

Spatially Enabling Coastal Zone Management: Drivers, Design Elements, and Future Research Directions

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Abstract

This paper provides an insight to the drivers, design elements and issues associated with spatially enabling the management of coastal zones, in particular coastal property rights, restrictions and responsibilities. Coastal zones are encumbered by hundreds of property rights, restrictions, and responsibilities. These are created to manage coastal population increases, climate change, and to deliver good governance. Currently, the interests are managed disparately across and between governments: sustainability requires these interests to be managed in an integrated fashion. Spatial enablement can deliver information integration and minimizes the need for redesigning legal, institutional and administrative frameworks. This is recognized in international, regional, and national coastal forums. Emerging concepts including Marine Cadastres, Marine SDI, Seamless SDIs, and Property Objects will inform the solution, however, this paper suggests further research is required to fully understand the complete legal, administrative and technical arrangements in the coastal zone. Moreover, methods for streamlining the integration of property and non-property information are required, particularly the harmonization vertical datums. Finally, the feasibility of spatially enablement needs to be assessed.

Keywords: Spatial Enablement; Coastal Zone; Marine SDI, Property Rights, Restrictions, and Responsibilities

1. INTRODUCTION

Coastal zones are the areas where population growth, climate change, sea level rise, and natural resource discovery are played out. In an effort to manage these complex environments, governments have increasingly legislated new property rights, restrictions, and responsibilities. Examples include special planning controls in coastal zones, protected coastline reserves, and submerged petroleum extraction rights. Coastal zone governance regimes are now extremely complex (Bartlett *et al*, 2004; FIG, 2006): the hundreds of new coastal property interests are managed disparately across and between different levels of government. Moreover, historically land and marine administration have operated in isolation to one another. The coastal zone includes both contexts and administrative voids and overlap between local, regional, state, and national management bodies are common (Strain *et al*, 2006).

Coastal challenges including flooding, sea level rises, erosion, population increase, planning, development and property insurance cannot be managed if coastal property administration and information remains disaggregated (Binns *et al*, 2005). Disaggregated information and processes means decisions are made without full knowledge of the surrounding legal context. In order to manage the coastal zone in a sustainable manner a holistic or seamless framework including legal, administration, and technical components is required in the coastal zone (FIG, 2006). The framework must enable governments, businesses and communities to make sustainable decisions in relation to the coastal zone.

Spatial enablement holds the key. Spatial enablement is an evolving concept (Holland, 2009), however, it is generally considered the establishment of an enabling infrastructure to facilitate use of place or location to organize information about activities of people and businesses, and about government actions, decisions and policies (Williamson *et al*, 2006). In the context of coastal property interest management, spatial enablement offers the opportunity to integrate land and marine information for a diverse set of stakeholders. Coastal property information sets could be linked via their spatial attributes. Blockages in decision-making processes caused by inadequate access to data would be eased. Moreover, spatial enablement would decrease the need to re-engineer pre-existing complex legal and administrative arrangements: a technical platform enabling data sharing would over-ride the need to undertake expensive institutional and legal reform.

The concept of spatial enabling coastal zone management already has some traction (Vaez *et al*, 2009), however, clearer articulation and quantification of the underlying problem is required. Moreover, an up-to-date review of the key drivers, current state-of-play, and future research requirements appears necessary. To this end, this paper aims to quantify the problem and provide an introductory synopsis of the key drivers, status, and future requirements for spatially enabling the management of coastal property rights, restrictions and responsibilities. First, the methodology underpinning the collection of data and collation of results is described. This leads to a discussion of the results. The size of the problem and key drivers for spatial enablement are articulated. The drivers are discussed under the headings of population increase and climate change. Australia is used as a case study. Second, existing theories underpinning the requirements for, and design elements of, spatially enabled coastal zone management are discussed. Third, current initiatives and planned future work relating to spatially enabling coastal property management are covered. Again, the Australian context is used to guide discussion. Finally, the paper concludes with a summary of the key issues emerging from the paper.

