Facilitating land-sea interface through seamless SDI

The paper discusses coastal zone and spatial information management issues and the potential for adding a coastal dimension to an SDI to facilitate coastal zone management

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THE land-sea interface is one of the most complex areas of management in the world consisting of both the marine and terrestrial environments. The coastal zone is also home to an increasing number of activities, rights and interests. Population along the coastline is continuously increasing, bringing about new pressures on the fragile eco-system of the coastal zone. This has brought with it an increased need to more effectively and efficiently manage this area to meet the economic, environmental and social outcomes of sustainable development.

In this respect, Coastal Zone Management (CZM) initiatives are turning to more integrated strategies worldwide, attempting to harmonise economic, social and environmental objectives, similar to the better-developed land use management frameworks of many urban areas. In coastal areas however, the diversity of interests, some terrestrial and some marine, compounds the issue. Integrated Coastal Zone Management (ICZM) recognises that the coastal resources management situation is unique; that is, it differs greatly from management of either land or water resources, being a combination of both (Bartlett et al. 2004).

It has been established that access to spatial data aids in decision making for management and administration .In response to this situation, on land, Spatial Data Infrastructure (SDI) have been developed to create an environment that will enable users to access and retrieve complete and consistent spatial datasets in an easy and secure way. Within the marine environment tools such as marine cadastre can provide a means for delineating, managing and administering legally definable offshore boundaries, however there is still the need for an overarching spatial information platform to facilitate the use and administration of these tools in a holistic fashion. Currently, most of the SDI initiatives mainly restrict their attention to the landward or seaward regions with little or no consideration of coastal zones. There is the growing and urgent need to create a seamless SDI model that bridges the gap between the terrestrial and marine environments, creating a spatially enabled land-sea interface to more effectively meet sustainable development objectives.

With this in mind, this paper discusses coastal zone and spatial information management issues and the potential for adding a coastal dimension to an SDI to facilitate coastal zone management. It looks at the complexity and issues regarding management of the land-sea interface. Further it discusses the need to develop a seamless SDI as an enabling platform to increase the efficiency and effectiveness of management across regions and disciplines.

Costal zone issues and challenges

On land issues and challenges such as data interoperability and data integratability have been identified as major issues. However, there are more issues facing marine environment as it is highly dynamic with 4D boundaries and thus natural resources or features are more likely to move with time which leads to poor accuracy, precision, consistency

