ENVIRONMENTAL HAZARDS

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research paper

ENVIRONMENTAL HAZARDS
Human and Policy Dimensions

Exploring systems interactions for building resilience within coastal environments and communities

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This paper focuses on identifying examples of first-order systems interactions, which make important contributions to building coastal resiliency for coastal zone management. This discussion is based on an application of the Institutional Analysis and Development Framework to a case-study analysis of coastal management in South Australia. The study suggests that cross-scale interactions and informal relationships within and between users and managers are key interactions defining resilience outcomes within the current system. A significant constraint on improving resilience was the lack of evaluative criteria for identifying sustainable forms of system behaviour. The paper argues that resilience is a function of a normative statement on the characteristics desirable in the functioning system. Analyses of coastal resilience, which facilitate greater understanding of the range of complexities in coastal behaviour, are therefore central to gaining the most useful insights into the options and pathways for building more sustainable coastal futures.

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1. Introduction: Understanding the complexity of the coastal system for coastal management

A primary emerging message from integrated or adaptive systems research is that approaches to knowledge– how it is defined, gathered and applied to problem solving– must imitate to a large degree the patterns and dynamics that define behaviour in the natural environment. This call towards social learning, considering different forms of knowledge as open, interlinked systems in constant dynamics, is currently considered vital towards more meaningful integration (Berkes et al., 2003; Folke, 2006). The move towards exploring interlinked knowledge is not also a call for simple solutions or answers. Rather, it highlights the necessity for environmental management to recognize and understand the complexity of environmental problems – the fact that they are systems problems (Holling et al., 1998; Ostrom, 2007). Understanding the patterns of interconnections within systems, and managing these to build more effective network links, is central to the vision for integrated management. This paper focuses on contributing to such system-based knowledge for integrated coastal zone management (ICZM), identifying patterns of network interconnections within coastal systems.

Recognizing and understanding complexity within coastal systems calls us to get better at diagnosing and managing system problems. Q3 However, what does doing better mean? Janssen and Ostrom (2006) argue from an institutional perspective that 'getting better' at recognizing complexity involves answering a series of questions relating to the following: (1) social dilemmas, for example, what are the conflicting and comprising interactions between the different agents involved?, (2) uncertainty, for example, how do resource users learn and how do their learning processes differ from how public infrastructure providers learn?, and (3) networks, for example, how does information spread among

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nodes in a network and how does this affect resource management? Applied to research in coastal zone management, some of these dimensions of getting better for ICZM have been explored, for example, what are the barriers and opportunities for increasing learning in developing strategic coastal management strategies (e.g. Bastien-Dalyle et al., 2008; McFadden et al., 2009; Smith et al., 2009)? How do resource users and managers view a functioning coast and what are the obstacles and opportunities for exploring coastal futures (e.g. Milligan et al., 2008; O'Riordan et al., 2008)? There is increasingly widespread awareness of the need to capitalize on shared views and knowledge, building network links in space and time for more sustainable coastal management. However, the fact remains that the specific success factors that can facilitate process patterns of integrated strategic coastal management for long-term are still relatively unknown. With this goal in mind, the primary objective of this paper is to use a case-study discussion of coastal management in South Australia to identify a series of first-order system interconnections that emerge as important to building resilience within the coastal system.

The paper uses a specific institutional framework as a template for identifying and exploring system interconnections, that is, the Institutional Analysis and Development Framework (IADF). This framework emerges from the seminal work of Elinor Ostrom (1990), identifying factors behind institutional choice in natural resources management. It focuses on the interactions among resources (e.g. beach), resource users (e.g. tourists), public infrastructure providers (e.g. government agencies, local users' associations) and public infrastructure (e.g. engineering works, policies and other regulations) to identify configurations that enhance or reduce the robustness of human–natural systems (Anderies et al., 2004) (Figure 1). Robustness is defined on the basis of the maintenance of some desired system characteristics despite fluctuations in the behaviour of its component parts or its environment (Carlson and Doyle, 2002). This means that the concept is clearly situated within a broad resilience framework, with its focus on non-structural dynamical change constrained within a stability domain. The concept of robustness is used within the model to highlight the importance of recognizing both the designed (i.e. robust) and self-organizing (i.e. resilient) components of systems. The key aim of the IADF is diagnostic, identifying why some social–ecological systems are sustainable whereas others collapse. It seeks to achieve this through a framework for organizing relevant variables at a series of different spatial and temporal scales. This paper uses first-order interactions from within the IADF as a template for exploring interactions within the case-study area.

Resilience to natural as well as anthropogenic-induced hazards is a much desired attribute of coastal systems and is widely discussed within coastal management literature. This paper contributes to existing research findings on coastal resilience by providing empirical-based reflections from an institutional perspective on specific system interconnections that may prove particularly effective for restructuring system behaviour towards increased resilience for ICZM. However, this analysis also highlights a contextual challenge in the use of the resilience concept for coastal management. It argues that measures of resilience are often a function of a normative statement on the social, physical or economic conditions considered to be desirable within a particular coastal system. Resilience analyses are therefore vehicles for gaining insights into the different preferred courses of action and the range of choices for managing complex coastal environments. This context of the use of the resilience concept is introduced within the following section. The paper then focuses on the case-study application and discusses a series of emerging themes for improving the broad-scale resiliency of coastal systems. Finally, the case-study analysis is contextualized, revisiting the idea of resilience as a relative concept. This section highlights the importance, to coastal management, of gaining an integrated perspective on the functioning coastal environment and suggests a conceptual

