Rajabifard *et al.* (2001) suggest the difficulties faced in the development of a SDI, which may precipitate a change in development and implementation strategies, occur more when the political structure of a nation is a federated system, or SDI development is at the multinational level, which are both cases relying on voluntary participation. They propose (Rajabifard *et al.* 2001) that selecting and aligning an appropriate model for SDI

development with the initiative objectives may assist jurisdictions to be better able to address and overcome some of the development difficulties currently faced, depending on the jurisdictional level of the SDI communities. However, an equally valuable extrapolation of these models may be made to SDI development occurring between jurisdictions, which are also reliant on voluntary participation

In regional (sub-national) SDI initiatives in Australia there lacks a formal mandate to develop SDI other than through the natural resource and regional development legislation at state and national levels. This raises many challenges to supporting sustainable development objectives and appropriate management and planning decision-making, due to the number and variety of jurisdictions, let alone stakeholders, involved in decision-making, as well as the scale of decision-making especially at the catchment and ecotone-scale (IREM 2000, Walker *et al*. 1999).

As a result, many SDI initiatives in regional Australia have followed an empirical approach to infrastructure design and development, which tend to integrate local resources and follow well-defined stages. This makes these initiatives open and flexible to the inclusion of complementary decision-support and other spatial technologies and demonstrates the variable use of product and process-based development models. By evaluating product and process-based development models for regional infrastructure initiatives the development and design features adaptable to support the information needs of DSS may be examined with a view to their value for future development, particularly in terms of supporting the complexities of decision-making for sustainable development.

Applications of Product and Process-based Approaches to Support SDI Development in Australia

There are many levels of information resource integration and facilitation involved in the development of SDI within a jurisdiction, such as a state or nation. Product and process-based development approaches can be applied to these different initiatives, which become an integral part of SDI within a jurisdiction. The interaction, alignment or combination, of product and process-based development approaches taken by individual initiatives not only has an important influence on how an initiative defines and achieves its objectives independently, though this is the principle focus of this paper, but also within the framework of the jurisdiction SDI.

This section will examine applications of how the product and process-based approaches have been taken within a state jurisdiction in Australia. Two examples of applications demonstrating different models of development and implementation within regional Australia (specifically the states of Queensland (QLD) and New South Wales (NSW)) are the Integrated Information Management System (IIMS) and the Herbert Resource Information Centre (HRIC). These models will be reviewed against the main criteria for discussing the development of any SDI initiative, including the motivations for the development, expected outcomes, management of the development, development participants, the measures of progress, the primary political/administrative function of the development, as well as the time-frame commitment of development. As a broad-brush assessment of the approach taken by SDI initiatives, Rajabifard *et al.* (2001) suggest these criteria provide a framework against which any initiative can be defined as product or process-based.

1. Process-based SDI model for the Integrated Information Management System (IIMS)

The Integrated Information Management System (IIMS) initiative was developed between 1996-1999 for catchment managers (IREM 2000) and demonstrates a process-based model for SDI development. It was funded by the Land and Water Resources Research and Development Corporation, and has been developed in collaboration between the Department of Natural Resources (QLD) and the University of Queensland in consultation with stakeholders and potential users (IREM 2000).

The motivation for developing the IIMS was the lack of resources (data, models and human skills) available for resource managers to adequately respond to management issues (IREM 2000). One key issue behind the project was that few attempts had been made in Australia, to integrate social, behavioural and economic data into spatial decision support systems (DSS) that could assist planning decision-making (IREM 2000). DSS are perceived to be central to facilitating the adoption of best management practices, which support the objectives of sustainable development.

The aims of IIMS are to facilitate the use of research outcomes and government information by Catchment Management Committees (CMCs) and allow them to identify the resource use options available to stakeholders (other CMCs, rural landowners and Local Governments) to improve the management of their land and water resources (IREM 2000). Specifically, the aims and expected outcomes behind establishing IIMS included:

- Develop a resource that is freely available to all stakeholders
- Develop a resource that is suitable for resolution of complex, integrated and multi-criteria resource management issues, rather than just single issue problems
- Develop an information and decision tool that facilitates the integration of component research, experiential and other information into a catchment and regional context
- Help to assess the appropriateness and potential impacts of new knowledge, technology and adoption processes.

The results of the IIMS development were three prototype facilities developed for catchments in QLD and NSW. IIMS prototypes for assessment in the Dee (QLD), Dawson (QLD) and Liverpool (NSW) catchments (IREM 2000) were established as web-based facilities where information, links to related information/legislation/technologies, research and particular DSS could be established to aid catchment decision-making. The IIMS provides web-link access to and advertises workshops for a Multiple Objective Decision Support System (MODSS) named *Facilitator* (IREM 2000).