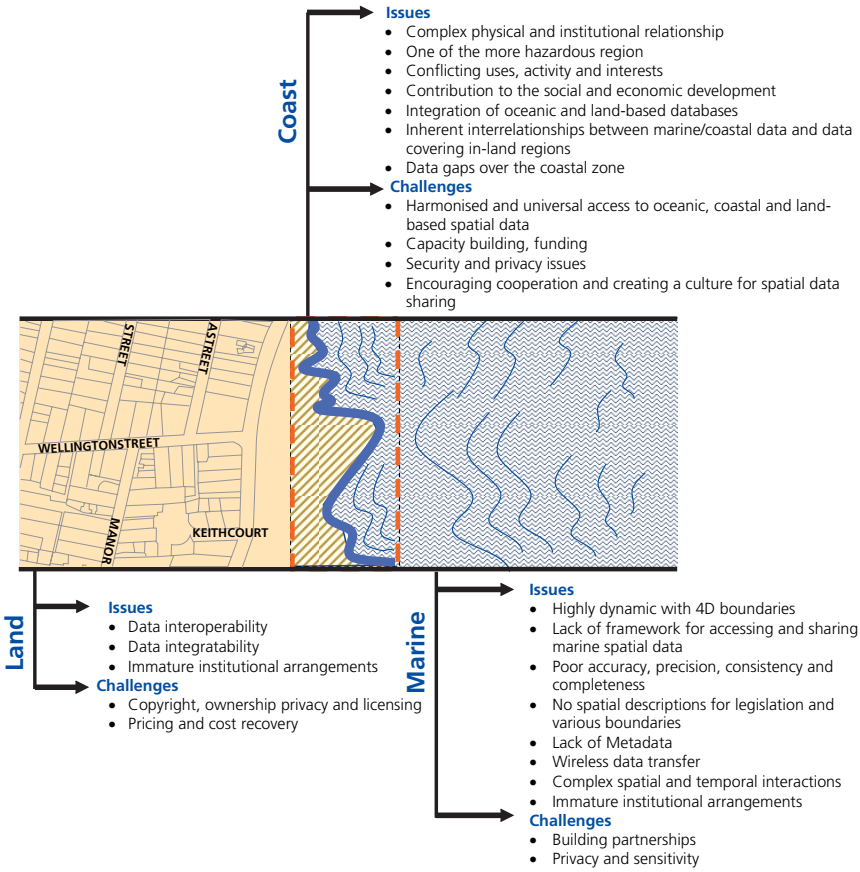

Figure 1: Issues and challenges of the land, coast and marine environments

and completeness of marine spatial data. These difficulties compound in the coastal zone, as it is both the on and offshore environments combined and interrelated.

As the interface between marine and terrestrial environments, coasts have diverse and ever increasing conflicting pressures and demands requiring effective administration and management. To improve management of the coastal zone, there needs to be access and interoperability of both marine and terrestrial spatial data.

However the need to effectively manage the coastal zone as well as the need for interoperable data between the three environments (land, coast, marine) requires a management system that incorporates them all. This has been recognised through the development of integrated coastal management (Gillespie et al. 2000), an initiative that aims to combine management of the coastal zone, spatially, institutionally, and ecologically. Figure 1 shows the conceptual demonstration of issues and challenges of the land, coast, and marine environments. It implies the need for overarching spatial information framework to facilitate the management of the whole environment.

Based on the issues and challenges demonstrated in the above figure and having said that, the development of a framework such as a seamless SDI would aim to aid in facilitating decision making in order to respond to these complexities a number of institutional, technical and policy issues would need to be overcome in order to facilitate the management of land sea interface.

Institutional Issues

The coastal zone is difficult to manage due to the fact that it is governed by a complex array of legislative and institutional arrangements from local to global scales. A coastal state may be a party to many international conventions (i.e. RAMSAR, MARPOL, and London Convention) in addition to developing its own national, and even state or local regulations. Activities and resources are usually managed in a sectoral and ad-hoc approach with legislations or policies created when the need arises and specific to only one area of interest (Strain et al. 2004). Furthermore, there is currently some confusion about the management of the land-sea interface, an example being in Australia where local governments manage land to High Water Mark (HWM), and state governments manage the marine environment from the Low Water Mark (LWM). This means that there are no overlapping arrangements in place to enable efficient coastal zone management. There is also a strip of land between the two boundaries which is not within a management jurisdiction at all (Binns & Williamson 2003).

There are also a large number of stakeholders with rights, interests, or responsibilities for management in the coastal zone. Binns (2004) states that there is often little cooperation or collaboration between these groups responsible for managing the same area offshore. To add to the complexity these rights and interests can often be overlapping and sometimes conflicting or competing for space.

In any jurisdictions groups typically collect and maintain data to support their own specific disciplines or programs, with little or no consideration given to collecting, processing or managing data for use by other users. As such, available data are often inadequate for clear, rational decision making which is both environmentally and economically sound (Gillespie et al. 2000). The result is that organisations working in the same country or in the same discipline collect similar data in different ways, engage in much duplication of effort, suffer from insufficient or inappropriate standards, or are insufficiently aware of methods that should be used, or of the availability of existing data.

