



Values, rules and knowledge: Adaptation as change in the decision context



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ABSTRACT

Responding to global change represents an unprecedented challenge for society. Decision makers tend to address this challenge by framing adaptation as a decision problem, whereby the responses to impacts of change are addressed within existing decision processes centred on defining the decision problem and selecting options. However, this 'decision-making perspective' is constrained by societal values and principles, regulations and norms and the state of knowledge. It is therefore unsuitable for addressing complex, contested, cross-scale problems. In this paper we argue that simply broadening the decision-making perspective to account for institutions and values is not enough. We contend the decision-making perspective needs to be connected with a broader 'decision-context perspective' that focuses on how the societal system of decision processes affects the manner in which a particular problem is addressed. We describe the decision context as an interconnected system of values, rules and knowledge (*vrk*). The interaction of systems of *vrk* both creates and limits the set of practical, permissible decisions; the types of values, rules and knowledge that influence the decision and the capacity for change and transformation in the decision context. We developed a framework to analyse the interactions between values, rules and knowledge and their influence on decision making and decision contexts of adaptation initiatives, and applied it retrospectively to three projects on adaptation to sea-level rise. Our analysis revealed: (1) specific examples of how interactions between *vrk* systems constrained existing framings of decision making and the development of options for coastal adaptation; (2) limitations in the adaptive management strategies that underpinned the projects and (3) how the linked systems of *vrk* can allow adaptation practitioners to structure adaptation as a process of co-evolutionary change that enables a broader set of social issues and change processes to be considered. Adaptation projects that focus on the decision context represent a pragmatic alternative to existing decision-focused adaptation. By using the *vrk* model to diagnose constraints in decision processes, we show how the reframing of adaptation initiatives can reveal new approaches to developing adaptation responses to complex global change problems.

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1. Introduction

Global change refers to the emergence of complex, non-linear, cross-scale and contested issues due to the increasing influence of humans on natural systems (Voss et al., 2007; Steffen et al., 2011; Wise et al., 2014). Many global change problems are intractable within existing decision-making processes (Walker et al., 2009) so addressing them requires change in the societal systems that structure decision making: political, legislative, bureaucratic and market systems that distribute responsibilities for decision making

(Geels and Schot, 2007; Rotmans and Loorbach, 2009; Kates et al., 2012; Markard et al., 2012). The societal dynamics of linked social-ecological systems are the subject of a growing body of theory (Stern et al., 1999; Leach et al., 2010; Fligstein, 2013; Garud et al., 2014). However, there is a need to represent insights from diverse worldviews about societal structures in terms that decision makers can act upon (Shove, 2010). Development of theoretical and operational frameworks of adaptive governance to enable deliberative, legitimate change in social systems remains a substantial challenge (Future Earth, 2013).

Adaptive governance requires an understanding of how the societal context of a decision process influences decisions and how people can intentionally influence that context. This dual relationship between human agency and social structure has been extensively

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theorised (Giddens, 1984; McLaughlin and Dietz, 2008) but remains subject to conceptual divides. For example, agency-focused biophysical science, decision science, and decision making tend to be disconnected from structurally-focused social science analysis of societal dynamics (Castree et al., 2014). Further, schools of institutional analysis with differing ontologies of the relationships between agency and structure (Garud et al., 2010) give conflicting advice on how institutions can adapt because terms such as 'institutions', 'behaviours' and 'beliefs' are used differently (Hall and Taylor, 1996; Hadfield and Weingast, 2014). The result is confusion about what adaptation involves, and how it can be addressed.

One reason that adaptation is particularly difficult and challenging is because top-down processes to control systems have tended to be ineffective. The complexity of social-ecological systems precludes policy and management panaceas and requires decentralised knowledge (Ostrom et al., 2007; Norgaard, 2010). Governments may provide a focus for leadership, but institutional change requires coordinated efforts by people with agency in diverse roles at different levels within a social-ecological system (Stirling, 2014). The required reflexive analysis of the societal context in which these actors are embedded is innately difficult. Decision makers may be unaware of the influence of societal structures such as norms, practices, cultural regimes, technologies and regulations (Ostrom, 2010, 2011; Leith et al., 2014), especially if such structures have been stable and thus taken for granted.

The roles and influences of values, rules and knowledge in adaptation decision making have been considered, though generally with a focus on the binary interactions, i.e. between values and rules (Kinzig et al., 2013), rules and knowledge (Termeer et al., 2011) or values and knowledge (Funtowicz and Ravetz, 1993; Jasanoff, 2004; Cornell et al., 2013). We argue in this paper that it is important to consider and understand the interactions among all three elements.

A focus on how values, rules and knowledge are used within a decision process can reveal the influences of these societal structures and enable a reframing of adaptation strategies based on an understanding of the limitations on agency and the dynamics of the societal structures that create such limits. Specifically, the values, rules and knowledge model of the decision context (*vrk* hereafter) enables people to: (1) articulate the *vrk* systems that decision makers use and identify how decision processes and options can be constrained by exclusion of certain forms of knowledge, values or rules; (2) recognise societal structures and processes that maintain constraints on decision making, and (3) develop strategies and agency to overcome these constraints.

In this paper, we describe the main concepts in the *vrk* model, its relationship to other theories, and its implications for the design and implementation of adaptation. We then describe an analytical framework for adaptation initiatives based on the *vrk* model. We demonstrate key steps in this framework by analysing three projects on adaptation of coastal communities and ecosystems to the risk of rising sea levels and more frequent and severe storms. The analysis was intended to reveal constraints faced by coastal planners, identify limitations in adaptive management strategies underpinning the projects, and show how the reframing of adaptation initiatives can reveal new approaches to adapting to complex global change problems.