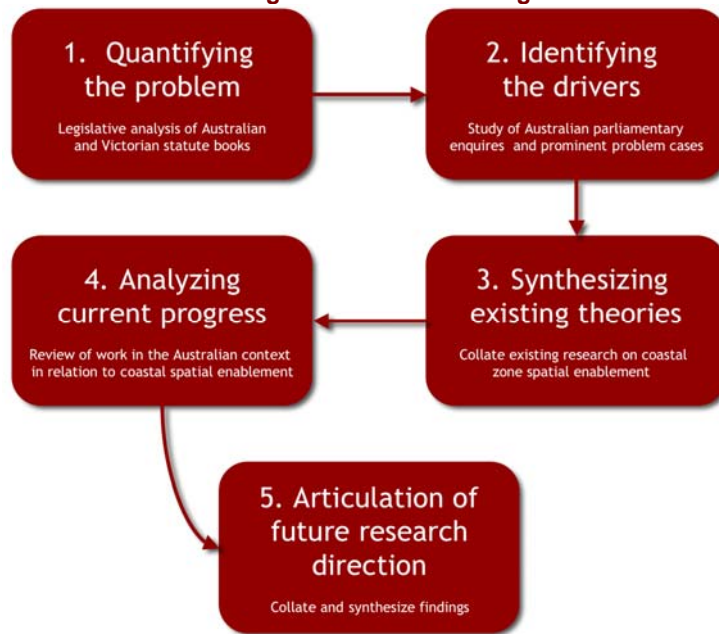
2. METHOD AND APPROACH

The research underlying this paper was centred on an exploratory case study. This is distinct from a 'descriptive' or 'explanatory' case study. Exploratory case studies discover new theories often after the completion of data collection (Yin, 1993). They can be used to develop hypotheses that are more rigorously tested in later studies. This technique appeared highly appropriate as the study aimed to review the current context and develop hypotheses relating to the future development of spatially enabled coastal property management.

In general, the global context was used as the underlying case study, however, the country of Australia and its state of Victoria were utilized as more specific case study sites. Selection was based on the country's extremely large coastal zone, inter-jurisdictional coastal management regimes, involvement in regional coastal management forums, and its proximity to the research team.

The study included qualitative and quantitative components. The qualitative components were used to answer the questions relating to drivers, current status, and future research directions of spatially enabled coastal property management. The quantitative component was used to measure the size of the problem. The study included five stages: quantifying the problem, identifying the drivers, synthesizing existing theories, analysing current progress, and articulating the future research directions. Figure 1 illustrates how these stages were interrelated.

Figure 1. Research Design



Stage 1 consisted of a legislative analysis. It intended to quantify the problem by determining the number of statues creating coastal property rights, restrictions and responsibilities at federal (Australian Government) and state level (Victorian Government). No study of this type has been undertaken in the Australian context. The statute books of both jurisdictions were reviewed and statutes that created coastal property interests were recorded. As statutes books do not remain static a snapshot date for the legislative analysis was determined.

Stage 2 involved a study of the drivers impacting decision-making in coastal zones. The review qualitatively considered contemporary parliamentary enquires and prominent problem cases relating to Australia's coastal zone.

Stage 3 collated existing research relating to spatially enabled coastal, marine and land property management. This included a literature review of recently developed theories and concepts related to marine, land, and coastal zone administration. The outcomes of this stage provide the theoretical underpinnings for spatially enabling the management of the coastal zone.

Stage 4 consisted of reviewing progress towards spatial enabling the management of the coastal zone. This component considered work being undertaken within Australia and more globally.

Stage 5 collated the outcomes of the previous four stages and resulted in the articulation of a future research direction required for spatially enabling the management of the coastal zone.

The results of all five phases were collated and synthesized. The subsequent results are discussed in the following sections.

3. QUANTIFYING THE PROBLEM

As the coastal zone is increasingly the most important 20% of the worlds land area, it demands good governance (FIG, 2006). Good governance relies on an effective legal framework. Legislative sprawl is often a sign of a legal framework

under strain. Legislative sprawl is the rapid acceleration in the creation of statutes and related regulations within a jurisdiction. It is generally seen as a bad thing as it impedes the drive for good governance by creating complex administrative systems. It is prominent in the marine context.

A simple method of measuring legislative sprawl is to quantify the amount of legislation relating to coastal zone management within a jurisdiction. Figure 2 and 3 provide results from the legislative analysis conducted on the Australian and Victorian (an Australian state) statute books. The graphs reveal the number of statutes legislating property interests relating to the coastal zone at state and federal level within Australia.

