

Building Seamless SDI to Facilitate Land and Marine Environments

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Abstract

Due to the high economic value of coastal and marine activities, and to the social value of coastal zones for quality of life, managing the coastal zone is a key component of the socio-economic framework in most nations with coastlines. In recent times several natural disasters hit some part of the coastal areas around the world in particular small islands and archipelagic countries causing hundreds thousands of peoples lost their lives, while those who survived had lost their properties. Learning from such kind of devastating disasters, it is important to have a functioning spatial data infrastructure (SDI) which facilitates discovery, access and sharing accurate, complete and up-to-dated spatial data for better planning and timely disaster management. Sustainable development requires the availability of integrated and comprehensive spatial information throughout the country both land and marine area, that can easily be found and accessed for public.

Having said that, however current SDI design is focused mainly on access to and use of land related datasets or marine related datasets, with most SDI initiatives stopping at the land-ward or marine-ward boundary of the coastline, institutionally and/or spatially. Consequently, there is a lack of harmonised and universal access to seamless datasets from marine, coastal and land-based spatial data providers. This leads to the creation of inconsistencies in spatial information policies, data creation, data access, and data integration across the coastal zone. The extension of an SDI covering the land and marine environments on a seamless platform would facilitate greater access to more interoperable spatial data and information across the land-marine interface enabling a more integrated and holistic approach to management of the coastal zone.

This paper aims to identify and discuss the main characteristics and criteria for utilisation of a Seamless SDI model and to examine the current barriers against implementation of this model. This would help to develop an extended framework to support a spatially enabled jurisdiction covering the land-sea interface. A Seamless SDI leads to the promotion of data sharing and communication between organisations thus facilitating better decision-making involving marine and coastal spatial information.

Introduction

Due to the high economic value of coastal and marine activities, and to the social value of coastal zones for quality of life, managing the coastal zone is a key component of the socio-economic framework in most nations with coastlines. In recent times several natural disasters hit some part of the coastal areas around the world in particular small islands and archipelagic countries causing hundreds thousands of peoples lost their lives, while those who survived had lost their properties. Learning from such kind of devastating disasters, it is important to have an accurate, complete and up-to-dated spatial data infrastructure (SDI) of coastal area for better development planning and timely disaster management. Evidently effective administration and management of these areas to meet the economic, social and environmental objectives of sustainable development is needed. Sustainable development requires the availability of integrated and comprehensive spatial information throughout the country both land and marine area, that can easily be found and accessed for public.

Worldwide countries are realising the need to balance development and exploitation of resources in the coastal zone with environmental and social needs. In the terrestrial domain, the need to share and integrate spatial data for more efficient resource information management has been recognised for over a decade, and has led to the development of Spatial Data Infrastructures (SDI) at all geographical levels from the purely local to the national and global. SDI is a framework for linking users with providers of spatial information. A national SDI comprises the people, policies and technologies necessary to enable the use of spatially referenced data through all levels of government, the private sector, non-profit organisations and academia (Rajabifard & Williamson, 2001). Until recently spatial information management and administration tools have focussed on the terrestrial environment. The concepts of marine SDI, marine cadastre and marine spatial planning have all emerged recently in response to a global realisation of the need to improve management and administration of the marine environment. 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 in order to facilitate a spatially enabled society.

Current SDI design is focused mainly on access to and use of land related datasets or marine related datasets, with most SDI initiatives stopping at the land-ward or marine-ward boundary of the coastline, institutionally and/or spatially. Consequently, there is a lack of harmonised and universal access to seamless datasets from marine, coastal and land-based spatial data providers. This leads to the creation of inconsistencies in spatial information policies, data creation, data access, and data integration across the coastal zone. The complex physical and institutional relationships existing within the coastal zone make it impossible for development of a marine SDI to occur in isolation from land based initiatives (Longhorn 2003, Gillespie 2000). The extension of a National SDI covering the land and marine environments on a seamless platform would facilitate greater access to more interoperable spatial data and information across the land-marine interface enabling a more integrated and holistic approach to management of the coastal zone. The ability to deliver the concept of spatially enabled society will require the creation of a seamless platform which covers both land and marine environments.