2. The decision context as interconnected systems of values, rules and knowledge

2.1. Decision making and decision context

Our focus here is on the decision process, the social routine whereby people in defined roles evaluate options, make a choice

and select one. In particular we examine public decision processes; where the choice is intended to influence the behaviour of people outside the decision process. An example of such a process is land-use planning (which we analyse in the examples of coastal adaptation projects below), in which local government planners choose the land uses permitted in different areas. We define two contrasting perspectives on a decision process: the decision-making (or agency) perspective and the decision-context (or structural) perspective (see Table 1 for definitions of key terms). An understanding of structural change can be used to inform and develop agency to direct societal change (Rotmans and Loorbach, 2009; Safarzyńska et al., 2012).

The decision-making, agency-focused perspective represents the outlook of actors when engaged in a particular decision-making process, with its various constraints of time, resources and institutional arrangements. Agency, i.e., the ability to make and act upon a reasoned choice, is created by (1) a values system in which the purpose of the decision-making process can be articulated; (2) a knowledge system that can be used to describe how different options will affect systems and people; and (3) a rules system that empowers actors to implement decisions. Within the decision process, values and knowledge tend to be treated as sets of *independently defined variables*, which implies that a decision maker can incorporate any relevant knowledge and values in order to reach a decision within the bounds of the societal rules that enable the decision process (Fig. 1a).

In contrast, the decision context perspective focuses on the influence of societal structures on decision-making processes. This structural perspective shifts the focus from solving particular problems using existing decision-making processes towards the societal structures that define the roles of actors and whether those roles enable effective and legitimate actions. From the decision-context perspective, values, rules and knowledge are *interdependent conceptual systems* that represent a particular way of viewing and framing the world (Baumgärtner et al., 2008; Lakoff, 2014; Moon and Blackman, 2014). By describing the decision context as a *vrk* system we aim to make these societal structures discernible from the decision-making perspective.

2.2. The values, rules and knowledge model

The *vrk* model (Fig. 1b) represents values, rules and knowledge both as the sets of variables used in decision making and as interconnected, mutually supporting conceptual systems upon which actors draw in order to create and analyse these variables. The *vrk* systems that underpin a decision-making process enable a discrete range of options to be evaluated, and necessarily constrain the types of values, knowledge and rules that can be used in the evaluation process. Interactions between the values, rules and knowledge systems determine which options, values, rules and knowledge can be incorporated into the decision-making process.

When the decision context is viewed as a *vrk* system, it is revealed as part of a larger social system, which we refer to as the *societal decision system*. Here, the decision context is continually reformulated or reproduced by complex societal processes, including the undertaking of the decision process itself (Giddens, 1984). We describe the societal processes that reformulate the decision context as the co-evolution of values, rules and knowledge systems, and emphasise that interactions among values, rules and knowledge systems are central to these dynamics. In these interactions, changes in one element may drive responses in one or more of the others. For example, the values encoded in a rule may motivate people to use that rule; or the assimilation of new knowledge may shift how values are expressed through behaviours that, in turn, may lead to changes in how rules are interpreted. Attempts to deliberately change one aspect of the

decision context may be hindered by these interactions, and strategies to influence the decision context can be informed by analysis of how these *vrk* interactions work to reproduce the established decision context. The *vrk* model is useful because by focusing on the *interactions* among *vrk* it enables both the analysis of the constraints on decisions and the examination of the societal dynamics that create these constraints. Examples of the interactions between *vr*, *vk*, *rk* and all three elements are developed below in the analysis of coastal adaptation pathways projects.

2.3. Values, rules and knowledge as dynamic systems

We use the terms *value systems* and *knowledge systems* to refer to the connected sets of concepts that people use within a decision process to describe the different options and their possible implications for the world, and for evaluating these implications. Schwartz (2012, p. 16) differentiated basic values from the related concepts of norms and beliefs as having “importance as guiding principles in life.” Schwartz (2012) identified types of values that differ according to the goals or motivations they embody, that are related by structures describing the conflicts or congruence among

them, and are assigned different priorities according to the individual and the context.

Knowledge systems from various cultures, academic and professional disciplines provide different processes for making sense of the different aspects of a knowledge system. Tensions between objective and subjective views of knowledge, and between monist and pluralist views of value systems become central in complex social–ecological problems (Funtowicz and Ravetz, 1993; Lakoff and Johnson, 2003; Jasanoff, 2004; Mason, 2011). These tensions form part of the conceptual divide between the decision-making focus of the biophysical sciences and the decision-context focus of the social sciences (Castree et al., 2014). The position on diversity of values and knowledge that is implied by the *vrk* model is that a particular decision process can encompass only a limited set of possible value and knowledge systems.

We draw on evolutionary economics to provide the concept of a rules system for the *vrk* model. Evolutionary economics suggests that “society is made of rules” (Dopfer and Potts, 2009). *Rules-in-use* (norms, practices, taboos, habits, heuristics) have the form “if in situation *a*, undertake action *b*” and provide evolutionary building blocks for society. Individuals carry and apply rules-in-use when

Table 1

Definitions and descriptions of key terms used in the present paper in the context of adaptation to global change.