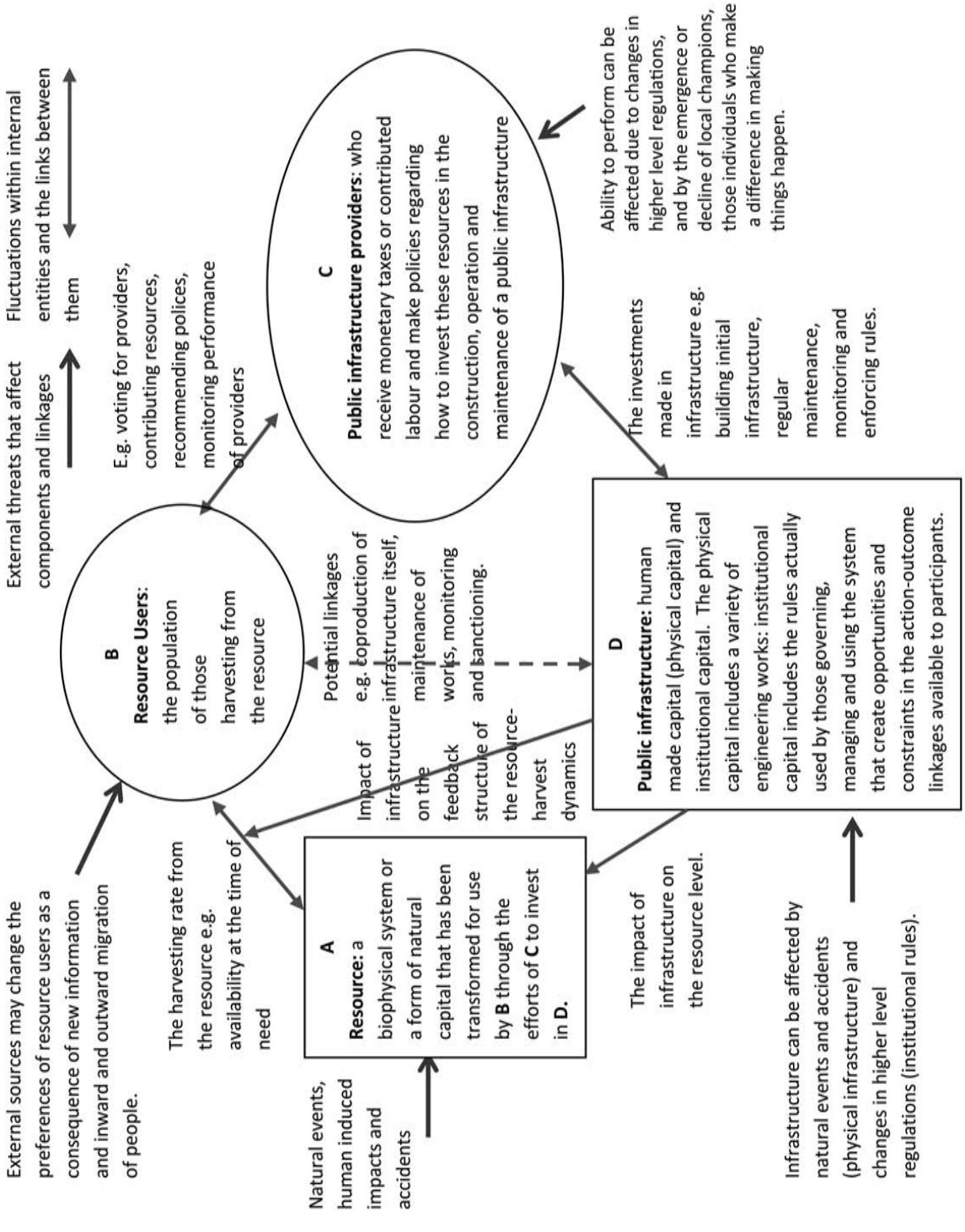

FIGURE 1 A conceptual model of a social-ecological system (Janssen and Ostrom, 2006 after Anderies et al., 2004)

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framework for coupling models of physical and institutional interconnections for a fuller understanding of the resilience of coastal systems.

2. Characteristics and complexities of resilience for coastal management

The literature specifically focusing on resilience is profuse, opening a field in which a wide range of concepts reside. It has been argued that ideas such as 'resilience', 'robustness' and 'vulnerability' can only be understood in relation to one another (van der Leeuw, 2001). Robustness is mostly used to refer to the structural and other properties of a system that allow it to withstand the influence of disturbances without changing structure or functional dynamics. Current levels of robustness may be based on past adaptations. If these were highly specific, the system may need to adapt upon encountering new types of disturbances (Anderies et al., 2004). As defined by Holling (1973), by contrast, resilience refers to 'the capacity of a system to absorb and utilize or even benefit from perturbations and changes that attain it, and so to persist without a qualitative change in the system's structure'. Such a system may take new external conditions into account by absorbing them into its mode of functioning (Holling, 1986). The difference between the two concepts thus seems to lie in the extent to which (non-structural) changes in dynamics may be introduced into a system under the impact of perturbations. Resilience allows for temporary changes in functioning and dynamics, as long as the system remains within the same stability domain. Finally, vulnerability refers to situations in which neither robustness nor resilience enables a system to survive without structural changes. In such cases, either the system does adapt structurally or it is driven to extinction. All three terms express a temporary condition of the interaction between a system and its context (Young et al., 2006). Q5

The importance of the stability domain to the analysis of resilience highlights the fact that functional systems may be temporally dynamic in form and indeed change may be a form of necessary flexibility to maintain the structure and functional provisions within the system. Within any system there is the possibility of multiple stable states that retain the essential functions of the system. Resilience is therefore a relative concept in the terms that the desirability of any given course of action for increasing residence depends on the initial starting point within this stability domain. However, the resilience of the system is also relative to the perceived essential functions of the system. There are many actors in the coastal zone who often have different preferences and strongly held beliefs as to the functionality of the coastal system. The stability domain being managed for resilience is defined by choices of actors regarding what is considered to be desirable physical, social and economic attributes of the system. Arguably what is most important for coastal management is mapping these potential stability landscapes, and thus the collision of interests defining the decision-making processes on resilience building, to create the most useful insights into managing the complexities of the system.

This definition of resilience as the capacity of a system to absorb disturbance and re-organize while undergoing change, so as to retain essentially the same function, structure, identity and feedbacks (Walker et al., 2004), has been challenged regarding its adequacy in describing resilient behaviour: particularly in view of the features of complex, adaptive systems. It is argued that resilience is not only about being persistent or robust: it is also about the opportunities that disturbance opens up in terms of recombination of evolved structures and processes, renewal of the system and emergence of new trajectories (Folke, 2006). The future of a system is therefore as much about evolution and emergence into new stability domains, as it is about persistence, and this gives another difficult dimension to understanding future states of the human–physical environment. This evolution of the resilience concept challenges us to consider new, dynamic ways of understanding the behaviour of complex systems.

The current state of art of coastal management is largely focused on a series of different stability domains or landscapes. These range, for example, from the perspective of resource dependencies and the ability of the coastal system to continue to provide a particular range of resources, to the basic continuity of the dynamic physical system as a space to absorb natural and human-induced pressures on the system. At best, we attempt to couple these perspectives for improved ICZM. This paper uses the IADF as a template for the case study and
Q6 thus focuses one such landscape, the institutional context as affecting interactions between the physical resource, multiple resource users, and the physical and institutional infrastructure within the system. It seeks to build lessons from this landscape with which to inform integrated assessments of coastal systems. However, the evolutionary perspective of resilience sets a challenging context for coastal management: can our understanding of the resilience of coastal systems for coastal management go beyond simple coupling of physical geomorphological processes (highly dynamic and evolutionary but lacking invention or mutation) with social and ecological responses (that have more complex evolutionary responses with potentials for innovation) to develop newer, dynamic ways of understanding the complex interactions within coastal systems?