Technical Issues

Results of a GIS pilot study undertaken on Port Philip Bay, Victoria summarised

coastal management issues as consisting of: overlapping coastal interests; data gaps between terrestrial and marine environments; resolution differences and scale variations in coastal demarcation, spatial relationship between conflicting interests over the coastal zone; and representation inconsistencies due to data errors (Loton, 2006).SDI must be based on 'interoperability' (seamless databases and systems). International standards organisations are addressing the development of standards for both land-based and marine-based spatial data and technologies. S-57 (Special Publication No. 57) cartographic standard developed and maintained by the International Hydrographic Organisation (IHO) International Hydrographic Bureau (IHB) in Monaco (IHO 1996). Within the terrestrial environment, the International Standards Organisation's Technical Committee 211 (TC/211) on Geographic Information/Geomatics creates a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth . For coastal zone users, a big issue is the difference in standards between land and ocean data products. In many instances, these data products are incompatible in terms of scale, projection, datum and format (Gillespie et al. 2000). Additional CSDI considerations include: metadata creation and related standards; guidance on spatial precision, accuracy and data formats; data access policies; and intellectual property and related legal issues (Longhorn 2004).

Table 1: Marine/Coastal issues

ISSUES	EFFECTS
Institutional Issues	
Various spatial datasets are collected and stored by different organisations	Finding and obtaining datasets is difficult
Immature institutional arrangements	Reluctance of organisations to share their data
Limited knowledge of marine and coastal environment, boundaries and their associated rights, restrictions and responsibilities	Inefficient and ineffective marine and coastal management and administration
Policy Issues	
Restrictive national security and pricing policy regarding marine and coastal data	Coastal and marine data being withheld from stakeholders and general public
Complex, fragmented regulating framework for marine and coastal management	Inability to adequately handle the pressure of different activities and stakeholders within the coastal zone
Lack of agreed framework of standards, policies and coordination mechanisms	Lack of coordination and sharing of marine and coastal spatial data
Technical Issues	
The dynamic and fuzzy nature of the shoreline as the one of the main fundamental datasets within the coastal zone	Complexity in representation and also barrier to seamless data sharing between disciplines and administrative sectors
Existence of different data formats, reference frames and also lack of metadata and consistency in data	Lack of interoperability of different datasets
Difference in scale, quality , coverage and format of spatial data as well as the lack of, or poor quality metadata	Difficulty in integrating different datasets
S-57 hydrographic data standards is not at the same level of completeness as ISC/TC 211	Difficulty in the interoperability between marine and terrestrial spatial data creates confusion in the coastal zone
Different technology to capture spatial data in marine and coastal environment	Difficulty in achieving the same level of completeness, currency and reliability as terrestrial data

Policy Issues

The population and development pressures that coastal areas experience generate a number of critical problems and policy issues and raise serious and difficult challenges for coastal planners. In many parts of the world, access to detailed information about the coast is considered a very sensitive issue, primarily due to concerns over national security. These restrictive national security and pricing policy regarding marine and coastal data lead to coastal data being withheld from stakeholders and the general public. Other issues also need to be taken into account, including the need for harmonised data access policies and exploitation rights for spatial information, particularly that collected by public sector agencies across different nations and even within single governments (Bartlett et al. 2004). These issues add to the institutional challenges described above, showing that current management strategies are 'fragmented, complex and poorly understood' (Neely *et al*. 1998).

Many coastal management issues could be overcome if a spatial data platform that enables a holistic, integrated and coordinated approach to spatial information for decision-making existed. SDI provides an enabling platform enhancing decision-making and facilitating a holistic approach to management (Strain *et al*. 2004).

Table 1 outlines the current institutional, policy and technical marine/coastal issues and their consequent effect.

Based on the above table, the institutional issues such as collecting and storing various spatial datasets by different organisations result difficulty in finding and obtaining datasets also existing of different data formats, refrence frames and lack of metadata leads to lack of interoperability of different datasets. Accordingly this complex, fragmented

regulating framework for marine and coastal management causes the inability to adequately handle the pressure of different activities and stakeholders within the coastal zone. Therefore there is a need for a framework to better respond to these issues and their consequent effects.

Seamless SDI

As a result, incorporation of marine and coastal regions within global, national and regional SDIs will bring substantial additional benefits of integration, standardisation and interoperability of technologies, enabling better policy formulation, monitoring and enforcement, often reaching beyond the coastal zone itself (Bartlett *et al*. 2004). A more integrated and holistic approach to management of coastal and marine environments would be facilitated by the extension of the SDI on a seamless platform. This would promote data sharing and communication between organisations thus facilitating better decision-making involving marine and coastal spatial information.