Concepts	Definition and description	Reference
Social-ecological system	A social-ecological system emphasises the importance of considering humans as part of ecosystems. Feedbacks within and across the social-ecological systems determine its behaviour which depends, in turn, on cross scale interactions	Folke et al. (2005); Folke (2006)
Decision process	The social-cognitive routine whereby people in defined roles identify and evaluate options in relation to an objective and make a choice from the alternatives available to them. In an adaptation context, the process might involve understanding the problem, planning adaptation actions, and designing and managing the implementation of the selected option	Moser and Ekstrom (2010); present paper
Decision system	The societal systems (e.g. socio-technical systems) that form a regime of linked, mutually supporting decision-making processes	Geels (2004); present paper;
Decision-making perspective	The approach whereby existing decision processes are centred on defining the decision problem and selecting options	Present paper
Decision-context perspective	The approach whereby the societal system of decision processes affects the manner in which a particular problem is addressed	Present paper
Decision context	The circumstances that form the setting of the decision process; specifically the interconnected systems of values, rules and knowledge that form the ways of viewing and framing the decision process	Present paper
Values (basic or universal)	A set of ethical precepts that determine the way people select actions and evaluate events. Schwartz's ten categories of universal values are: power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity, and security	O'Brien and Wolf 2010; Schwartz (2012)
Knowledge	The mix of evidence-based (scientific and technical) knowledge and experiential, meanings-based knowledge that forms part of constructed knowledge systems in the decision-making process	Vogel et al. (2007); Stoutenborough and Vedlitz (2014)
Rules-in-use and rules-in-form	<i>Rules-in-use</i> include norms, practices, taboos, habits, heuristics and have the form “if in situation <i>a</i> , undertake action <i>b</i> ” and provide evolutionary building blocks for society <i>Rules-in-form</i> include regulations, legislation, treaties and ordinances. Related to formal and informal rules	Dopfer and Potts (2009) Ostrom (2011)
Institutions	Rules governing the behaviour of actors and decision makers. Institutions may be formal, i.e., linked to governments and bureaucracies and with codified regulatory frameworks; or informal, i.e., socially shared rules and cultural norms	O'Riordan and Jordan 1999; Pahl-Wostl 2009; Ostrom 2011
<i>vrk</i> interactions	The interrelationships between values-knowledge, values-rules and knowledge-rules and those of all three elements and how one affects the other two in influencing the decision-making process	Present paper
Knowledge deficit model	The assertion that scientists and experts have an understanding of specific issues that non-scientists (including policy makers and the public) do not. By supplying more knowledge the knowledge gap will be narrowed, thus providing greater congruence between scientific world views, public attitudes and policy options	Vogel et al. (2007); Stoutenborough and Vedlitz (2014)
Co-evolution	Development and change as a process of coevolution between knowledge, technology, social organisation, values and the natural world; the perspective that adaptation requires collective, social learning and doing in order for institutions to develop and change.	Norgaard (1995); Collins and Ison (2009); Pelling (2011)
Triple loop learning	The form of anticipatory or forward-looking, reflexive learning that can trigger changes in norms, world views, behaviours and governance structures	Pahl-Wostl (2009); Tschakert and Dietrich (2010)
Agency	The process that enables people to influence decisions, co-construct alternatives based on their framings, and make a reasoned choice within a particular decision making process;	Giddens (1984); McLaughlin and Dietz (2008)
Structure	The institutional units that make up society and how their characteristics, dynamics, roles and interactions relate to capacity for decisions and actions relating to adaptation	Giddens (1984); McLaughlin and Dietz (2008)
Frames and frameworks	A metaphor for the basic structure underlying a system or concept that helps its user in making sense of that system or concept	Lakoff and Johnson (2003); Lakoff (2014)

deciding how to act in a particular situation. Each rule-in-use is part of a complex societal rule set that individuals help create. Alignment of rule sets is fundamental to a functioning society and societal change represents an evolutionary process of selective propagation of rules-in-use. Changing a rule-in-use is limited by the need to enable the people carrying it to operate effectively in society.

There is a complex relationship between rules-in-use and rules-in-form such as regulations, legislation, treaties and ordinances (Kingston and Caballero, 2009; Ostrom, 2011). The model of a one-way translation of changes in rules-in-form to changes of rules-in-use does not adequately explain societal change. Systems of rules-in-use create the potential for agency and legitimacy, allowing decisions to influence people outside of the decision process. The ability to use changes in rules-in-form to change a decision context may be limited by the rules-in-use that define the perceived legitimate scope and role of a decision process, the interpretation of the new rules-in-form, or the legitimacy of the process for changing the rules-in-form.

The *vrk* perspective expands the co-evolutionary model of rule dynamics by emphasising that rules-in-use are inextricably linked with values and knowledge. Rules-in-use define individual actions in particular circumstances, requiring both a knowledge system in order to identify situations and higher-order “rules-for-choosing-rules” that draw on basic values and beliefs. Thus, rules for decision making will embody and reflect particular systems of values and knowledge.

3. Changing the decision context as a focus for adaptation

The *vrk* model emphasises that an important focus for adaptation is changes to the societal context of key decision processes. We describe context-focused adaptation as an attempt to influence the dynamics of *vrk* systems, motivated by analysis of the limitations imposed by existing systems on a decision-making process, and an understanding of the dynamics and processes of the systems. This framing of adaptation raises questions of what is changing, who is involved, and how changes in *vrk* occur.

3.1. What is changing?

We describe the decision context as the conceptual frameworks that people draw on when engaged in a decision process. Acknowledging the three *vrk* elements broadens the decision-

making perspective on the adaptation task beyond just improved decision making and learning by emphasising that adaptation may result in profound and diverse types of change to society. The societal processes that change the *vrk* context may also span diverse knowledge generation processes, values-based social movements, and rules-based changes including legislative reform.

3.2. Who is involved?

The framing of adaptation as change in the decision context highlights that adaptation involves change in a wider set of actors beyond those with formal decision-making roles and responsibilities. The relevant *vrk* systems operate at three levels: (1) the individual, as used by people in decision-making processes; (2) the group, via the coordination of *vrk* systems of individuals involved in decision-making processes, and (3) at the societal level, as the conceptual frameworks of those agents in society who empower and sustain decision-making processes by resourcing, legitimising and implementing them. This latter group of agents are an important yet often neglected part of the decision context. They determine the scope of decisions that can legitimately and feasibly be implemented, so changing the decision context involves changing their *vrk* systems.