The IIMS was established with the principle time frame being that of establishment, prototype testing and feedback. Therefore the measures of progress have been in terms of the proof-of-concept, the value of the political and administrative function of the development, and the achievability of the concept. For longer-term development the IIMS will need to gain government, community and industry support to become a sustainable business venture and a permanent part of state SDIs. However, well-established models of similar process-based regional SDI-building initiatives exist, such as the Central Highlands Regional Information Service (CHRIS) in Queensland (CHRIS 2001). The success and support for CHRIS (CHRIS 2001, CHRRUPP 2001) suggests the sustainability of the IIMS will be a matter of momentum from the government, business and information needs of the community.

IIMS demonstrates a process-based model for SDI development. It principally facilitates access to the necessary resources for decision-makers to achieve the management and planning decisions necessary to support their business needs within the limits of sustainable development, derived from the utilisation of the information, technology and research made available.

2. Product and Process-based SDI models in The Herbert Resource Information Centre (HRIC)

The Herbert River catchment drains an area of approximately 10 000km^2 in North Queensland, Australia, and is bounded by two areas of World Heritage: The Great Barrier Reef and the Wet Tropics (Walker *et al.* 1999). Competition between alternative resource uses in the catchment requires that industry imperatives need to be reconciled with the requirements of other users to achieve ecological and economic sustainability for the Herbert River catchment. This corresponds with increasing community expectations of preservation of the natural environment, involvement in decision-making and conflict resolution.

The Herbert River Mapping Project was formed in 1993 to facilitate the collection and sharing of data between 11 agencies from industry, community and the 3 tiers of government (local, state and federal) and was completed in 1996 (Walker *et al.* 1999). The motivation for the project was the need to address the challenges associated with sustainable development objectives, which are frequently constrained by paucity of the data at spatial and temporal scales relevant to decision-making, poor coordination or communication between participant stakeholders, limits to data processing and analytical capabilities of participants, and a poor understanding of key issues (Walker *et al.* 1999).

During the course of the Herbert River Mapping Project it became clear the access and on-going facilitation of benefits from the data, especially advanced analysis of the digital data through GIS, DSS and complementary spatial technologies would require an evolving collaboration to manage the resource data (Walker *et al.* 1999).

The result was the formation of the Herbert Resource Information Centre (HRIC), a catchment-based GIS facility that supports the management of natural resources in the Herbert River catchment by providing and allowing access to geographic information, GIS tools and expertise (HRIC 2001). The HRIC currently involves 6 partners from 3 tiers of government, industry and primary producers to facilitate a common geographic view of the catchment and to enable synergistic planning amongst partners and the community (Walker *et al.* 1999). Beyond the sphere of collaboration, though, the HRIC acts as a conduit for delivering research products and services to decision-makers at the local and community level. The HRIC specific aims are:

- Improve the quality of data available for the catchment
- Improve access to data
- Support better informed decisions in planning and implementing data collection and use
- Support better informed decisions in natural resource management
- Improve collaboration between stakeholder groups with an interest in the management and use of the catchment's resources (Walker *et al.* 1999).

The HRIC can be considered to have adapted both product and process-based models of SDI development in order to meet its objective of supporting resource management planning and decision-making in the catchment, specifically in the face of the challenge of supporting the objectives of sustainable development. From a product-based approach, the HRIC collaboration removes duplication and its associated costs and has ensured availability of a high quality dataset that meets user requirements and business needs. This was very much the formative stage of HRIC development, especially through the Herbert Mapping Project. However, the product-based approach has in turn provided an economy of scale for GIS services that enables small organisations to have access to data and expertise not normally available in rural areas. The HRIC does not resource data capture and maintenance directly, but acts as a project manager to coordinate these activities, fulfilling a much more process-based approach.

The process-based aspect of the HRIC has enabled the introduction of supporting technologies to be made available to users of the centre facilities, as well as consultation as to the application and modification of such technologies for appropriate decision-making. One particular example has been the introduction of the web-based spatial decision support system, NRM-Tools, which has been jointly developed by the CSIRO, the Sugar Research and Development Corporation (SRDC) and the CRC for Sustainable Sugar Production (CSIRO 2001). NRM-Tools has been designed to explore issues and options in integrated natural resource management and is being run in prototype through the HRIC such that the data and tools being run within the current version are focussed on integrated resource issues from the Herbert River catchment (CSIRO 2001).