With this in mind this paper discusses the need to develop a seamless SDI as an enabling platform to increase the efficiency and effectiveness of management across regions and disciplines followed by an introduction to issues and challenges that must be overcome in developing an overarching architecture for a seamless SDI that allows access to and interoperability of data from marine, coastal and terrestrial environments.

Seamless SDI

Currently there is a lack of coordination and sharing of marine spatial data mainly due to a lack of standards for sharing data, different data formats, little to no recording of metadata, different reference systems used, lack of willingness to share data, difficulty in finding data and gaps in data availability (Barry *et al.*, 2003). These issues have been recognised as a barrier to effective marine management in many countries and in response in Canada, Ireland, USA, New Zealand and Australia and at regional and global levels, the concept of a Marine SDI is emerging (Strain 2006). While the initiatives within each country have different names and are at a different stage of achievement, they all have very similar aims – to improve marine and coastal zone administration and management through better availability and applicability of spatial data. Although many countries are now addressing this problem, often the Marine SDI is developing as a separate initiative to the terrestrial one. The uniqueness of the marine environment means that the existing terrestrial system may not be appropriate for use in these areas. In a land based environment, there is a land administration system that is supported by an SDI, as a facilitating framework and a cadastre, as one of the important layers. There are ideas and drivers to support the development of a marine administration system and it is usually recognised that this must also be supported by an enabling platform such as an SDI.

A more integrated and holistic approach to management of coastal and marine environments would be facilitated by the extension of the current SDI model to include land and marine environments on a seamless platform. This would promote data sharing and communication between organisations thus facilitating better decision-making involving marine and coastal spatial information. Both the marine and terrestrial environments are tightly integrated systems in which all the parts are interrelated and dependent on one another. Destruction or degradation of one component can lead to impairment of other parts or the dysfunction of ecosystem as a whole (Strain 2006). If two separate SDIs were created it would deepen the gap between these two administration systems and make coastal zone management more difficult. There is an opportunity for more research to be conducted into combining these initiatives and developing a seamless SDI that can include spatial data from all environments. This will recognise the interrelatedness of the marine and terrestrial environments and also improve management of activities or resources that occur across these boundaries.

The ability to access and integrate data has been identified as a problem by people involved in coastal zone management, as can be seen from the development of ICM (Integrated Coastal Management) initiatives. 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). Seamless geospatial datasets across the land-marine interface are needed by almost all users struggling with issues of navigation, resource management,

planning, hazard delineation and mitigation, environmental studies, and regulation issues.

Recently, a recommendation of the 17th United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP) in Bangkok 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). It reminded that the Asia and the Pacific region is a potential area for disasters (e.g. earthquake, tsunami...) and the importance of generating a seamless dataset covering the entire Asia and the Pacific region. With this in mind it notified the significant interest expressed by the participating countries and the results obtained so far in the context of the pilot project for the generation of a set of seamless data layers for the tsunami affected area. In this respect Global Mapping project and UNGIWWG SALB project putting a great effort in the generation of global seamless data sets including those for Asia and the Pacific.

A seamless SDI can be seen to have the following characteristics:

- Seamless, the digital spatial data is stored continuously throughout and across any jurisdictions
- Multi-purpose, the same data can be used for different purposes.
- Multi-users, the same data can be accessed by different users concurrently.
- Interoperable, the data stored in the database can be accessed using different GIS software and applications.

Spatially enabled government builds on SDI initiatives and is about improving the operation and processes of government, and delivering better policy and decision making. This enabling infrastructure provides the set of tools combining technical, institutional, legal and policy aspects which can be used to assist the delivery of sustainable development at all levels of government and society. Realising the vision of spatially enabled government is dependent on the development of appropriate mechanisms to facilitate the delivery of data and services (Masser *et al.* 2007). This has been acknowledged by INSPIRE initiative that is currently being implemented by the European Commission and one of its foundation principles is the possibility to combine seamlessly spatial data from different sources and share it between many users and applications (<http://inspire.jrc.it>). A seamless SDI provides a foundation to facilitate a spatially enabled government and society can occur.