3. Key system interactions for building increased resilience: lessons from coastal management in South Australia

The South Australian coastline stretches for more than 4,000 km (including many offshore islands) across commonwealth and state jurisdictions. The natural coastal environment within the region ranges from cliffs, rocky shores and sandy beaches in the South East and West Coast to mud flats, seagrass, samphire and mangrove habitats in the upper St Vincent and Spencer Gulf regions. Approximately 80 per cent of South Australia's population live in the coastal zone, and there is an accelerating trend of population movement to the coast. This 'sea change' is a national phenomenon in Australia, where the rate of population growth in Australian coastal areas is greater than 60 per cent higher than the national average (Seachange Taskforce www.seachangetaskforce.org.au). In the context of South Australia, much of the coastal population is concentrated in metropolitan Adelaide, with the remaining coastal region remote and sparsely settled. Thirty-two coastal councils (in the year 2000) have major statutory functions and responsibilities for local management of the coastal zone, which is both bio-physically and socio-economically diverse. There are 24 regional and eight metropolitan councils.

Thom and Harvey (2000) discuss the legacy and contemporary reform of Australian coastal management. Historically, although the Commonwealth (the federal or national government) has previously shown an interest in taking an active role in coastal matters, the management of the coast has been characterized by state domination. Coastal management has continued to be predominantly the responsibility of state and local governments. As discussed by Clarke (2003), the different roles of the three spheres of government, in relation to coastal management, have been pithily described by the following aphorism: 'the Commonwealth has the money; the States the power and Local Government the problems' (Kay and Lester, 1997). However, recent major reviews of Australian national environmental policies and legislation (e.g. Inquiry into climate change and environmental impacts on coastal communities) have signalled a change in the governance framework towards a new model of ICZM that has a stronger national leadership. This proposed Intergovernmental Agreement on the Coastal Zone will be a national cooperative approach and will be overseen by a new Coastal Zone Ministerial Committee. At the state level, two government agencies are currently responsible for managing the South Australian coast (Clarke, 2003). One is concerned with development and has a strong planning focus, whereas the other manages the technical

day-to-day maintenance of coastal facilities. The role of the local council in coastal management in South Australia is primarily to implement coastal planning principles and the objectives from the States Development Plan (Harvey et al., 2002).

The following case-study analysis is based on a first-order application of the IADF to coastal management within South Australia, using themes as highlighted by the model as a template for mapping system interconnections. The case-study application is exploratory in nature, based on the analysis of a limited number of in-depth interviews with key actors in local and state government and with coastal academic experts. Data gathering from within the interviews was supplemented by a desktop analysis of reports, journal articles, policy documents and other published material, which provided some overview of the network of interactions within the coastal system. Figures 2–4 outline the overview from this desktop analysis. Figure 2 highlights examples of the impact of public infrastructure on coastal system resources. The focus of Figure 3 is on identifying examples of the interactions between public infrastructure providers (e.g. resource managers) and public infrastructure (e.g. physical and institutional capital). Figure 4 highlights key interactions between resource users and resource managers, those public infrastructures providers who make policies on how to invest in the construction, operation and maintenance of the public infrastructure to manage the coastal zone resources. The figures focus on the links or interactions between the various components of the system, identifying examples of interactions and potential problems for increasing sustainability of the system. Three broad themes with regard to systems interactions emerge from the interview and desktop analysis: (1) the role of cross-scale interactions in defining challenges for increasing the resilience of the coastal system, (2) the importance of knowledge exchange and interactions that facilitate learning, particularly between informal and formal system components, and (3) the lack of performance measures as a barrier to building more resilient coastal systems. The themes are discussed in the following sections.

3.1. Role of cross-scale interactions in defining challenges for increasing resilience

Many studies of ICZM have highlighted the necessity for greater clarity in the various responsibilities of local and state government in relation to coastal management. This challenge also emerges from within the South Australian coastal context. The interviews highlighted the clear tension in existing interactions from within the governance components, discussing the difficulties stemming from ineffective interactions between the local, state and federal government. These challenges particularly emerge within an assessment of the linkages between physical and institutional capital and the biophysical state of the coastal resource (Figure 2). The impact of public infrastructure on increasing the resilience of natural resources is seen to be constrained (less effective or ineffective), due particularly to problems in the application of the institutional capital or rules for managing these resources. Figure 2 highlights some of these constraints: for example, inadequate definitions of roles and responsibility between state agencies **Q7** and between state and local government, as well as between state and federal level; inadequate and overstretched planning controls as reflecting lack of state support at the local council level. Within the system, these interactions in turn emerge from internal conflicts within the public service providers' group of actors (i.e. the resource managers) and the impact of this conflict on investing, maintaining and enforcing the rules (Figure 3). Such conflicts relate, as an example, to perceptions that federal government uses community organization as a 'cost-cutting exercise' replacing, and hence reducing investment in, permanent civil services at the state and local level. Scaling challenges within the institutional context of coastal management emerge as a strong influence constraining the effectiveness of network links within the system.

