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### Journal Item

How to cite:

Pelling, Mark; High, Chris; Dearing, John and Smith, Denis (2008). Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations. *Environment and Planning A*, 40(4) pp. 867–884.

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© [not recorded]

Version: [not recorded]

Link(s) to article on publisher's website:

<http://dx.doi.org/doi:10.1068/a39148>

<http://www.envplan.com/abstract.cgi?id=a39148>

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# **Shadow spaces for social learning: a relational understanding of adaptive capacity to climate change within organisations**

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**Abstract.** Recent UK government policy on climate change, and wider policy movement within the UNFCCC, emphasise the building of adaptive capacity. But what are the institutional constraints that shape capacity to build adaptive organisations? This paper synthesises theory from social learning and institutional aspects of multi-level environmental governance to help unpack the patterns of individual and collective action within organisations that can enhance or

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restrict organisational adaptive capacity in the face of abrupt climate change. Theoretical synthesis is grounded by empirical work with a local dairy farmers group and two supporting public sector bodies that are both local actors in their own rights and also shape the operating environment for other local actors (the Environment Agency and the Welsh Assembly and Assembly Sponsored Public Bodies). Providing space within and between local organisations for individuals to develop private as well as officially sanctioned social relationships is supported as a pathway to enable social learning. It is also a resource for adaptation that requires little financial investment but does call for a rethinking of the personal skills and working routines that are incentivised within organisations.

## **1. Introduction**

The United Kingdom Climate Impacts Programme (West and Gawith, 2005) identifies a lack of policy and academic research on the institutional constraints to building local adaptive capacity as a principal barrier to further progress on climate change adaptation. Particular challenges noted include problems of working in regimes where regulations and standards do not reflect climate change, difficulty in finding examples of best practice of adaptation, and the challenge of working in organisational settings without strong support from senior management. These concerns demonstrate the need to plan how adaptive capacity to climate change and variability might be built as an operational imperative alongside existing demands for efficiency, transparency, accountability, legitimacy and equity within local organisations, and those organisations of the state (national, regional and local) that form the institutional architecture in which local actors operate.

Within the climate change literature, institutional approaches have principally been applied to mitigation. These studies have had an international (Rayner and Malone, 1998) or national (Wynne et al., 2001) focus, although O’Riordan et al. (1998) note that

understanding the mechanisms through which national climate policy might unfold requires work on the vertical interaction between local, regional and national actors. Despite the lack of a strong focus at the local scale, where adaptive behaviour is most prominent, these studies nevertheless offer a conceptual foothold for understanding the role of institutions in shaping policy response to climate change risks. Rayner and Malone (1998) argue that variations in environmental perceptions and behaviour are explained more by the character of social networks, interconnectedness and rule sharing than by demographic variables such as age and gender. They identify social networks, rather than the form and volume of information as a key variable explaining whether people pay attention to climate change and enter into behavioural change that is adaptive or mitigative, arguing that informal agreements should be included in explanations of climate change policy formation. This goes further than the more limited view of the IPCC (2001) that presents failure in local mitigative action as a result of information deficit rather than a question of constraining institutional architecture.

Adaptation research has described, categorised and analysed adaptive actions (Smit et al., 2000) and outputs (Adger et al., 2005). Too often, the literature reduces the individual to a rational economic actor; an approach that enables aggregate assessments of vulnerability to particular climatic scenarios but closes off research on the underlying socio-psychological determinants of adaptive action. Few studies have responded to this gap. Grothmann and Patt (2005) recognise the influence of psychological factors in determining individual adaptive capacity. Iwanciw (2004) shows adaptation can be a source of contestation for political actors operating across hierarchies of scale. Tompkins (2005) demonstrates the tensions that can be reflected by contrasting

ideologies, emerging through the interplay of top-down command and control risk management and local self-organised adaptation.

Little research has investigated the relationship between individual learning and the underlying communication pathways and institutional constraints through which adaptive capacity and action is negotiated within and between organisations (Pelling and High, 2005). In this paper we respond to this lacuna in climate change research by proposing and ground-testing a framework for tracking the relational spaces within organisations that cut across the formal organisational structures for learning and adaptation, and which relate individual to social learning. We argue that the relational attributes of organisations and policy regimes is central to adaptive capacity, enabling robust responses not only to unknown shocks and trends associated with climate change, but also the inter-penetrating uncertainties of economic, social and political change (Schneider, 2004, Willows and Connell, 2003). These spaces allow individuals or sub-groups within organisations to experiment, imitate, communicate, learn and reflect on their actions in ways that can surpass formal processes within policy and organisational settings. This approach offers a potential method for measuring adaptive capacity that focuses on process rather than output, enabling proactive adaptation.