Figure 2. Australian federal statutes creating coastal property interests

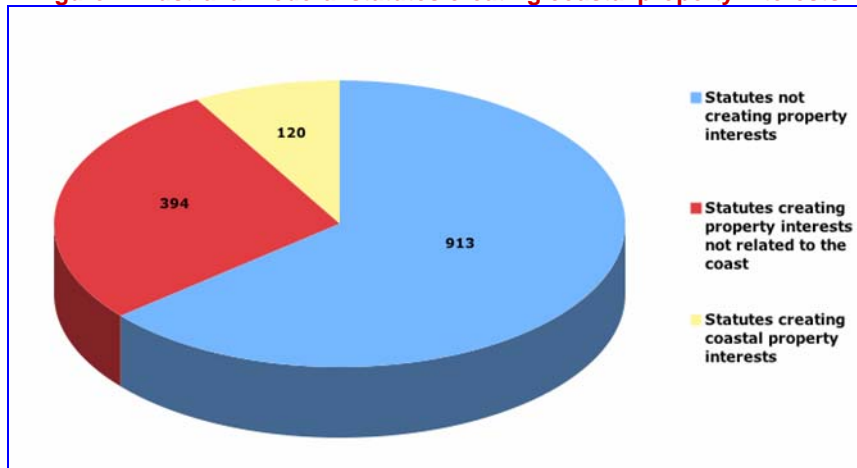
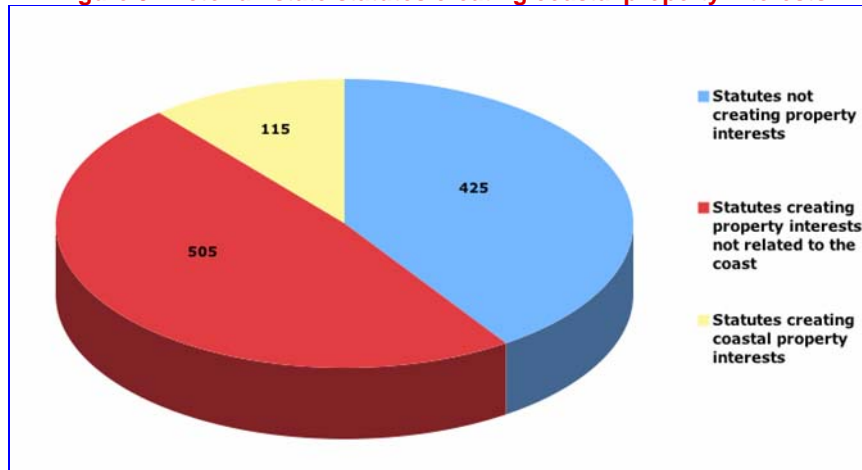


Figure 3. Victorian state statutes creating coastal property interests



A number of points are worth making about the figures. First, the number of statutes creating coastal property interests is significant. Of the 1427 statutes in total at the federal level, 514 create property interests. Of these 120 relate to the coastal zone. Of the 1045 statutes at the state level, 620 create property interests. Of these 115 relate to the coastal zone. These statutes represent hundreds of rights, restrictions, and responsibilities in the coastal zone, all potentially managed using different institutions, databases and processes. It is also worth noting that within each statute there could be multiple interests created. Therefore, the graphs under represent the total number of interests in the coastal zone. Second, the graphs do not reveal the acceleration in the creation of interests over the last thirty years. This acceleration is a concern as it is contributing to the unwieldy complexity of coastal

zone management. Third, while the number of coastal statutes appears to be a small number in comparison to the total number of statutes, the activities they administer certainly are not. These statutes constitute some of the most significant built and natural environment coastal management functions of government.