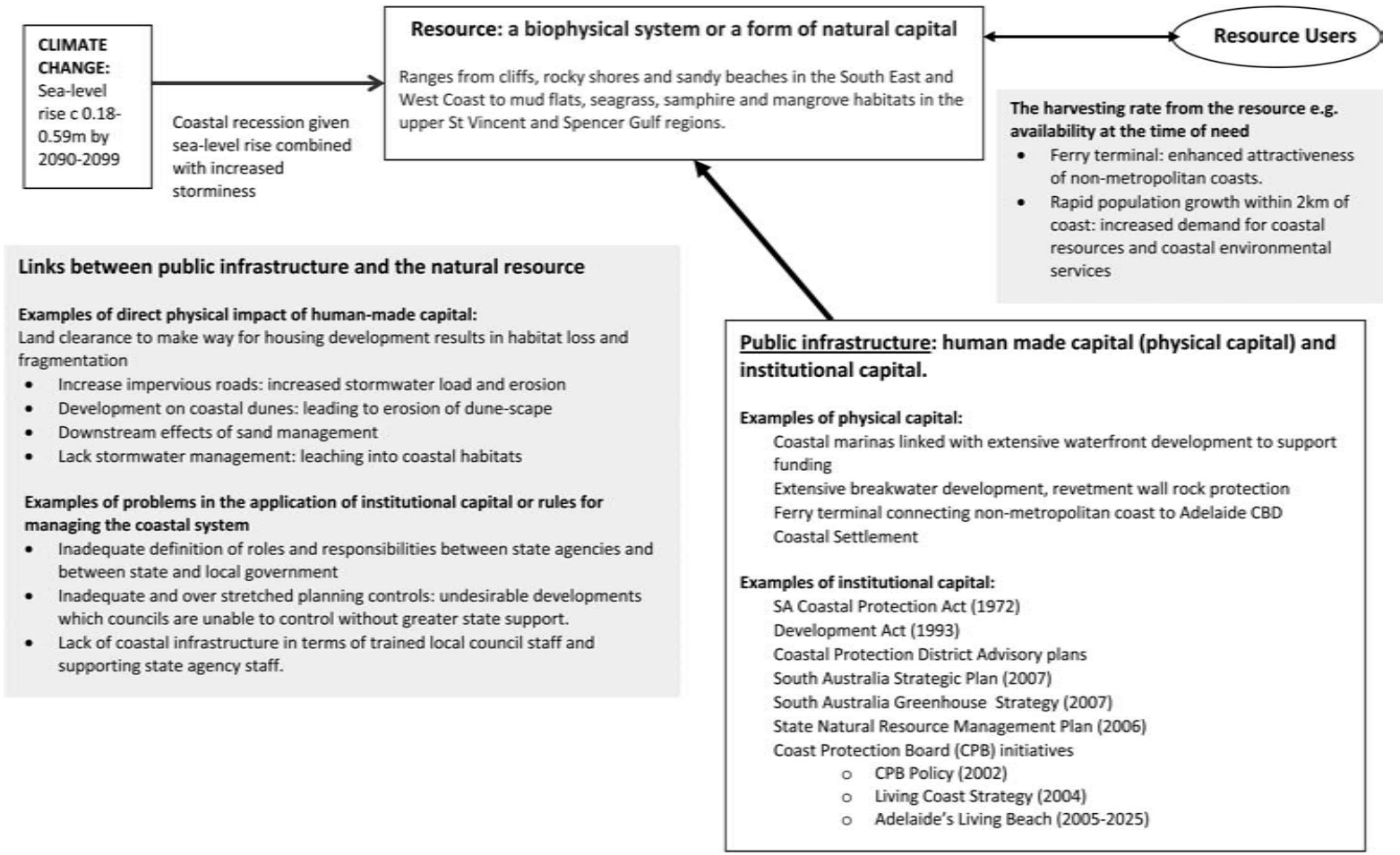

FIGURE 2 Identifying examples of key links between public infrastructure, resource users and the physical resources

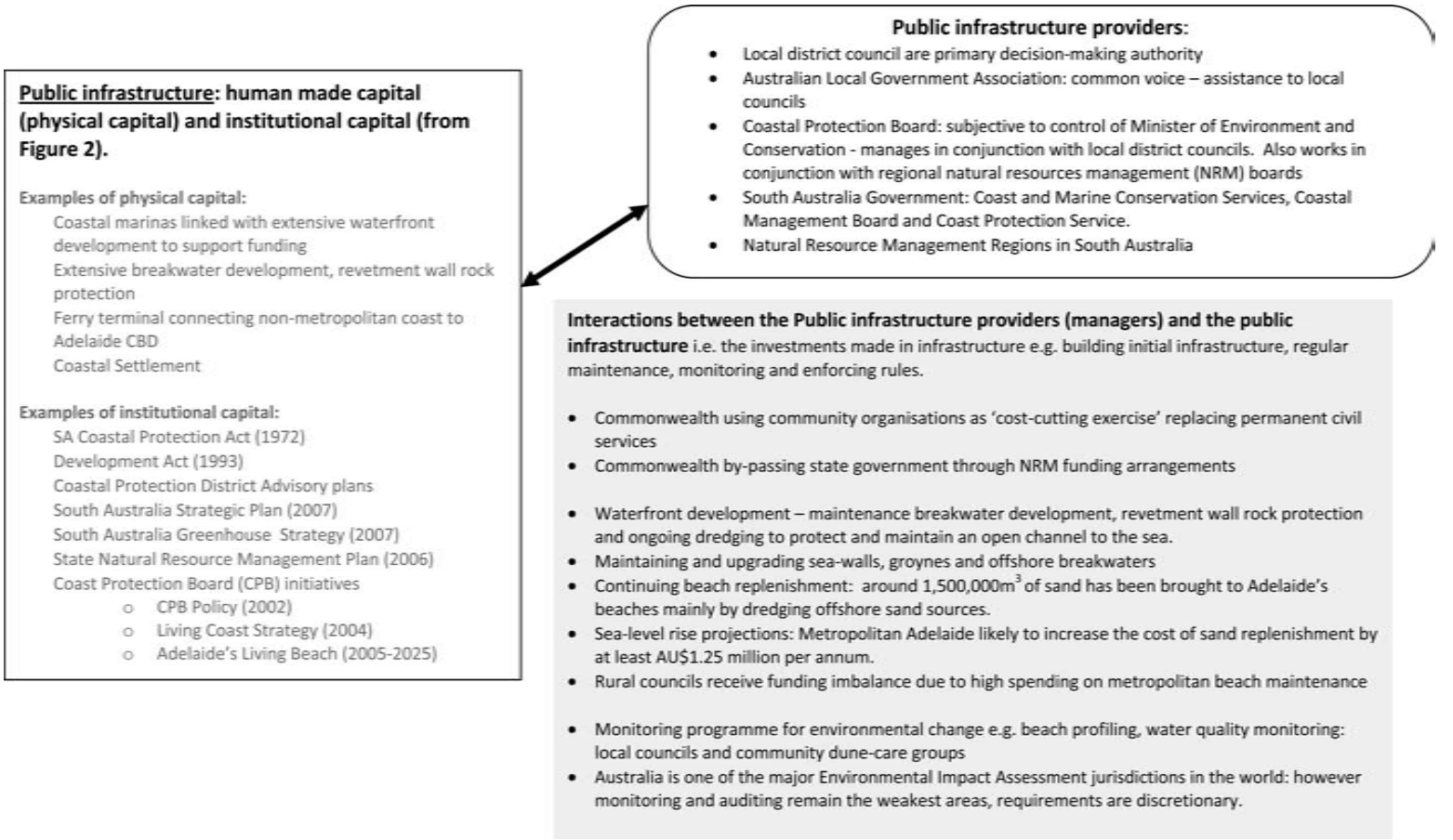

FIGURE 3 Identifying examples of key public infrastructure providers and of linkages between this group of actors and actual investment in public infrastructure