The *vrk* model shifts the focus for analysis from the individuals involved to the individuals as they think and behave within a collective decision process. An individual may learn about adaptation issues in one social context (an adaptation workshop, for example), but may be able to apply this knowledge within a decision process only when given agency by the collective.

3.3. How does change in *vrk* systems occur?

The *vrk* model can help investigate how the interaction between agency and structural influences can determine the dynamics of a decision context. A focus on rules-in-use reveals the limits to top-down government processes of changing rules-in-form. Decision processes for changing rules-in-form are not simply drivers of change in a decision context; they may be part of the change process by enabling changes in future decision contexts, but are constrained by existing decision contexts. Even extreme changes such as revolutions draw on the capacity of society for coordinated action (Giddens, 1984; North, 1993). This capacity is determined by the *vrk* systems of the group of agents that determine the group response to a given formal rule change.

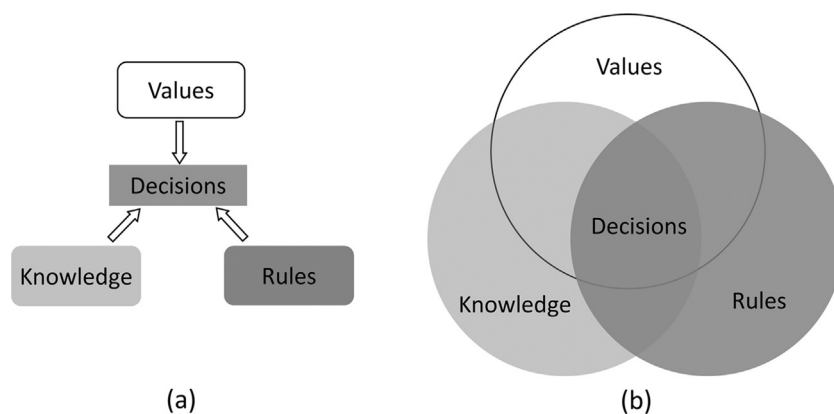


Fig. 1. Two perspectives on decision making: (a) from the decision-making perspective, values, rules and knowledge are independent sets of variables and constraints to be considered when selecting an option; (b) from the decision-context perspective, values, rules and knowledge are interconnected systems that define a decision process and enable the construction and evaluation of options. Interactions between values, rules, and knowledge systems limit the set of practical or permissible options; the types of values, rules, and knowledge that can influence the decision and the potential for change in the decision context.

Adaptation initiatives may need to focus on feasible short-term objectives as part of a longer-term strategy for changing the decision context because a series of constraints may need to be overcome in a sequenced, strategic manner. A sequence might involve first disseminating knowledge about climate impacts, then supporting social deliberation about the values affected, followed by a process of legislative reform. However, this simple stepwise strategy is unlikely to work for complex problems. To change a particular aspect of the decision context one needs to account for how the interactions between *vrk* systems constrain the potential for change. Therefore, strategies for knowledge generation and dissemination need to account for how the established systems of values and rules influence what forms of knowledge are allowed to be used and generated. While the *vrk* model can help inform adaptation strategies, it has a more important role in motivating a broader, more strategic approach to adaptation by consideration of a wide range of theories and types of societal change. Such an approach would include consideration of mechanisms that minimise attempts by a particular interest group to build agency in order to influence a particular decision context. This prospect raises questions about what kind of attributes and powers an effective adaptation initiative might require.

3.4. The role of *vrk* in adaptation for linking theory with practice

The decision-making perspective underpins the adaptive management loop or iterative learning cycle (Hinkel and Bisaro, 2014, 2015). Iterative learning has become a standard approach to adaptation in which the decision problem is defined, options are evaluated and implemented, and the outcomes monitored. It has been used in the analysis of adaptation barriers (Moser and Ekstrom, 2010), and underpins the European Climate Adaptation Platform support tool (<http://climate-adapt.eea.europa.eu>) and the Thames Barrier analysis (Reeder and Ranger, 2011). Iterative learning frames the decision-making process for those whose central role in the process is research and monitoring. However, research alone is not enough. Much of adaptation research is focused on the generation of scientific knowledge to inform policy (the so-called 'knowledge deficit model'; Table 1), with the implicit assumption that it is sufficient to provide the necessary knowledge to policy makers to ensure successful adaptation.

The concept of triple loop learning emphasises the need to address *vrk* elements and proposes that agency for change arises from collective learning and decision making (Tosey et al., 2012). The *vrk* perspective can augment triple loop learning by emphasising that agency is distributed, limited, and that scope for deliberate changes is constrained by innovations compatible with the existing system. Knowledge-based learning is thus only one way to influence the decision context, because interconnected *vrk* systems will determine what forms of knowledge need to be generated, retained and used. The *vrk* model can therefore motivate and inform strategies for addressing the three loops in an integrated manner using a range of societal change mechanisms. In so doing, the *vrk* model highlights the need to expand the adaptive management model to consider both the limits on the agency of managers and adaptation practitioners, and the societal dynamics of those limits.

Communication between proponents of different perspectives on decision making is "difficult and rare" (Tetlock, 1985) because concepts from one perspective do not have meaning or validity for the internal logic of another perspective. However, the need to relate differing perspectives is essential for adaptation to complex problems. By highlighting those aspects of social systems that are likely to be of relevance to a particular decision context, the *vrk* model may help reveal areas of social theory that can inform and modify the perspectives of the decision makers.