It is also worth noting that this simple legislative analysis cannot reveal the detail in complex problems relating to existing coastal management systems. For example, in Australia land and marine components are generally managed separately through a range of community, local, state, regional and federal organizations. In the marine environment there is legislative frameworks for managing the oil and gas sector, fisheries, aquaculture, shipping, conservation, marine heritage, native title, and cables/pipelines. These activities are generally managed in isolation to one another. Example legislation includes: Petroleum (Submerged Lands) Act 1967 (Cth), Petroleum (Submerged Lands) Act 1982 (Vic), Fisheries Administration Act 1991 (Cth), Fisheries Management Act 1991 (Cth), Fisheries Act 1995 (Vic), Fisheries Management Act 1995 (Vic), Navigation Act 1912 (Cth), Australian Maritime Safety Act 1990 (Cth), Marine Act 1988 (Vic), Environmental Protection and Biodiversity Conservation Act 1999 (Cth), Environmental Protection (Sea Dumping) Act 1981 (Cth), Historic Shipwrecks Act 1976 (Cth), Submarine Cables and Pipelines Protection Act 1963 (Cth) and many others. In the land domain there are legislative frameworks for managing all land-based activities including land tenure organization, land valuation, land-use planning, and land development. Example legislation includes: Surveyors Act 2004 (Vic), Subdivision Act 1988 (Vic), Property Law Act 1958, Land Act 1958, Planning and Environment Act 1987 (Vic), Native Title Act 1993 (Cth) and hundreds more including the planning controls of local government. Again, many of these land activities are governed in isolation to one another. Further complexity is added in the coastal zone where the already disparate land and marine legislative frameworks interact. How the various pieces of legislation interact along the coastline is often unclear. This makes management and decision-making relating emerging issues such as coastal erosion and sea-level rise quite problematic. More specific issues relating to coastal zone management is revealed in the works of Neely *et al*, 1998; Binns, 2004; and FIG, 2006).

At any rate, it can be summarized that the management of coastal zones depends on a complex legal web of overlapping and conflicting property rights, restrictions and responsibilities governed by disparate land and marine interest groups.

4. IDENTIFYING THE DRIVERS

Many issues were found to be driving the need for improved management of the coastal zone, however, here two key drivers are focused upon: managing population increases in the coastal zone, and managing climate change and variability. These drivers are now outlined.

3.1 Population Increase

Human societies are increasingly tending towards coastal zones. Approximately half of the world's cities with over one million people are located around river and coastal areas (UN-PCGIAP, 2004). Since 2000 a dramatic migration of people to the coast occurred. Now over three billion people, half the world's population, live within 200km of the coast (FIG, 2006). It is estimated that by 2025, this figure will double. Combined with other cities, coastal metropolises will use 75% of the world's resources and expel equal amounts of waste. More people in coastal areas create more pressure on both land and marine environments. Management of these large

coastal populations will be an ongoing challenge for the remainder of the 21st century.

Governments have responded to the pressures created by population increases in coastal areas by creating new property interests to organize people movement, sustain land-use, and control land development. An ad hoc approach has prevailed with different interests groups and arms of government developing, implementing, and administering the new interests in isolation to others. The coastal zone is now a complex legal quagmire of overlapping property rights, restrictions, and responsibilities. A single textual or graphical view of the situation is unobtainable as no agency has the responsibility, authority, or capacity to deliver it. This results in slower decision-making processes for government agencies, often without the complete legal situation being clear to the responsible authority. A new legal, institutional, and administrative approach is required in order to better manage the relationship between people and coastal zones.

3.2 Climate Change

Climate change is another force driving the need for improved governance of coastal zones, in particular coastal property interests. It is predicted sea levels will potentially rise hundreds of millimeters (IPCC, 2007), if not hundreds of centimeters (Allison, 2009), over the coming decades. The impact of these rises has radical implications for countries that conduct activities and desire to protect their coastal zones. Many nations are dependant on their coastal zones for economic, social and political strength. Ports and harbours act as hubs for trade, commerce and transport networks. Millions of people use coastlines as places for dwelling and recreation. Coastal zones are also host to diverse natural environments and sensitive ecosystems. Large changes in sea levels will impact upon all these activities and all the property interests that relate to them. Interests related to parcels, buildings, trade hubs and the natural environment are all potentially impacted. An integrated understanding of all coastal property interests and the impact of climate change on them appear increasingly urgent.

In Australia, climate change will also result in areas of decreased rainfall. This will mean decreased inflows from rivers into ports, harbours and lakes. Holders of commercial oyster leases, fishing licenses and recreational permits, will feel the impact. Fishing stocks including Taylor, Salmon and Brim are already under increasing stress in areas of southeast Australia. Decreased rainfall has the potential to radically alter the nature, use and economic viability of existing agriculture in coastal zones. Many property rights, restrictions and responsibilities relate to the management of coastal fisheries and coastal infrastructure. It appears that in order to manage the impacts of climate change, sea-level rise models need to be integrated with coastal property information.