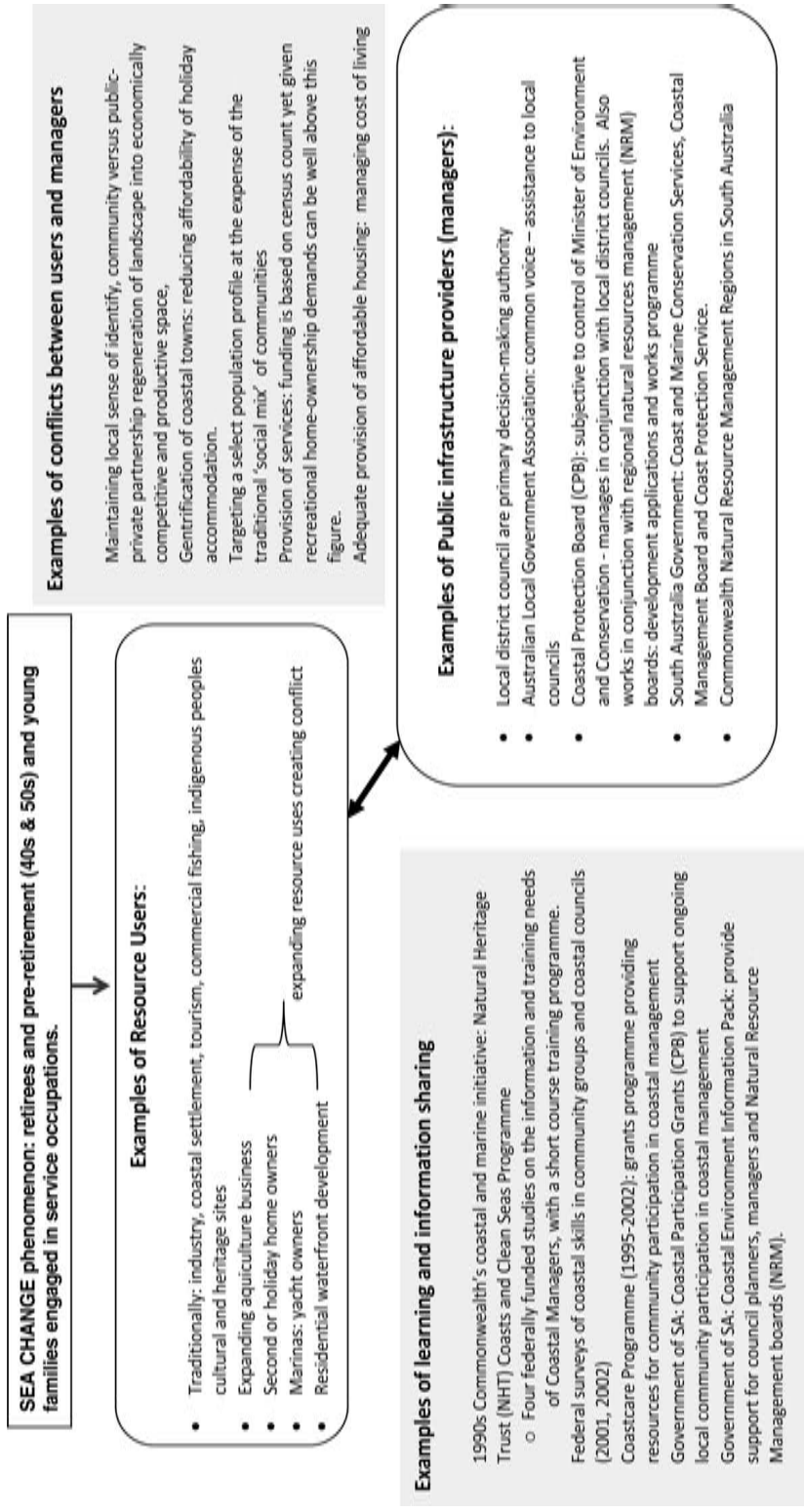

FIGURE 4 Identifying examples of interactions within the case-study between public service providers and resource users

The interviews highlighted the fact that these ineffective relations are underpinned to a significant degree by political changes under the current liberal government, which mean that on-ground advice to coastal councils and access to funding come directly from the federal level, largely bypassing state government. This was seen, particularly by the interviewees at the state level, to reduce state instrumentality and the role of the state in coastal management to managing hard protection, although they retain a degree of power regarding development control. A consistent perspective emerging from across the interviewees was that a strong disconnect particularly exists between the state and federal levels and that this has a negative influence on building effective coastal zone management policies and strategies. The tension between state and federal governments also emerged within the interviews in the discussion of networks of information exchange. It related to groups directly lobbying federal government so that state levels have less or limited influence on the decisions relating to these special interest groups. An example given was the National Seachange Taskforce representing coastal councils and local communities, which is a strong and influential group on policy making for coastal management. However, it is a network within which the state government has no direct discussion.

This theme reinforces the centrality of cross-scale interactions to the resiliency of coastal systems. One important take-home message from this analysis is that building more effective cross-scale interactions between the various levels of governance within the region has a key role to play in promoting more sustainable approaches to coastal management. Achieving such interactions depends on a greater understanding of structural relationships between the governing scales. An important related point is that redundancy and diversity in institutions play a key role in building resilience, providing 'back-up' options when governance systems fail to respond and allowing for prompt re-organization after a shock (Low et al., 2003). Addressing the cross-scale management challenges reflected in the case study depends on understanding what are the most sustainable patterns of resourcing, operational monitoring and enforcing and policy-making processes, with redundancy and diversity factored into this analysis. This necessitates deliberation between the various scales of governance.