The following section develops a framework for conceptualising the interplay of institutions and social learning in the production of relational spaces for adaptive capacity. An analytical frame is then proposed to assess the adaptive capacity of organisations and collectives. This work is then grounded in an examination of the ways in which local adaptive capacity to abrupt climate change is fostered in a local dairy farmers group and two public sector bodies that communicate with and set the institutional environment for local actors.

## **2. Learning for Adaptation**

### ***2.1 Institutions***

Institutions are the constraints that shape social behaviour: the rules of the game (North, 1990) that provide common ground for the negotiation and performance of power and influence in relationships between individuals and groups. In this paper we distinguish institutions from organisations. Organisations are collectives that have agency, part of which is directed towards the maintenance and renegotiation of institutions. Institutions shape the operation of organisational agency and its emergence from the interaction of individual agency. This dialectic between institutions and organisations, structure and agency gives institutional analysis traction on a range of relevant topics, such as communication (eg Drevenšek, 2005), and the scale and sites for adaptation (e.g., Næss et al., 2005, Bakker, 1999).

Institutional analysis can highlight both the formal and informal aspects of social and organisational life. Formal institutions, including legislation or work-guidelines are overtly formulated. Brown & Duguid (1991) describe formal institutional systems as canonical. They are visible and subject to rational control and management through public institutional frameworks. Informal institutions are embedded and tacit, and include intangibles such as cultural norms, values, and accepted ways of doing things. They lack a constitutional basis, and the dialectical relationship with agency comes to the fore; informal institutions give shape to, whilst being reproduced by, repeated rounds of customary behaviour. This shadow (after Stacey, 1996) view draws attention to the hidden, implicit patterns of behaviour and organisational forms that are hard even to delineate and thus hard to rationally control.

Informal institutions are commonly seen as either too intractably complex to work with, or as legitimising of behaviour that runs counter to the professed aims of canonical organisations, for example through corruption (Ostrom, 1999; High et al., 2006) and resistance to change (Argyris & Schön, 1996). The uncertainties of climate change suggest it is worth re-visiting the possibilities of enabling internal dissent as a positive force for local innovation and adaptation. Demeritt and Langdon (2004) show dissent at work in a study of UK local authority officers who often prefer unofficial information sources from the media or internet to those provided through the UK Climate Impacts Programme.

The space of informal interaction that lies outside of but interacts with formal institutions and relationships has been dubbed the shadow system by Stacey (1996). Griffin et al (1999) describe the ideal balance between formal and informal institutions that give shape to relational space as lying at the boundary between stability and instability, regularity and randomness. This place of bounded instability allows novelty to emerge, but in a form that is at least potentially positive and with a sense of continuity with earlier innovations. Stacey (1996) and Shaw (1997) argue that shadow systems might contribute most to learning and innovation in organisations when they are recognised but allowed to have a life of their own. The shadow and canonical view of organisations highlight separate features, but in practice organisational realities arise from the interpenetration of shadow and canonical forms.

## ***2.2 Conceptualising informal organisations***

The intangibility of informal institutions creates difficulty in exploring the local sites and informal spaces of engagement where learning and adaptive capacity can be constrained or enhanced (North, 1990). To provide some analytical grip on informal

institutions we draw from Wenger's (1999) work on communities of practice. Communities of practice refer to structures that are often not officially recognised by the organisations they permeate. Their official invisibility relegates them to the shadow system, which can be thought of as being made up of constellations of communities of practice held together by bridging ties of social capital. Wenger (2000) distinguishes individual communities of practice, which, he argues, can be defined by a shared identity, and held together by bonding ties of social capital. The link between communities of practice, informal networks and un-official activity in organisational settings is an important association to make in tracing the workings of the shadow system in building adaptive capacity.

We argue that it is meaningful to distinguish between two qualitatively different institutional architectures, which can be characterised in terms of the different qualities of relationships that they sustain, and the institutions that they entail. We label these communities and networks (High et al, 2005). Communities are associations founded in shared identity, where shared values and practices are reinforced. Networks comprise those relationships that cross boundaries of identity, providing an informal vehicle for the flow of information in an organisation.

Both community and networks relate to learning and adaptation, and can support or hinder it (Pelling and High, 2005). For example, communities can enable co-ordinated action, but can also suppress unpleasant truths – communal identity is often characterised by Goleman's (1998) 'vital lies', the lacunas of attention that enable community identity to be maintained. Thus, communities can nurture adaptive action, but they can also prevent aspects of adaptive capacity from being socially permissible or even discussable. Similarly, networks provide an informal vehicle for the flow of



information in an organisation (for lobbying decision-makers or testing out new policy), but this says nothing about the normative associations or ideological sub-text of messages being conveyed (Bührs, 2003). They can support adaptive action or provide pathways through which adaptation is subverted by competitive pressures.