In summary, coastal population increase and climate change are driving the need for existing land and marine administrative systems to better deliver the property information requirements of stakeholders in coastal areas. A new infrastructure or re-engineered cadastre for the coastal zone is required, one that bridges the gap between marine and land environments and enables holistic definition and sustainable management of all property rights, restrictions and responsibilities in the coastal zone. Moreover, property information needs to be integrated with other forms of spatial data such as sea-level rise models and demographic trends. The underlying theory of this new infrastructure is now discussed.

5. SYNTHESIZING THEORIES ON SPATIAL ENABLEMENT AND COASTAL ZONE MANAGEMENT

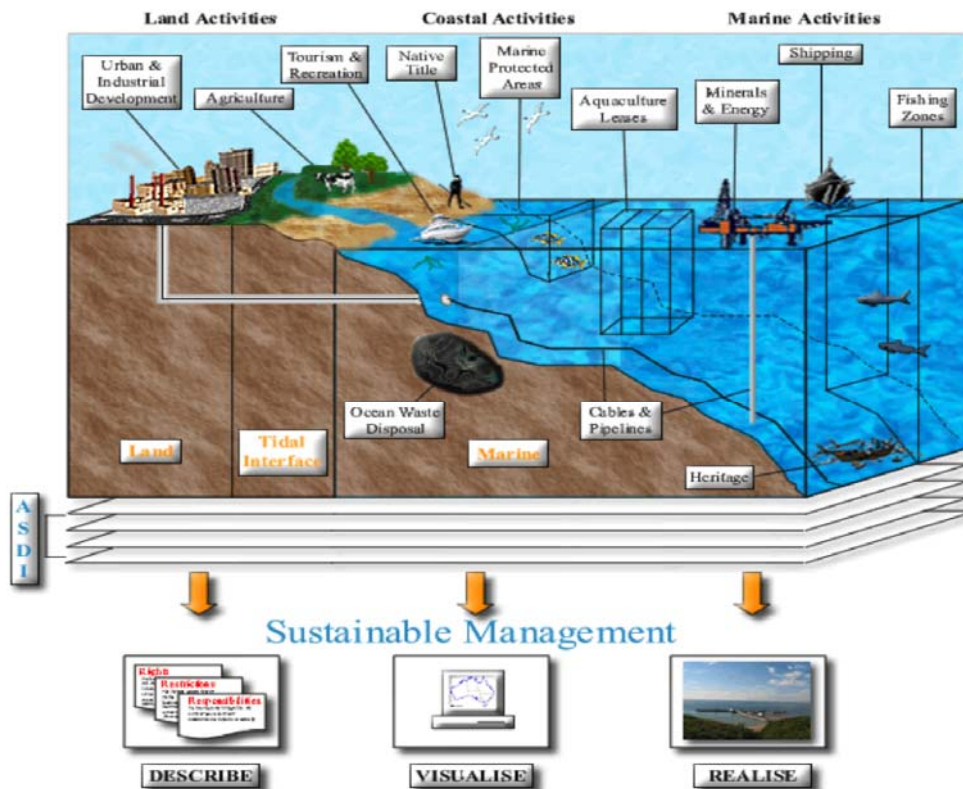
Over the last decade researchers in geomatic engineering, land administration, and marine management have focused on improving information management in land and marine environments. Initial work focused on defining the underlying problems (c.f. Clark, 1997; Gillespie, 2000; Longhorn 2003). In the marine context the concepts of Marine Cadastres (Binns *et al*, 2004), Marine SDI (Stain *et al*, 2005; Tolvanen and Kalliola, 2008) and Seamless SDI models (Vaez *et al*, 2009) were defined. Property Objects (Bennett *et al*, 2008) and Land Administration Systems enabling sustainability (Williamson *et al*, 2009) emerged in land context. In the Australian context a number of Australian Research Council grants focused on the land and marine interface. These included 'Defining and Developing a Marine Cadastre for Australia' (2002-2003), and building 'A Marine Cadastre for Australia - Addressing Key Scientific and Policy Issues (2003-2007). This work brought together the usually disparate land and marine administration communities. The problems with managing the land-marine interface were seen with greater clarity.