One of the strongest emerging points from the interviews related to asymmetry within the region's network for coastal management. That is, the imbalance that exists between the capacity for coastal management between different local councils. These limits of professional capacity across the councils were viewed at the local scale as the single most important factor in limiting sustainable integrated management of the coast within the state. Given that some local councils within the state are small, they have very limited capacity and might not have a professional planner or professional knowledge of the coast: for example, Kangaroo Island, which has a population of 20,000 people. With a state population of just under 2 million, half of the population reside in the greater Adelaide area. The view from the local level is that the professional interest and expertise is concentrated in Adelaide and particularly within the state government agencies. This presents a significant problem, because the mechanisms are very limited whereby this professional capacity is available to assist local government in the shared task of management. The interviewee highlighted the fact that there are individuals in local government who make a significant contribution to managing the coastal resource system through the expertise that they have accumulated over many years in the field. However, when these 'linchpin people' leave their current positions, this will leave a significant gap in the network, which will have major repercussions for the resilience of the system. An alternative perspective emerged from the interview with state level government. In this case, the accumulated expertise within the Coastal Management Branch of the Department of Environment and Heritage is valued as a centralized professional

expert group. A strong feeling from this group is that any attempts to decentralize this expertise will reduce the critical mass of professional experience and have major negative impacts on the provision of coastal management within the region. At the regional level, the critical mass of expertise is seen to produce conditions that are conducive to efficiency: at a local level, interest is more sensitive to principles of equity. The interviews suggest that working through, in very practical terms, the relation between these two principles of sustainability is important to designing more resilient configuration for decision making.

3.2. Importance of knowledge exchange and interactions that faciliate learning, particularly between informal and formal system spaces

A key theme to emerge from within the interviews was the high value placed on the coastal environment within local communities. This was perceived by the interviewees to relate to the ethos that the beach is a 'very public good', that is, it 'belongs to everyone'. The perspective raised was that the Australians put great value on 'Joe Blogs on a modest income being able to access the coast in the same manner as Mr Mansion'. This gives a strong cultural imperative towards maintaining rights and obligations for coastal zone management. This was related by the interviewees to the perceived importance within the Australian culture of the willingness to 'speak out' and 'stand up' and in turn to effective information exchange between local communities and local decision makers.

Further evidence of the importance of informal rules (i.e. cultural, moral or ethical) in defining attitudes and expectations from the coastal system emerged during the interview discussion. In Australia in general and in South Australia in particular, the natural coastal resource system is large, expansive and sparsely settled. Although the expansive nature of the coastal system produces significant challenges for monitoring and enforcement, the size of the resource was perceived to provide a key driving force for incentivizing behaviour towards maintaining and improving the coastal resource. This was related by the interviewees to the strength and attraction of the coast in terms of the value that is placed within Australian culture on space and distance. An additional point raised within this discussion was that often the 'beach is the community' that is the social space where people meet, relax and talk. There is a clear emphasis emerging from the interviews on the importance of culture in characterizing resource users' perspectives on the coastal environment. Q8

This emerging message highlights the strength of the attraction of coasts within Australian culture and, in doing so, points to the importance of effective links between the informal rules that constitute and define these perspectives and the formal policies and regulations governing the coastal environment. The importance of informal space as a vehicle for developing relationships that are meaningful to individuals and groups, enabling flows of knowledge and learning, is highlighted by the literature on social learning (e.g. Pelling et al., 2008). However, the challenge exists of effectively integrating learning from within such informal space with formal rules and regulations that define the behaviours of the organizations or institutions managing the coastal system. Discussions within the interviews suggested that while particular forms of information, for example, user information, project information and news, may be exchanged relatively well, processes of dialogue that facilitate collaborative and deliberative approaches to decision making are less well formulated. The inherent value placed on the physical coastal environment within the Australian social fabric suggests the importance to coastal management of harnessing the networks and experiences of coastal resource users. It also points to the potential usefulness of participatory processes to share knowledge, discuss and deliberate on recommended policies and management actions, with the aim of further increasing incentives within resource user groups towards building resilient coastal systems.

Figure 4 outlines examples of learning and information sharing between resource users and public infrastructure providers. These processes take the form of federal and state-funded initiatives on capacity building for coastal managers and local community participation in coastal management, ranging, for example, from grants for local community participation, surveys of skills and needs of managers, and training to support mangers at local and state scales. The evidence points to a relatively significant legacy of processes for learning and information sharing across the coastal system, as well as ongoing processes of facilitating some exchange of information for coastal management. However, Figure 4 also identifies examples of conflicts or tensions between the two groups of actors. These largely focus around the maintenance of the cultural and social identities of the coastal towns and suburbs against government-driven processes for change of this identity towards economic regeneration. It points again to the central role that the cultural context has in determining the effectiveness of interactions between the two actor groups within policy making relevant to building resilient coastal communities.

One simple perspective that could emerge from this first-order analysis is that although the state has a legacy of government-initiated participation vehicles, a sharp conflict remains between local vision for the local community and the vision that drives public–private partnership pressures on these communities. At one level there would seem to be discontinuity between the learning processes and the impact of these processes on the two actor groups. The ineffectiveness of these learning processes within the region is already reflected in published literature and a number of contributing factors are highlighted, for example, the inability to develop lasting partnerships with the community, the reluctance of government to share power to allow effective participation (Lazarow, 2006) and the absence of review indicators for the success of community participation schemes (Clarke, 2006). The perspective of ineffective learning needs to be underpinned by an understanding of the fact that learning processes are complex and are distributed unevenly among society. They depend on the tasks and roles that actors and organizations play in their contexts of action as well as on the power and abilities they hold (Tàbara et al., 2005). Historical contexts, the continuity of learning and information sharing processes, the degree of participation and power inequalities are also examples of barriers to learning. The analysis suggests that a greater understanding of the constraints and opportunities that define the learning potential, particularly between informal and formal system interactions, Q9 may create useful pathways towards building more resilient, sustainable systems.

3.3. A lack of performance measures to assess outcomes of systems interactions is a barrier to building resilient coastal systems

A third theme to emerge from the series of interviews relates to scientific knowledge and how this information is transferred across the network of actors in coastal management. It was considered by the interviewees that exchanges of research and scientific data could be significantly improved between the scientific community and policy makers, as well as exchanges within the policy-making community. This was seen as a particularly relevant challenge for management at the level of local government, where ineffective transfer of knowledge to the local level acts as a significant barrier for improving integrated management of coastal resources. A key constraint was also seen to be the lack of mechanisms by which various sources of information are brought together and maintained as a continuous and long-term investment.

This context of the need for continuous and long-term investment in data also emerged when considering the linkages between public infrastructure providers and the range of public infrastructure affecting how the system functions over time (Figure 3). It proved challenging within the context of this exploratory analysis to identify emerging lessons from the interaction between these components for improving the

resilience of the system. A critical barrier was the difficulty in obtaining an overview of the effectiveness or sustainability of these various system interactions. There are a range of both national and state-based analyses of coastal vulnerability of the South Australian coastline (Harvey and Woodroffe, 2008). However, performance measures of the behaviour of the coastal system – social outcome measures (e.g. efficiency, equity and accountability) as well as geomorphological and ecological outcomes (e.g. resilience, diversity and redundancy) – were difficult to obtain, and in some instances (e.g. social indicators) do not exist. An analytical review of both the impact of public infrastructure on the feedback structure of the resource and the effectiveness of rules used for governing, managing and using the system becomes difficult in the absence of this information. Thus, the sustainability of the interactions and the possibility for restructuring towards resilience cannot be effectively explored. An important emerging message is that developing such diagnostic skills is central to also developing the capacity to predict, explain and improve the sustainability of the system. This is critical to gaining meaningful insights into how resilient and sustainable the current configuration of users, governance system and resource system is, as well as insights into how this might be further improved.