Models need to be established to extend the concepts of SDI into coordinated operational models enabling the production of spatial data products, services, the long term support of spatial industry processes and decision-making. The utility and uptake of the concepts and components of SDI, and thus SDI functionality, is dependent on the current and developing capabilities of SDIs to support complementary spatial and decision support technologies, which contribute to the support of multicriteria decision-making for the management and planning activities of the spatial industry, particularly in relation to the mandate for sustainable development.

By demonstrating two applications within the state jurisdiction in Australia this paper proposes the benefits that different models for development of SDI initiatives may have.

Product-based development models like the Herbert River Mapping Project have been shown to remove duplication and its associated costs and ensure availability of a high quality, integrated dataset that meets user requirements and business needs. Walker *et al.* (1999) found the benefits from such an approach included increased confidence in data use, consistency of presentation, consistency and comparability of results because all parties operate using common data, as well as augmenting an understanding of data needs and data resources used by other stakeholder groups. The product-based approach was responsible for establishing and fulfilling collaborative data-sharing agreements as well as creating an understanding of the data needs and data resources used by other stakeholder groups (Walker *et al.* 1999). This product-based approach created particularly an increased awareness of data availability, quality and limitations within the catchment, which fed into the design of further process-based development to complement the Herbert River Mapping Project.

Process-based development models like that of the Integrated Information Management System (IIMS) have enabled the introduction of supporting data, information and technologies to be made available to users, as well as a forum for consultation, application and modification of these resources to support decision-making. This model facilitates SDIs acting as a conduit for the transfer of relevant research and development products to stakeholders by increasing the opportunities and incentives to integrate social, environmental, economic and spatial data into services that support decision-making and planning.

Combined product and process-based development models, such as that applied for the Herbert Resource Information Centre (HRIC), have demonstrated that the benefits of one model can be fed into the other. In this example the product-based approach provided an economy of scale for GIS services, based on the integrated datasets, to enable access to data, expertise and decision support tools by the community that would not normally be available. The combined model enables improved data availability, data collection and data storage through evolving custodial partnerships committed to fulfilling the potential of the data projects with which the collaboration commenced.

Conclusions

The need to support decision-making to address the multiple issues concerning sustainable development creates a growing need to organise data across disciplines and organisations through development of spatial data infrastructures (SDI). The principle objective for developing SDI is to achieve better outcomes from spatially related economic, social and environmental decision-making. The product and process-based development models proposed by Rajabifard *et al.* (2001) for SDIs are supporting differently structured decision problems, such as multicriteria decision-making, as demonstrated by the case studies conducted for regional initiatives within state SDI development in Australia. The case studies demonstrate how product and process-based models use different techniques to meet the information needs of decision-makers in a community, complemented through methods for promotion of, discovery and access to different DSS by community members.

By demonstrating these applications within the state jurisdiction in Australia this paper proposes the benefits that different models for development of SDI initiatives may have. Product-based development models like that of the Herbert River Mapping Project have been shown to remove duplication and its associated costs and ensure availability of a high quality, integrated data set that meets user requirements and business needs, especially in terms of standardising the data accessible for multicriteria decision-making. Process-based development models like that of the Integrated Information Management System (IIMS) have enabled the introduction of supporting data, information and technologies to be made available to users, as well as a forum for consultation, application and modification of these resources to support decision-making. Product and process-based development models, such as that applied for the Herbert Resource Information Centre (HRIC), have demonstrated that the benefits of one model can be fed into the other. In this example the product-based approach provided an economy of scale for GIS services, based on the integrated datasets, to enable access to data, expertise, decision support tools and DSS by the community that would not normally be available.

“There are real challenges to establishing the operational linkages between data, information and ‘decision support’ ” (Birk 2000). There are many levels of information resource integration and facilitation involved in the development of SDI within a

jurisdiction, such as a state or nation. Product and process-based development approaches can be applied to these different initiatives which become an integral part of SDI within a jurisdiction. The product and process-based SDI development models provide different ways for meeting these challenges for individual initiatives. However, the interaction, alignment or combination, of product and process-based development approaches taken by individual initiatives not only has an important influence on how an initiative defines and achieves its objectives independently, though this is the principle focus of this paper, but also within the framework of meeting the objectives for the jurisdiction SDI.

This paper is part of ongoing PhD research on the means for developing SDI to support decision support systems within a jurisdiction, with particular emphasis on the challenges faced by state SDI initiatives. The methods by which individual SDI initiatives design and achieve strategies to support decision-making for multicriteria problems, such as those posed by sustainable development, is the first stage to fulfilling research on the influence of aligning and combining development strategies on the effects of SDI development across a jurisdiction.

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