Combined research into land and marine administrative systems naturally resulted in a focus on the coastal and zone. It was increasingly clear that the complex layers of coastal property interests lacked reliable, organized and accurate spatial data (Clark, 1997; Li, 2000). Moreover, the complex physical, legal and governance relationships existing within the coastal zone further inhibited sound management of the coastal zone: the 'silo' approach could not continue (Longhorn 2003, Gillespie 2000).

Many issues associated with the management of coastal property rights, restrictions, and responsibilities could be overcome if a holistic framework for integrating coastal property information system existed. Redesigned legal, institutional and administrative frameworks would be important components of any long-term solution, however, it was the integration of information via spatial technologies that would improve the situation in the short term. Therefore, the concept of spatial enablement holds great promise to the realm of coastal property interest management. The concept emerged in the mid 2000s and provides for the establishment of an enabling infrastructure to facilitate use of place or location to organize information about activities of people and businesses, and about government actions, decisions and policies (Williamson *et al*, 2006).

Spatial enablement provides the conceptual solution to improving management of coastal property rights, restrictions and responsibilities. Spatial enablement of the coastal property interests would enable the hundreds of competing coastal zone interests shown in Figure 2 and 3 to be brought together within a single view as all property interests share the common characteristic of being attached to a place (Williamson *et al*, 2004; Rajabifard *et al*, 2005; Masser, 2005). It is the linking ability of spatial information that can improve decision-making as it enables holistic understandings and integrated management of the complex coastal zone (Figure 4).

Figure 4: Spatial information enables a holistic view of coastal zone property objects (Williamson *et al*, 2004)



The International Federation of Surveyors (FIG) now recognizes the potential of spatial technologies in the coastal zone (FIG, 2006). It advocates for a seamless information-sharing platform connecting the land and sea interface. There must be a move away from traditional cadastres that focus on land and stop at the shoreline. Additionally, existing spatial data infrastructures (SDIs) must undergo the same transformation: they tend to direct their attention landward or marine-ward and neglect the complex coastal zone. Achieving these objectives would position a jurisdiction as a leader in coastal zone management and the sustainable administration of coastal property rights, restrictions and responsibilities.

6. CURRENT PROGRESS TOWARDS SPATIAL ENABLEMENT

At the international level a number of global and regional initiatives aim to improve the management of the marine and land interface. These include the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA), Integrated Coastal Zone Management (ICZM) and the 3rd United Nations Convention on the Law of the Sea (UNCLOS). Whilst these initiatives do not explicitly mention spatial enablement, they are important steps towards a shared understanding of the need to improve coastal zone management. These initiatives are mimicking the well-developed land use management frameworks from urban areas. However, in the coastal zone, the diversity of interests, some terrestrial and some marine, compounds the issues (Rajabifard *et al*, 2008).

International land and marine administration communities are naturally more inclined to highlight the importance of the spatial information and its use in coastal zone management. In Malaysia in 2004 The Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) conducted a conference on 'Administering the Marine Environment – The Spatial Dimension.' The meeting was endorsed by the United Nations (UN) and highlighted the importance of coastal information infrastructures. Accordingly a resolution was passed at the 17th United

Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP) in Bangkok in 2006. The resolution defined the spatial dimension of the marine cadastre and recommended that a marine cadastre be added to existing national information infrastructures to ensure a continuum across the coastal zone (UNRCC-AP, 2006). Additionally, the International Hydrographic Organization (IHO) is developing strategies for integrating land and marine SDIs. Its seminar on “The Role of Hydrographic Services with regard to Geospatial Data and Planning Infrastructure” formally recognized an option for Hydrographic Offices to become national SDI partners (Maratos, 2006).