Another significant barrier to understanding interactions within the case study was the relative lack of analytical material on the interface between governance components and the physical resource. There is a significant body of detailed information discussing elements of the physical resources within the region (e.g. Boman and Harvey, 1986; Bourman et al., 2000; Harvey et al., 2006). However, there is limited discussion within the literature as to how these resources are linked in behaviour through space and time in system dynamics: the network links within the physical sub-component of the system. Nor was it easy to obtain information on how such physical system knowledge interfaces with management plans and policies for the region. The evidence indicates that this interaction is likely to be minimal; for example, the Adelaide Living Beach Strategy is built on a series of notional physical resource units that do not relate to the dynamics of the bio-physical resource. In practice, this was an area of coastal management strategy development within the state that needed to be considerably strengthened. It is a critically important aspect of building resilience because it relates directly to the centrality of understanding what makes the South Australian coastal zones viable as a functioning resource system.

4. Contextualizing the perspective of resilience emerging from the exploratory analysis

As highlighted in a previous section, by using the IADF as a template for this case study, this analysis of resilience is embedded in one stability landscape that is focused on the sustainability of rules defining the governance, management and use of coastal resources: that is, the institutional context of coastal management as affecting the sustainability of the system through interactions between the physical resource, multiple resource users, and the physical and institutional public infrastructure. There is significant theoretical value to building an assessment of coastal systems for coastal management on a governance-based model. Governance is about power, who has it, who should have it, how it should be exercised and for what purposes. It is about how resources should be allocated, what are the goals of society and how society should be organized (Green, 2009). Thus, governance is one of the fundamental essences of ICZM. The fragmented nature of institutional frameworks and the challenges of adopting stakeholder-based decision making mean that improving governance is central to ICZM. This provides a strong context for the usefulness to coastal management of adopting an institutional-based approach such as that represented by the IADF.

A governance-based model commonly referred to within ICZM literature is the Four Orders of Outcomes by Olsen (2003). This model aims to

group together the sequences of institutional, behavioural and social/environmental changes that can lead to more sustainable forms of coastal development. The Four Orders of Outcomes are goals or indicators of sustained positive progress towards ICZM. The IADF could bring significant added value to this approach for understanding governance dimensions of coastal system behaviour. Focusing on diagnosing the causal patterns of interactions within the coastal system that affect ICZM outcomes, the IADF brings a critical depth of analysis to an outcome-based approach. The framework of institutional attributes and variables within IADF provides a comprehensive foundation for thinking about which aspects of the system are likely to have a major impact on the patterns of interactions and the outcomes of these interactions. A key strength of the framework is therefore the opportunity it affords for a detailed and systematic understanding of the governance components of coastal systems. Increasing our understanding of the roles of organizations and institutions within decision-making processes and the nature of rules defining the governance, management and use of coastal resources could considerably strengthen an analytical approach for ICZM.

However, as an institutional model, the IADF approach has little facility for identifying the essence of what makes the coastal system a viable bio-physical system. Physical coastal vulnerability is often associated with coastal sensitivity, that is, the relationship of disturbance event frequency to relaxation time of the physical environment (the time taken for the coastal feature to recover its form) (Pethick and Crooks, 2000). Anthropogenic occupation and functionality of coastal zones means that such a physical system orientation of resilience is ineffective as a stand-alone model for coastal management (Orford et al., 2006). However, the perspective captured within this approach reflects an alternative and viable stability domain to that within the institutional model. From this perspective of coastal sensitivity, the resilience focus is on management for change within the physical environment, rather than managing the system to maintain its capacity to provide resources or services to society.

These two perspectives on resilience of the coastal system can potentially be coupled. For example, the analysis of resource unit dependencies within IADF could have a more explicit link with neighbouring resource units at the same scale within the physical behavioural system. A basic parameter of geomorphic systems analysis is that the evolution of one particular element of the coast is strongly influenced by, and influential on, evolution in adjacent areas (Burgess et al., 2002). At a first-order level, this could be achieved by a simple conceptual development of the IADF, highlighting the significance of interactions between adjacent coastal resource units to the assessment of the coastal system resilience. The depth and complexity of this analysis could be further increased within a nested, multi-scale analysis of the physical behaviour systems (e.g. Halcrow, 2002). Exploring the range of interactions with the governance components of the system, across such physical behavioural scales of analysis, provides a fuller perspective of the complexities of coastal change. Such a physical behavioural analysis could itself be embedded within a Source Pathway Receptor (SPR) model, which highlights the pathways within the physical and human environment through which hazards (sources) are transferred to communities, society and the natural environment (receptors) (DETR et al., 2000) (Figure 5). This allows a valuable added perspective in that the geomorphic system is seen itself as an entity that may be harmed (i.e. it is a receptor as well as a pathway) irrespective of human presence (Evans et al., 2004). The combined physical behavioural and SPR analysis facilitates a comprehensive understanding of the nature of the physical environment as a viable system of systems and its consequent role in structuring and defining interconnections within the complex functioning coastal environment. Coupling this analysis with the IADF provides a strong conceptual framework for exploring the potentials in ICZM for managing processes of change within the coastal systems towards more resilient,