The sharing and integration of coastal databases across regions and disciplines through SDI development would permit harmonised and universal access to datasets from land-based, coastal and marine spatial data providers so that complex issues affecting the coastal zone can be properly and efficiently addressed in many economic, environmental and policy areas (Bartlett *et al.* 2004). To improve management of the coastal zone, there needs to be access and interoperability of both marine and terrestrial spatial data.

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, 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. However for creation a seamless SDI, a number of technical, institutional and policy issues would need to be overcome in order to facilitate the management of the land sea interface.

Issues in Developing a Seamless SDI Architecture

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 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 highlighted by Vaez *et al.* (2007) figure 1 implies the need for an overarching spatial information framework to facilitate the management of the whole environment.

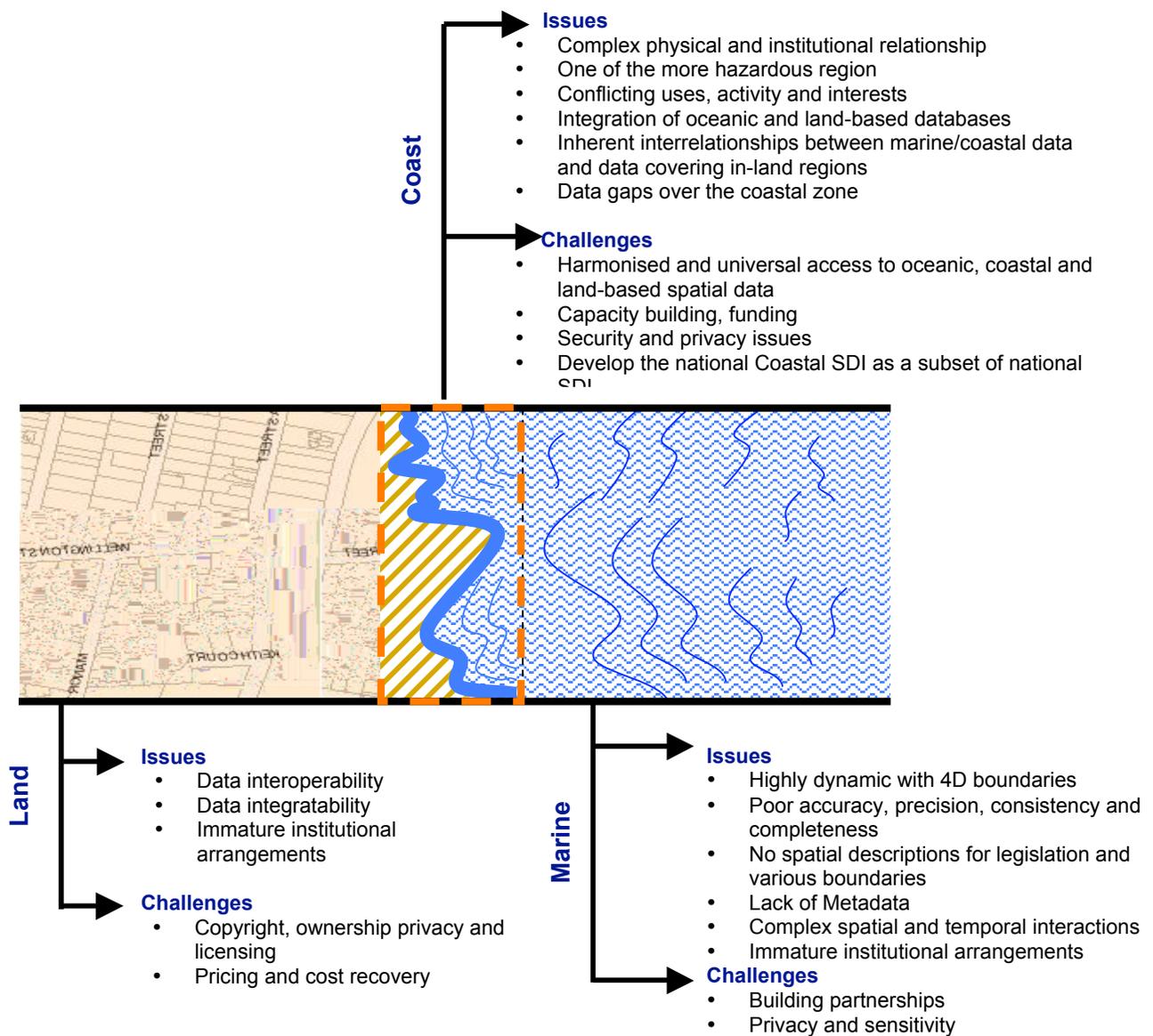


Figure 1: Issues and challenges of the land, coast and marine environments

In order to create a seamless SDI across land and marine environments and jurisdictions, it is important to recognise and accept that building and maintaining an SDI is not an easy task even for well-developed states. It is a dynamic and complex process at different levels of government and requires research and collaboration with academia and private industry. Issues and challenges in developing seamless SDI can be divided into three different categories which are technical, institutional, and legal and policy issues.

Technical Issues It is often difficult to find coastal geospatial data and/or derived products. Once located, it is often difficult to judge the quality of the data or to understand the limitations that apply to their use. With differences in scales, datums, projections, formats, or resolution, the data are often difficult to handle and even more difficult to integrate. From a technical point of view, the lack of spatial data standards that are implemented at a national level is the main problem of the above differences. Each institution or organization creates spatial data for their own purposes using their own technical specification without considering that the data may be shared or distributed to larger communities.

The implementation of spatial standards at a national level will assure that every institution and organization creates spatial data in the same manner and it will ease spatial data sharing and exchange. These must be developed using the international procedures and practises in order to cover not only the national needs but also cooperation at an international level. . 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 and will make provision for imagery and gridded data in addition to the existing vector data, defined in the present version. This will facilitate the development of additional products and services other than for navigation requirements (Maratos 2007). Therefore common standards and well documented metadata are essential for data discovery, management and compatibility within a SDI.