Shadow systems can thus be conceptualised as the interactions between communities and networks, and the institutionalisation of learning that arises within community and network interactions brings a range of adaptive potential into view. For example, Wenger proposes that connecting communities of practice into constellations is made possible by boundary people (with bridging ties) and boundary objects (such as meetings or documents created with the purpose of bringing communities of practice together). It is the quality, quantity and aims of individuals connected together in communities of practice, and of their linking boundary people and objects that determine the influence of the shadow system on adaptive capacity. The relevance of this view to public policy and sustainable development is confirmed by Williams (2002), who discusses, the influence personality traits and the role of personal and professional sources of trust in bridging across different epistemic communities.

### ***2.3 Adaptation and Learning***

Adaptation is an alteration in the state of a system in response to a stressor under which key variables are conserved or enhanced. This systems definition of adaptation directs attention towards uncovering processes rather than accounting for specific events or resources (Dyball et al., 2005), with a focus on the social institutionalisation of learning. In the context of adapting to the negative implications of climate change the stressor may be external (flooding), internal (revised policy goals to reduce flood exposure), direct (damage to physical assets or health by a changed environment) or indirect (threat

or harm emanating from the economic and social consequences of a changing climate). Seeing adaptation in terms of learning highlights both material adaptation and institutional modification as valid adaptive strategies (Pelling and High, 2005). If learning itself is considered a kind of adaptive behaviour, then this opens up questions surrounding the process through which actors can learn to learn (or learn to be adaptive), what Bateson (2000[1972]) calls deuterio-learning.

Learning is defined as a transformation in the *potential* for behaviour of an actor in response to experience, as seen from the viewpoint of an observer (Ison et al, 2000). Seeing learning in terms of changes to agency opens to scrutiny the adaptive behaviours of a range of actors, including individuals, formal and informal organisations, and even non-human actants such as elements of technology or nature, provided they are viewed as capable of changing behaviour in response to experience. Accepting that learning is observed differently according to viewpoint allows for the delineation of a range of contrasting perspectives that accept that learning has occurred (or not), without being forced to accept one or the other. For example, a learner's own perspective on their learning could be accepted, as could the views of others, which may differ. The differences may have more explanatory power than any one view taken in their own terms. This intersubjective view of learning (Checkland & Casar, 1986) directs attention beyond simply what has been learnt and towards the institutional forces and actor attributes that direct capacity and ability to learn, and that determine who feels or recognises whether learning has taken place. This more dynamic and process oriented understanding of learning is useful in helping to conceptualise adaptive capacity as a shifting property rather than as a static attribute of individuals and the organisations they inhabit.

The definition refers to changes in behaviour, a point of convergence between many different theories of learning (Ison et al. 2000). However, rather than the behaviourist focus on 'objective', externally validated, physical behaviour, we accept that behaviour in the widest sense as that which learners do. Following Maturana and Varela (1992) and Ison et al. (2000), we accept the inclusion of internal actions as behaviour. As individuals, this recognises that we can learn in relation to different modes of interacting with the world: emotional and conceptual as well as physical. Our learning corresponds to differences in the way that we act (consciously or unconsciously) within these modes, which in turn arise in concert with our ongoing experience. When considering adaptation in collectives, the focus on internal actions draws attention to the processes of emergence through which collective behaviour arises from individual learning. In both cases, the judgement of what constitutes behavioural change lies with the observer in question, and the definition does not rule out internal and tacit activities such as conscious or unconscious cognition, emotional affect or the formation and operation of personal relationships.

Identifying different realms of behaviour in the interaction of the shadow and canonical systems it is important to sharpen our focus on the site(s) where social adaptation can be observed; not only in material actions, but in contrasting attitudes or views that have not been allowed translation into action. Pred and Watts (1992) identify private language as a mechanism for resistance amongst marginalized and observed actors. We are also interested in the extent to which hidden, silent or private behaviour is proactive rather than reactive, an essential feature of social life within and between canonical organisations.

Adaptation to climate change and variability can be read at different levels of learning operating as a range of system-hierarchic scales: the behaviours of components and subsystems of the system, as well as changes to the emergent properties of the system, and this can be used to unpack different adaptive trajectories – international, national, local. It may also be that adaptive behaviour emerging at one scale – say the local – is the result of learning that has been ongoing amongst a range of actors networked across a range of scales. Additionally, adaptation at one spatial (or temporal) scale can impose externalities or constrain adaptive capacity at other scales. In short, the system-hierarchic scale where adaptation is or is not enacted is a socio-political construction (Adger et al, 2005), and the analytic flexibility in abstracting the relationships between different levels allows questions to be posed about the appropriateness of particular constructions of adaptation.