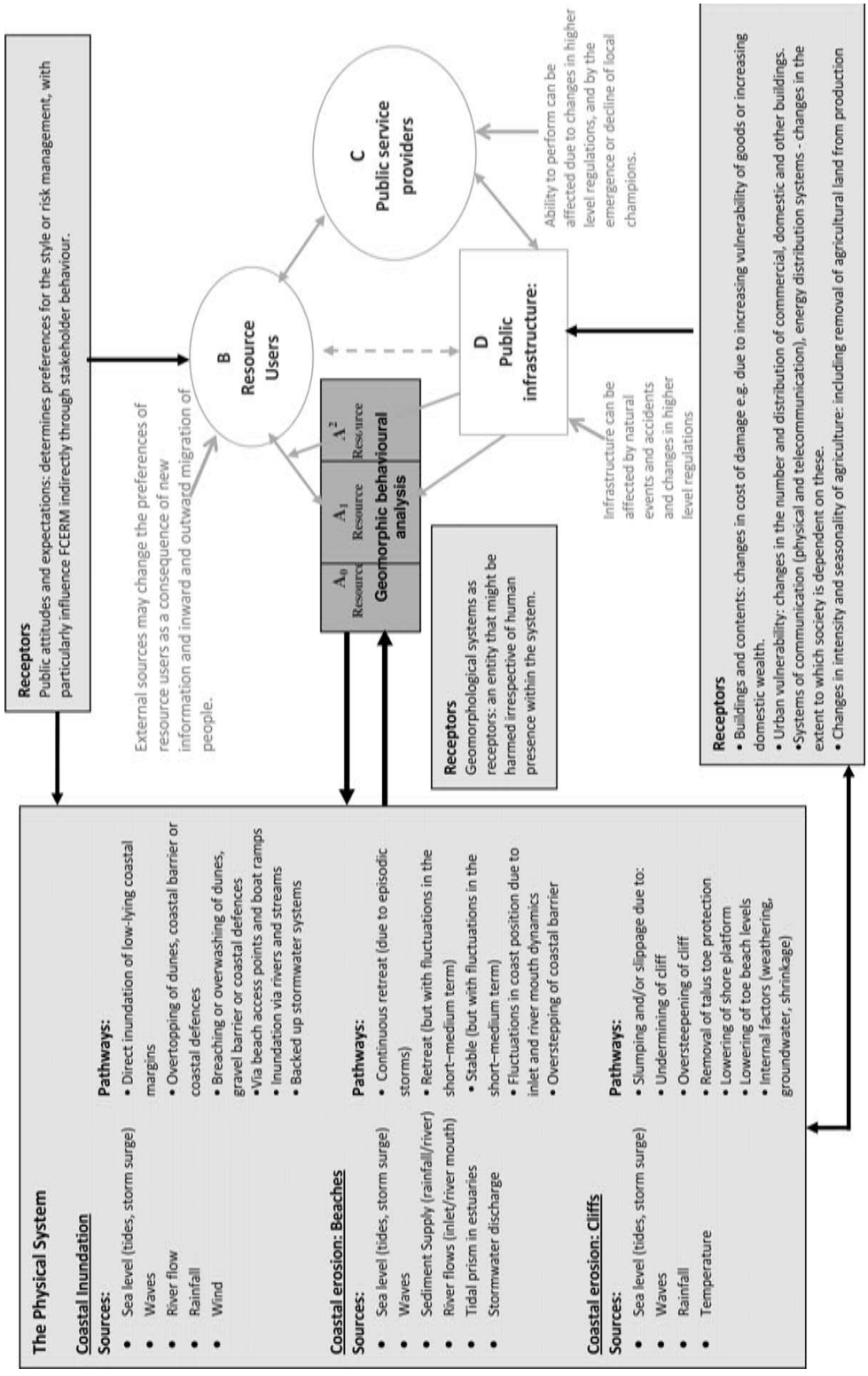

FIGURE 5 A coupled model for understanding coastal system interactions: embedding physical behavioural analysis within the Source Pathway Model and linking this with the IADF approach

sustainable outcomes. Such a proposed conceptual framework is, in essence, a simple development, focused on meshing existing models for exploring coastal systems: the challenge of going beyond this approach to developing transdisciplinary models for understanding resilience remains significant within ICZM. However, reflections on the case-study analysis would suggest that there are still important lessons to be learned for coastal management from such a coupled approach to integrated assessment.

5. Conclusion

Exploring ideas from the IADF within the South Australian coastal management context has identified a range of interactions as potentially significant drivers for increasing the resilience of the coastal environment. These interactions may be summarized under three broad themes. The first widely recurring theme is the importance of scaling issues in determining resilience and the need to better understand cross-scale interactions to build capacity for increasing resilience within coastal systems. This necessitates increasing our understanding of what are the most sustainable patterns of resourcing, operational monitoring and enforcing coastal management, and includes exploring the relations between, and appropriate balance of, equity and efficiency in cross-scale governance processes. The second theme relates to the prominent role that informal rules and interactions play in constructing the behaviour of resource users and managers of the coastal system and highlights the need to integrate these informal components into the rules and policies driving coastal management. Culture and societal norms proved to be a very important influence in the case study in relation to attitudes to the coast and expectations for coastal management, as well as on the effectiveness of network links between users and managers of the system. Increasing existing understanding of the complexities of learning processes is important to facilitating greater exchange between the formal and informal spaces within the system. A third emerging theme relates to the lack of performance measures for assessing the outcomes of interactions within the system and highlights this issue as a significant barrier to building more resilient coastal environments. Developing diagnostic skills and identifying social as well as physical outcomes measures is important to gaining meaningful insights into how sustainable the current system configuration is as well as insights into opportunities for enhancing coastal resilience. The primary conclusion from this exploratory analysis is that broad-scale resiliency of the coastal system could be substantially improved by focusing attention on a better understanding of, and facilitation between, informal and formal knowledge and processes of decision making and on the scaling challenges within the region, supporting these with a careful, well-constructed analysis of the evaluative criteria of physical, social and institutional systems.

However, analyses of the resilience of coastal systems are often a function of a normative statement as to what is perceived as a desirable stability domain for the system. The lessons identified above, for example, are embedded in a perspective of exploring the sustainability of rules defining the governance, management and use of coastal resources. They emerge from the institutional context of coastal management as affecting the sustainability of the system through interactions between the physical resource, multiple resource users, and physical and institutional public infrastructure. A comprehensive understanding of the complex interactions of the coastal system requires coupling of the institutional perspective on resilience with bio-geomorphological analyses of the processes defining a resilient coastal environment. This paper has suggested, in essence, a simple development of the IADF approach to allow a fuller understanding of the role of the geomorphic component in the functioning coastal system. Integrated analyses are critical to gaining the most useful insights into pathways for building more resilient coastal futures.

Increasing our understanding of opportunities and barriers for improving coastal resilience ultimately depends on building lessons from the

application of resilience ideas to a wide range of case studies of differing physical, social and ecological contexts and legacies. These case studies need to be conducted within a theoretical framework, which recognizes the complexity defining how combinations of variables affect the behaviour of the coastal system. This paper has presented one exploratory analysis of South Australian coastal management focused on an assessment of resilience based on an institutional analysis. There is a clear need to continue to build comprehensive case-study examples from which comparisons can be used to more confidently identify the strategic system variables and relationships that can most significantly contribute to the resilience of coastal systems.

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