4. An approach for reframing adaptation initiatives to focus on the decision context

The *vrk* model can be used to help frame adaptation initiatives (see Table 1 for definition) in order to explicitly consider the decision context. This can aid in adaptation by assisting with sense-making, developing new options for planning, and considering the legitimate and feasible roles of the adaptation initiative. A possible sequence of steps in an adaptation initiative is as follows:

1. Based on knowledge of emerging circumstances and an understanding of how the social–ecological system may respond, identify the major issues for adaptation, and the focal decision-making processes needed to address aspects of these issues;
2. Describe the decision context of a focal decision process as a *vrk* system by analysing the decision process as it occurs (not as it is idealised) in order to identify the *vrk* systems in use;
3. Identify new knowledge, values or rules that may become relevant for the focal decision process in the context of emerging issues of global change;
4. Analyse if the new elements in the *vrk* systems identified in step 3 are likely to be excluded from the decision process, by examining pair-wise interactions in the prevailing *vrk* system (i.e., *vr*, *vk* and *kr*) of the focal decision process;
5. Analyse if the decision context can adapt without intervention. That is, examine how the decision context is maintained or recreated over time, and identify any *vrk* interactions in this recreation process that prevent the decision context from being changed to incorporate the newly relevant value, rule and/or knowledge elements identified in step 3;
6. Identify actions that could influence the dynamic processes that recreate the decision context as described in step 5;
7. Reflect on the decision context of the adaptation initiative in order to: (a) evaluate the limits of the adaptation initiative to either implement the actions suggested in step 6, or to build the capacity of future initiatives to do so, and (b) evaluate if the adaptation initiative has a legitimacy for strategies to influence the decision context.
8. Undertake the actions suggested by step 7 to either influence the decision context of the focal decision process, or to build legitimate and effective adaptation initiatives.

This framework provides an iterative processes for developing adaptation initiatives that reveal and address emerging issues of concern. For a potential issue, it helps determine which decision process is relevant (step 1); whether the process accounts for the emerging issue (steps 2–3); if not, whether the decision process will change to account for emerging issues (steps 4–5); if not, whether the adaptation initiative can address this (step 6–7); if not, whether future initiatives can be built that do (step 8).

5. Illustration of the framework for adaptation practice—coastal adaptation pathways projects

The framework suggested above has yet to be fully incorporated and tested as part of an adaptation project. This is because *vrk* is a novel concept, presented herein for the first time, and further work is required to develop an operational approach for *vrk* that can be proactively built into the design and implementation of adaptation projects. However, as part of the process of building an operational approach, the framework can be applied to projects, retrospectively and in part (covering steps 3–6 above), in order to examine how it can extend adaptive management and provide examples of the *vrk* analysis in steps 4 and 5 by examining pair-wise interactions in the *vrk* system and how the decision context is

Table 2

Characteristics of the three coastal adaptation projects, assessed retrospectively using the framework for changing the decision context of adaptation initiatives, using an analysis of the interactions between values, rules and knowledge (*vrk*).

Location	Victoria	Queensland	Tasmania
Project aims	Design of a framework to support coastal adaptation planning and development	Implementation of new legislation requiring the development of coastal hazard adaptation strategies	Development of adaptation plans to protect private property from coastal erosion and storm surge
Project methods	Assessment of risks and costs, develop options, apply cost-benefit analysis to prioritise options	Assessment of hazards and risks using cost-benefit analysis to inform spatial planning decisions	Assessment of hazards and risks, community consultation to scope and prioritise options
Framing of the adaptation problem	As a decision process. Decision context not considered	As a decision process. Decision context not considered	Primarily as a decision process, with some consideration of the decision context
Motivation and social-political context	Adaptive management and the development of an adaptation pathway approach to flood risk	Compliance with a legislative requirement	Development of an adaptation pathway approach: strong desire to protect existing investments, co-create options and review planning processes for coastal areas
Participants and roles	Consultants to provide technical analysis and processes. Council officials to implement and make decisions	Consultants to provide technical analysis and processes. Council officials to make spatial plans.	Government & council officials to frame adaptation, consultant to facilitate deliberation, property owners to co-develop options
<i>vrk</i> analysis			
<i>vr</i> interactions	Rules-based cost-benefit framing excluded non-monetary values	Rules-based legal liability framing excluded amenity and ecological values	Public deliberation about policy options accounted for concerns about procedural fairness as well as outcomes
<i>vk</i> interactions	Focus on direct property scale impacts and options excluded regional scale and indirect values e.g. lost coastal amenity.	Spatial planning framework excluded values without defined spatial mapping: e.g. foreshore amenity and environmental landscape values	A focus on assessing private property damage excluded stakeholders who primarily valued public assets
<i>rk</i> interactions	Rules requiring standardised assessment process excluded knowledge about unquantified climate effects	Mandated, fixed projection of sea level rise drove a narrow knowledge base for hazard assessment	Public consultation on knowledge base of adaptation options enabled deliberation about the rules and values that underpinned the options

maintained. Such an approach allows for evaluation of the limits of the project and of future initiatives that build on it, in order to implement strategies (step 7) and identify actions for future initiatives that can influence the decision context to achieve effective adaptation (step 8). In the following section we apply the framework retrospectively to three coastal adaptation projects (Table 2).

The adaptation projects, part of the Coastal Adaptation Pathways program (Commonwealth of Australia, 2013), were in Townsville, Queensland (GHD, 2012), four local councils in Tasmania (Tasmanian Climate Change Office, 2012), and Port Phillip Bay, Victoria (AECOM, 2012). Our analysis was based on project reports, semi-structured interviews with local councillors (i.e., elected officers responsible for planning decisions) and council officers (i.e., employees tasked with advising the decision makers) and assessment of the broader social-political context using a survey of public perception of risks of sea level rise (Ryan et al., 2011), government documents, and media reports.