#### *2.4 Social learning and systems scales*

We are interested in processes through which adaptive capacity is socially transformed or produced, and consequently draw on theories that recognise a social dimension to learning (cf Jarvis et al, 1998). Within the literature, social learning has been interpreted to mean both individual learning that is conditioned by its social environment, and learning in the sense that social collectives such as organisations can be said to learn in their own right. We argue that these are distinct, but complementary and coupled aspects of learning within organisations.

The first case, which Wenger (1999) describes as social theories of learning emphasises the role of institutions in shaping individual learning. There is a longstanding interest in the extent to which learning is determined by culture and socialisation (Jarvis et al., 1998). Organisations are seen as environments that enable or inhibit individual learning

through their culture, structure or sanctioned practices (Wang and Ahmed, 2003). Collaborative learning amongst peers is believed to facilitate faster and deeper learning compared to learning received through the transmissions of an instructor (Elwyn et al., 2001). This leads to the possibility of informal communities of practice operating as vehicles for peer learning, facilitating adaptation to complement officially communicated or 'taught' adaptations to policy or practice. Within climate change (Pelling, 1998) and natural hazards (Wisner et al., 2004) research there is much debate on the influence of social context and social position on constraining information flows and so opening or closing options for adaptation. In seeking to understand adaptation to climate change, social theories of learning prompt a questioning of the social variables that influence the learning of individuals and how this relates to collective adaptive capacity.

The second sense of social learning sees organisations themselves as learning entities. From an analytical perspective there is a danger that accepting the possibility for organisations to learn might result in a loss of clarity by concealing the action of individuals operating within the organisation (Argyris and Schön, 1996). However, it is clear that collective learning is not the linear sum of individual learning. Janis's (1989) 'groupthink' is a clear counter-example, where the social/institutional environment of a group suppresses the knowledge of its constituent individuals - collective learning being deficient in comparison to individual learning. The existence of the converse case, where collective learning and adaptation perform better than the sum of individual potential behaviour is reflected in studies of organisational learning (Senge, 1990; Argyris & Schön, 1996), and the 'wisdom of crowds' (Surowiecki, 2004). In studies of adaptation, this is often expressed in terms of solutions to problems emerging out of joint action and innovation (Hutchins, 1996), and within environmental management

more broadly has led to a focus on social learning as the collective action and reflection that occurs among different individuals and groups (Keen et al., 2005).

The two senses of social learning that we have examined operate at different levels. While neither determines the other, they produce the conditions for one another through the ongoing emergence of institutions. The adaptive behaviour that an organisation manifests emerges from the individual behaviours of its members, and the emergence of group behaviour arises from the institutionalisation of the interactions between organisational members. On the other hand, the social environment in which individuals find themselves shapes the space of possibility for individual learning, and changes to the institutional framework that configures this space is an important collective behaviour in its own right.

### ***2.5 Pathways for adaptation***

Building on the discussion of learning above, we propose an analytical framework for assessing and understanding adaptive capacity from an institutional perspective. The framework identifies discrete adaptive pathways, the potential or actual existence of which is interpreted as an indicator of adaptive capacity. This differs from existing approaches that have developed typologies for adaptive action - reactive, concurrent or anticipatory, spontaneous or planned, short-term and tactical or longer-term and strategic (Pelling and High, 2005). Our concern is not with static expressions of capacity measured through adaptive action, but rather with the underlying institutional arrangements of the shadow and canonical systems that give shape to adaptive capacity and so prefigure adaptive action. We argue that this approach not only sharpens the analytical lens but can also be used to support proactive policy to support the building of adaptive capacity, even under conditions of high uncertainty.

In considering the relationship between the learning of an agent - an individual or discrete subgroup - and learning within the wider social organisation in which they exist, we propose six pathways through which adaptive capacity can be indicated and adaptive actions are operated.