In Australia the need was recognized by most recently by the Australian Parliament’s Standing Committee on Climate Change, Water, Environment and the Arts. Recommendation 11 of their 2009 Report on ‘Managing our coastal zone in a change climate’ calls for the establishment of a ‘National Coastal Zone Database to improve access to and consistency of information relevant to coastal adaptation.’ The significance of an integrated coastal information infrastructure for managing the coastal zone is now patently clear at the highest levels of government. The report ‘National Coastal Zone Database’ will be an important tool in the management of climate change. However, the report only focuses on the provision of elevation and vulnerability data. The inclusion of information relating to property rights, restrictions and responsibilities would radically enhance the database, enabling stakeholders to visually assess the actual impact of climate change on the property interests of people. Also in Australia, research into the coastal zone is a National Research Priority as work in the area is seen as supporting environmental sustainability and also responds to climate change and variability.

Technical solutions are emerging. At the consumer level, Google Earth now integrates various forms of land and marine data within its single visual platform. Whilst the platform is not used to deliver property information, extended licensing agreements would allow it to do so. In Australia, Google Maps does provide access to the parcel outlines; however, no tenure or valuation details are provided. This trend is likely to continue, as governments are extremely cautious about licensing private property datasets to private companies. Additionally, Google Earth cannot provide an authority on accuracy, reliability, and integration on this type of data. Vaez *et al* (2009) relates how much work is being done in the realm of technical standards. The ISO/TC211 terrestrial based standard is the basis of the S-100 hydrographic standard currently in development. The S-100 standard will enable sharing and integration of hydrographic information with other forms of spatial data. It will have manageable flexibility that can accommodate change and facilitate interoperability with other terrestrial standards.

7. FUTURE RESEARCH DIRECTIONS

While this paper provided an initial insight into the size of the problem via the legislative analysis, more in-depth analysis of the complete legal, institutional, and administrative situation relating to these coastal statutes is required. This type of analysis will inform the development of a framework for spatially enabling coastal zone property management.

To further support the spatial enablement of the management of coastal property rights, restrictions, and responsibilities, there is a need for a number of new techniques and associated tools. These include designing an infrastructure that integrates technical, legal and institutional management of all property rights, restrictions and responsibilities in coastal zones; developing methods for integrating other forms of non-property information within the management infrastructure,

including environmental data, sea-level rise data, climate change data, social data and economic data; testing the infrastructure and methods by developing a scenario to assess how sea-level rise and climate change will impact on coastal property rights, restrictions and responsibilities; and identifying requirements and indicators of resources needed to facilitate the implementation of the infrastructure. None of these components currently exist within the Australian context.

These initiatives will improve data management and support new products and solutions for the sustainable development of the coastal zone. They will directly service the needs of government, business and society at local, state and national levels. They will assist with emerging challenges including climate change, potential sea level rise, ecological conservation, population increase, planning, development, property insurance, and risk management. In the Australian context it will assist in the delivery of the 'National Coastal Zone Database' as called for in Recommendation 11 of The Australian Parliament's 'Standing Committee on Climate Change, Water, Environment and the Art's' 2009 report on 'Managing our coastal zone in a change climate'.

The need for methods for integrating property and non-property coastal information (e.g. sea level rise data) is worth highlighting. The focus on developing technical solutions for overcoming existing impediments to data integration is essential. Vertical datums continue to be an issue for data integration, particularly in the Australian context. A seamless platform will enable the impact of sea level rise on various forms of property to be assessed. Also worth highlighting is the feasibility plan for implementing the coastal management infrastructure. The feasibility of the infrastructure through in terms of costing, timelines and resource requirements has currently not received attention

8. CONCLUSION

Coastal zones are encumbered by hundreds of property rights, restrictions, and responsibilities. These are emerging due to population increase and climate change. The interests are managed disparately across and between governments. Sustainability requires that these interests be managed in an integrated fashion. Spatial enablement can deliver this integration with minimal redesign of legal and administrative frameworks. International, regional, and national coordination bodies now recognize the power and need for seamless spatial information sharing platforms in coastal contexts. Concepts such as Marine Cadastres, Marine SDI, Seamless SDIs, and Property Objects provide components of the required framework.

Further research is required to understand the complete legal, administrative and technical arrangements in the coastal zone. Moreover, methods for streamlining the integration of property and non-property information is required, particularly the harmonization vertical datums. Additionally, the feasibility of spatially enabling coastal zone property management needs to be assessed: the technical and economic constraints need identification. Outputs from these short-term research activities will be significant components of future coastal SDIs: an essential infrastructure for enabling sustainable coastal zone management.

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Spatially enabling coastal zone management: drivers, design elements, and future research directions