The projects focused on local government planning processes. They were short-term (<18 months); intended to begin a decision process that, if continued, would lead to implementation. In Tasmania, dunes that had protected houses from storm damage were being eroded by increasingly frequent and severe storms. Affected councils developed adaptation plans in consultation with communities (Fig. 2a) and considered options for changes to local planning processes. The Victorian project focused on developing a framework to support coastal adaptation planning in urbanised and industrial areas (AECOM, 2012). The framework (Fig. 2b) was applied to evaluate options to address threats to private property using cost-benefit analysis. Community consultation was to be included at a later stage. The aim of the Queensland project was to demonstrate implementation of a new law introduced in February 2012 requiring local governments to prepare coastal hazard adaptation strategies (CHAS) for urban areas. The CHAS required spatially explicit land-use zones that accounted for threats from sea-level rise of up to 80 cm by 2100 (DEHP, 2012) (Fig. 2c). The project focused on private property and used cost-benefit analysis to assess planning options. Repeal of legislation in October 2012

meant the CHAS was not implemented (Bell and Baker-Jones, 2014).

6. The case for a decision-context perspective on coastal adaptation projects

The three projects were framed from the decision-making perspective and involved developing decision-making processes that would be used by planners. This framing of adaptation allowed all three projects to be broken into standardised, achievable steps (Fig. 2): (1) gathering knowledge about risks and responses; (2) consulting people about costs and benefits of options; (3) evaluating options according to agreed criteria, either in a deliberative process (Tasmania) or via cost-benefit analysis (Victoria and Queensland); (4) implementation, and (5) monitoring and review. This adaptive management framework has been successfully applied to problems with simple social contexts (Kingsford et al., 2011) or simple systems (Roe and van Eeten, 2001).

The prevailing assumption in the projects that implementation was achievable tended to obscure the decision context. The focus was on decision processes and the inputs that inform them, rather than on the decision context. These processes—community consultation in Tasmania, cost-benefit analysis in Victoria and the interaction between council planners and decision makers in Queensland—were regarded by the project designers as legitimate and credible for the decision-making process. It would have been out of scope to consider whether these processes were adequate to achieve the objectives or whether the decision context should be questioned. The Tasmanian project did consider some aspects of the decision context by acknowledging the shortcomings of the existing planning system and the need to better define governance frameworks and funding mechanisms. However the primary attention on selection and implementation of options reduced the scope for changing the decision context of the planning system or building the capacity of a group of people to continue to change the system.

Given that implementation has proven difficult for such complex problems, we consider that adaptation initiatives require

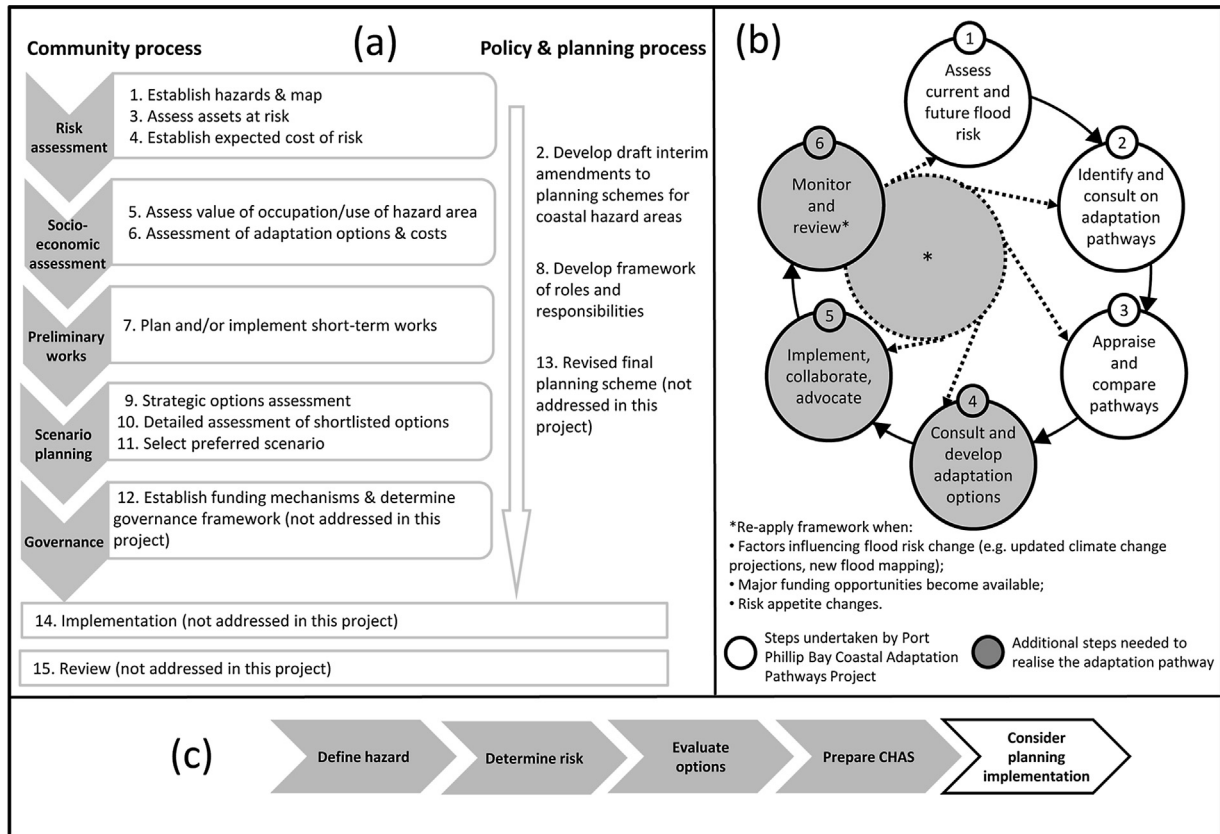


Fig. 2. The project frameworks for the three adaptation projects described herein; (a) Tasmania (Tasmanian Climate Change Office, 2012), (b) Victoria (AECOM, 2012) and (c) Queensland (GHD, 2012). (CHAS is a Coastal Hazard Adaptation Strategy). See text for details.

an explicit focus on how they can contribute to changing the decision context if they are to be effective and accountable. In the following sections we examine how the interactions between elements of *vrk* in each decision process excluded certain forms of knowledge, values and rules.