Another concern linked to the establishment of seamless SDI is the issue of a national shoreline. As the fundamental boundary for so many applications and studies, the lack of a consistently defined shoreline has frustrated coastal zone managers, planners, and scientists for many years. Therefore different representations of the coastline in marine and land datasets leads to data overlaps while most of the application requires a single seamless layer of information with no duplication of common features. Additionally differences in shoreline definition can also lead to unnecessary duplication of data acquisition efforts (Ocean Studies Board 2004). A single nationally accepted and consistent shoreline should be defined. The consistent definition of the shoreline would thus not only reduce legal and jurisdictional confusion but also would undoubtedly lead to increased data acquisition efficiency.

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).

Each institution or organization has different policies and rules on managing spatial data. Another exiting problem is that communication between different sectors is poor. There is little understanding of different organizational cultures and enormous administration fragmentation. As a result of this issue there are conflicts between sea users and pressures for services and facilities. Most conflicts have at least some relationship with the multi-objective nature of demand for coastal resources.

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.

Legal and 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. 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.

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

Table 1: Technical, Institutional and policy issues

ISSUES	EFFECTS
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
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
Legal and 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

It is believed that the above non-technical problems can be overcome through coordination arrangements and existence of a single management authority or forum for collaborative planning, and deficient legislation. More information about national SDI are required to have a better understanding and knowledge about SDI among different institutions and organisations and there should be proper regulation to enforce that all spatial data providers should involve in and contribute to the development of national SDI.

Conclusion

In the terrestrial domain, the need to share and integrate spatial data for more efficient resource information management has been recognised for over a decade. There is now increasing recognition by the public at large of the need to support sustainable development of the coastal and marine environments as well. At the moment the practical implementation of a marine SDI is mainly occurring separately to the terrestrial

SDI, using the same components but adapting them to suit the different environment. 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.

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. A seamless platform will be able to model, monitor and manage both marine and land environments particularly the land-sea interface.

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