For modelling the coastal zone, there is likely to be one source for the land, another for the sea and potentially other subsidiary datasets straddling both. In these cases there will inevitably be some data interoperability issues. One of the typical problems is differences in scale when trying to join together data captured at different scales. Seaward datasets which are often at smaller scales simplifying the geometry of the features while landward datasets are large scale with much more complexity and greater density of details. This results in a disparity in the feature common to both zones. Another barrier to a seamless SDI is in different projections regarding land and sea data, which creates a problem in defining the parameters required for transformations (Gomm 2004).

Common standards and well documented metadata are essential for data discovery, management and compatibility within a SDI.. In this respect the IHO has an important role to play in developing the appropriate standards needed for its hydrographic and cartographic applications, in close cooperation with appropriate organisations responsible for standardisation, such as ISO. As an example the IHO S-57 standard, although limited in scope and implementation, provides important compatibility for data sharing in the hydrographic information community. The next edition of the standard will not be a standard just for hydrography, but will have manageable flexibility that can accommodate change and facilitate interoperability with other GIS standards. It will also allow hydrographic offices to use other sources of geospatial data. The next edition of S-57 (which will become S-100), is being based on the ISO/TC211 base standard. This will facilitate the development of additional products and services "other than for navigation" requirements. Funding for the development, maintenance and dissemination methods adapted to user needs and new technology of this Infrastructure, is a very crucial issue, which of course will depend on national policies for recovery or not of the necessary funds (Maratos 2007).

A seamless infrastructure was endorsed by the UN as part of the International Workshop on Administering the Marine Environment held in Kuala Lumpur, Malaysia, 2004 (Rajabifard et al. 2005). It was recommended that a marine cadastre act as a management tool within a marine SDI as an extension to NSDI's across Asia-Pacific. Recently, a recommendation of the 17th United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP) in Bangkok further supported the inclusion and development of a marine administration component as part of a seamless SDI to "ensure a continuum across the coastal zone" (UNRCC-AP 2006).

A seamless SDI platform would enable the utilisation of common boundaries across the coastal zone to ensure no ambiguity exists and no areas are unaccounted for over the coastal interface. This infrastructure will become a powerful information resource for managers in fields as varied as fisheries habitat management,

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pollution monitoring and control, shoreline erosion, weather forecasting and tourism development, etc. The information that can be derived from such a fully integrated information infrastructure will facilitate improved decision making at all levels.

Future direction and concluding remark

As discussed above there is a growing need to develop the seamless SDI model as one platform instead of two to increase the efficiency and effectiveness of the management and administration of the land, marine and coastal environment. However, the differences in the marine and terrestrial environments in fundamental datasets, data collection and technology used in these environments will make interoperability and integratability between marine and terrestrial spatial data a big challenge.

In order to create a seamless SDI across terrestrial and marine environments and jurisdictions, it is worth accepting that it is a dynamic and complex process at different levels of government and requires research and collaboration with academia and private industry.

Research into the technical and institutional aspects of creating a seamless SDI in Australia is one of the major research priorities of a research project being undertaken in the Department of Geomatics at the University of Melbourne. The aim of this research project is to design an overarching architecture for developing a seamless SDI that allows access to and interoperability of data from marine, coastal and terrestrial environments.

The ultimate aim will be a refined SDI model and implementation guidelines that seamlessly covers both land and sea that can be used by jurisdictions to create an enabling platform for the use and delivery of spatial information and services. This development aims to aid in meeting the sustainable development economic, environmental and social objectives of the region through the development of a seamless enabling platform to provide more efficient and effective decision making capabilities across both the marine environment and the land-sea interface. However the multidisciplinary interactions in the land–sea interface require sophisticated information infrastructures that not only do not yet exist, but which will not appear if disciplines continue to develop their SDIs in isolation from one another.

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