6.1. Interactions between values and rules

The favouring of particular sets of values may be built into the way that rules are interpreted by decision makers or can be imposed upon the decision process. For example, the Victorian project used cost-benefit analysis, which embodies a rules-based system whereby utilitarian values that can be monetised are included and other, non-monetary, values are excluded. In Queensland, rules-based legal liability concerns influenced the decision process by limiting the consideration of amenity and ecological values in zoning decisions. In Tasmania, environmental and amenity values were considered but the protection of private property values was accorded the highest priority, even if major environmental modification was required as part of the adaptation plan.

Our analysis of values-rules interactions revealed that limitations on local governments to change rigid planning frameworks constrained their ability to manage for social-environmental values because ecosystems, characterised by high uncertainty, require adaptive planning approaches. Similarly, the use of land zoning rules to achieve conservation outcomes restricts the types of environmental values that can be considered and the types of ecosystems that can be protected.

People place value on the rules used in decision making and local councils develop investment plans to meet goals that reflect the values of residents. However, the threat to property from

climate change creates new concerns about equity and procedural fairness (for example, the rules and expectations regarding compensation for damage), illustrating the close relationship between rules and values in the decision process (Abel et al., 2011).

Fiske (2004) argued that four models can be used to explain how human relationships are structured: communal sharing, authority ranking, equality matching and market pricing. These models define the rules that enable coordinated action and articulate the value system that guides choice. Rules and values interactions that define the decision context are therefore jointly determined and intimately related, and these should be anticipated whenever the decision process raises novel issues about values.

6.2. Interactions between values and knowledge

In Victoria, perception of the problem from a perspective of economic values resulted in the exclusion of some forms of knowledge because information was deemed unavailable. The analysis focused on inundation hazards, benefits of avoided damage and costs of protective structures. Topographic data and land values were used, but hazards from erosion and changes in rainfall were excluded, as were non-market costs of the loss of public recreation space. Public land was regarded as a buffer against erosion and damage to private property. The emphasis on private monetary values marginalised the role of public coastal land as a community asset with multiple uses and values. The threat of erosion was also ignored because it primarily affected public land which was viewed as a means of protecting private assets. In Tasmania the focus on private property values meant that public consultation was with private property owners and focused on the spatial analysis of the extent of the threat. As a result, environmental and recreational interests were under-represented.

In Queensland, the relevant knowledge for planning was structured as spatial mapping of asset values and threats, with a focus on the impact of one-time approval decisions for development of individual housing plots. Issues arose where the impact of plot-scale decisions on multiple diverse values were not easily represented or were entirely excluded from consideration, such as the public amenity of foreshore use or the visual amenity of coastal landscapes.

Our analysis of values-knowledge interactions reveals ways in which framing of technical analyses can be narrowed and stakeholder groups excluded. Predominant values determined the views of decision makers regarding natural and social systems, restricting knowledge and values to forms considered valid for the decision process and marginalising those related to nature, culture and sustainability. Such constraints are not new: economic, rational-choice models do not enable all costs and benefits to be accounted for in decision processes (Lindblom, 1959; Etzioni, 1967; Gershuny, 1978). Funtowicz and Ravetz (1993) stated: “The traditional fact-value distinction has not merely been inverted; in post-normal science the two categories cannot be realistically separated.” A common response is for inclusive, deliberative process-oriented approaches to decision making, including ethical and equity implications (Funtowicz and Ravetz, 1994; Rittel and Webber, 1973). Adaptation also requires value and knowledge systems suited to novel trade-offs that emerge under climate change (O’Brien and Wolf, 2010). However, the post-normal approach still separates decision making from the societal decision system. How societal conventions influence a given decision process requires a focus on the rules that define and legitimise that process and empower actors.

6.3. Interactions between rules and knowledge

In Victoria, the use of cost-benefit analysis as the rules basis for evaluating adaptation options restricted the knowledge base and resulted in a relatively narrow set of options. Decision makers focused on inundation hazards and the economic benefits of avoiding property damage based on local land-values. Economic estimates were limited to the study area only and adaptation options were not fully costed. Hence, impacts and adaptation options for the broader region surrounding the study area were excluded. This exclusion results from the cost-benefit approach, which discounts long-term effects and uses partial-equilibrium models that exclude uncertain cross-scale effects.

In Queensland, planning decisions required spatially-defined inundation risks. Accordingly, the Queensland government passed legislation that defined an 80 cm rise in sea level by 2100 as the basis for inundation hazard mapping. The focus on spatial planning led to investment in high-resolution surveys of coastal topography. This spatial planning framework cannot account for the high probability that future estimates in the rate of sea level rise will be revised. As a result, uncertainty about sea-level rise was excluded from consideration in the decision process. Public support for the legislation may have been undermined by the questionable credibility of the predictions.

The relationships between council officers (local government employees) and the councillors (elected representatives) also resulted in exclusion from decisions of the environmental and social effects and values relating to inundation. Officers provided information to councillors about costs, benefits and risks of proposed developments, but had limited capacity to report on environmental and social values that were hard to quantify. Officers considered that councillors would be aware of the limits of their reports and use their judgement to include these values when making their decisions. However, a history of major floods in the region meant that technical analysis of flood risk was pre-eminent

in decision making. Councillors felt that legal liability made it difficult to oppose recommendations of officers based on technical analyses, so social and environmental impacts of developments were not fully considered.

This analysis of rules-knowledge interactions shows that knowledge that did not fit the existing (formal and informal) rule system was excluded. Rules systems are built upon particular knowledge systems (e.g. spatial planning), and the decision process tends to reinforce the situation, in Queensland leading to both new rules (sea level rise benchmarks) and new knowledge (spatial elevation mapping) that favour options supported by the prevailing knowledge system.

Rules-knowledge interactions can also shape public deliberation of emerging issues. As an example, knowledge that sea walls to protect beach-front housing displaces and magnifies wave impacts to adjacent areas and may lead to calls for restrictions on building walls. Knowledge about risks and types of solutions therefore help shape the policy responses that may be required. Conversely, cultural theory (O’Riordan and Jordan, 1999) suggests people may alter their views on the need to address a novel risk according to whether they support the type of policy response required. Anticipation of the need for collective action is likely to influence perceptions of the importance of that risk. In Tasmania, consultation with property owners included what was known about inundation risks, infrastructure options for adaptation, policy mechanisms such as rebuilding and compensation, and the process for choosing a policy. By discussing knowledge and being explicit about related rules and values, the deliberation process allowed connections to be made between knowledge about adaptation options and the rules systems that might constrain or enable them.

7. Using *vrk* interactions to explore the process of change in the decision context

The *vrk* interactions described above determine which values, knowledge and rules influence decisions and which are excluded. These interactions therefore constrain the decision process from changing to allow broader sets of values, knowledge and rules to be included in future decisions on emerging issues. How *vrk* systems are used in the decision processes revealed feedback mechanisms that recreated and perpetuated existing processes. For example, in Queensland, the importance of managing for mitigation of storm damage was embedded in both legal liability rules and in the structure of the relationships between council officers and councillors. This relationship ensured that only limited forms of knowledge about flood risks were used in planning decisions. Similarly, the spatial planning framework led to knowledge generation in the form of maps of inundation threats that emphasised impact on private property values. The introduction of a new law specifying a fixed sea level rise projection to be used for further spatial planning resulted in the exclusion of any consideration of uncertainty regarding future projections of sea level rise.

Our analyses found that adaptation options are created within, and limited by, the prevailing *vrk* systems that decision makers use. Previously tried, tested and accepted options will be favoured over novel approaches. The options available will depend on the perspective of those who frame the problem and the types of knowledge they consider relevant: engineers tend to seek infrastructure solutions, planners tend to adjust regulations which lawyers will seek to implement or circumvent. An example of where novel approaches may be constrained relates to schemes such as rolling easements, or conditional property rights, which have been proposed for coping with uncertainty about how sea level rise will affect property (Titus, 1998). Such schemes have rarely been implemented, partly because they represent a hybrid

legal, market and planning solution and are incompatible with the discipline-specific knowledge systems used in planning.

Rules-in-use may preclude options even where rules-in-form specify powers for decision makers to consider a wide range of options. For example, compulsory purchase by councils of freehold private property to allow for implementation of adaptation options is possible under current rules-in-form, but widely shared values and rules-in-use obviate its use. Under current Australian planning laws, land development and occupancy rights are generally conditional, but the common perception by property owners is that they are permanent, and it is therefore not legitimate for planners to grant rights that are conditional on changes in the risk of inundation. Attempts to impose such conditions have been strongly challenged (Ryan et al., 2011).

Proponents of the evolutionary economics perspective argue that changes in societal rules-in-use are co-evolutionary rather than controlled by design. This is because societal change requires shifts in diverse sub-systems of rules embodied in different agents and contexts and because change processes use and modify existing societal decision-making processes (Dopfer and Potts, 2009; Norgaard and Kallis, 2011; Safarzyńska et al., 2012). By emphasising changes in rules, this perspective stresses the importance of social processes that drive innovation, diffusion, selection, expression and retention. Potential for change in one part of the *vrk* system therefore depends on the state of the other parts. The interactions among *vrk* elements described above not only describe limits on the performance of the decision-making process, but also define limits on the ability to change. For example, a land zoning system that lacks a process to grant conditional ownership rights will prevent change to the decision context to incorporate knowledge about changing risks of inundation. Thus the *vrk* elements of the decision context must co-evolve.

Creating new options involves changes in the *vrk* systems. In Tasmania, including public deliberation on adaptation knowledge and the related rules and values helped expand the possible options that property owners were willing to regard as legitimate. This deliberation established community expectations about how the decision process would be framed, what could be considered legitimate and what values systems would be applied. From a decision-making perspective, the Tasmanian project could arguably be criticised for excluding groups that represented environmental values, and therefore producing biased recommendations. However from a decision-context perspective, this approach represented an important strategic step in developing new, adapted *vrk* systems among a key stakeholder group affected by sea-level rise.

8. Conclusions

In this paper we present a model of decision making that can assist adaptation practice by enabling reflexive analysis of societal constraints on decisions. The model emphasises values, rules and knowledge as concepts that link the decision-context (or structural) perspective to the decision-making (or agency) perspective on decision processes. Bridging the agency-structure divide will be increasingly important in adaptation practice as global change reveals limitations of existing environmental management systems. In helping to bridge this divide, the *vrk* model can contribute to several aspects of adaptation practice. The model may help decision makers to acknowledge and articulate how the decision-making system limits, and simultaneously creates, the scope for decision making. It can also help decision-makers understand the nature of the challenge of changing the decision-context to cope with global change issues. Global change casts decision-makers as actors in complex societal change processes, placing demands on them that are fundamentally

different to their roles within defined decision processes. We show how the *vrk* model can help identify and explore relevant theories of societal change, and question the legitimacy and agency of proposed reforms.

The role of research in supporting society to address these novel and contested issues therefore also needs to be re-examined and expanded beyond the roles implied by the decision-making perspective. Herein we have suggested an approach that helps to identify new roles for research in adaptation initiatives. These roles include identifying and reframing emerging issues, developing new options that are feasible within existing decision contexts, and developing ideas for strategic societal change processes. Defining these transdisciplinary research tasks and developing the research programs and processes and institutions that enable them remain important challenges for adaptation.

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