**Table 1: Six adaptive pathways**

	<b>Pathway</b>	<b>Summary</b>	<b>Example</b>
1	Organisational internal action	The organisation takes collective action within its environment in order to facilitate adaptation to environmental changes.	The organisation changes its management structure or practice
2	Organisational external action	The organisation takes collective action to modify its relationship with the external environment, or an element of the environment itself.	The organisation changes its external communication strategy.
3	Agent centred command and control	The agent follows centrally prescribed pathways in undertaking a realignment of capacity to facilitate adaptive action.	In complying with work guidelines a manager adjusts work routines to meet performance targets.
4	Agent centred resource management	The agent unilaterally changes the selection or use of resources to undertake predetermined adaptive action.	While no guidelines exist, a manager adjusts work routines to meet

			performance targets.
5	Agent centred reflexive adaptation	Learning from experience causes the actor to re-assess the goals as well as the methods and resource uses that shape adaptive strategies.	A manager decides that the pre-existing aims of work are undermining sustainability and so changes these aims and consequent work routines.
6	Agent centred institutional modification	The agent undertakes to alter the institutional context within which it operates so as to shift the institutions which control its scope for future adaptive capacity and action.	A scientific advisor lobbies policy-makers to change policy priorities.

The six pathways are summarised in Table 1. Pathways 1 and 2 acknowledge that the adaptive capacity of an agent is in part expressed through the collective action of which the agent is a part. Pathway 1 speaks to adaptive pathways that result in internal institutional change, Pathway 2 to actions on the external environment.

Three pathways connect adaptive capacity to material action by the agent. Pathway 3 describes non-reflexive realignments of resources used to make adaptations in response to top-down command and control. Pathway 4 is an intermediary learning pathway where the agent self-learns from experience to refine the selection of assets with which to enable established adaptive trajectories. Pathway 5 is a reflexive pathway where the



goals as well as the mechanisms for adaptation are reviewed and potentially changed. Reflexivity is also present in Pathway 6 where the target of adaptation is the institutional architecture of the canonical or shadow systems that constrains or enables future material adaptations.

As we have argued above, self-organised (agent centred), reflexive adaptation targeted at the external environment (5) or institutional architecture (6) are arguably the most significant indicators of sustainability. An organisation that enables reflexive adaptation is more likely to be able to respond to abrupt and unforeseen threats and opportunities associated with climate change. Reflexive adaptation, especially that which seeks to challenge existing canonical institutions, is strengthened by a strong shadow system. The key challenge for organisations is to support – but not to manage - the shadow system.

### **3. Examining Pathways for Social Learning and Adaptation**

In this section we ground our theoretical argument to show how reflexive adaptation has been enabled and constrained in particular institutional contexts. We are primarily interested in local organisations as the front line actors in adapting to climate change and variability, and present evidence from work with members of a Welsh dairy farmers co-operative called Grasshoppers. We are also interested in evidence that shadow systems for social learning have influenced behaviour in public sector bodies that shape the enabling environment within which local actors operate. To this end we review evidence from the Environment Agency and officials in the public bodies that report to the Welsh Assembly. A Welsh regional context was chosen for two reasons. First, because of access through established research contacts, and prior knowledge of the institutional thickness of the shadow system within the Welsh polity, making the region

a rich case study. Secondly, the formalisation of the regional level of governance through the Welsh Assembly provided an opportunity to compare the interplay of shadow and canonical institutions and of adaptive capacity and action with the more hierarchically organised Environment Agency.

Group discussions were held with members of each organisation and this was followed up with 14 individual or joint interviews. Notes taken during discussions were written up with analytical notation as intermediate stage research reports and then circulated back to respondents for comments and clarification. This served to verify the researchers interpretation of respondents' comments and also acted as a way to feedback research insights into the policy communities.

To position conversations on climate change adaptation around capacity to learn and change behaviour in response to the unexpected and un-planned for, respondents were presented with a hypothetical, abrupt climate change scenario for which no contingency plans existed. The scenario specified a warming trend for 20 years to reach a climate similar to that of contemporary southwestern France, followed by a rapid cooling over a subsequent 10 years to reach a new climatic equilibrium close to that of southern Norway, based on thermohaline break-down in northwest Europe (IPCC, 2001; Hulme et al., 2002). To generate concrete evidence for the interplay of shadow and canonical systems in learning and adaptation respondents were asked to identify past analogues for this scenario – events that were unforeseen, unfolded at varying paces and scales but tended to overwhelm the everyday activities of their organisation. The analogues chosen included the political and social impact of BSE, the foot-and-mouth outbreak in 2001, ongoing changes to European Common Agricultural Policy and the impact of the European Water Framework Directive. These analogues provide a window into

analysing adaptive capacity for similar future events associated with the direct (environmental) and indirect (economic and social) impacts of abrupt climate change.

The following summaries present analyses of the interplay of shadow and canonical systems in each organisation, and indicate the influence these systems have on social learning and capacity to adapt to abrupt climate change. For a complete analysis and copies of the intermediate research reports, see the project website, <<http://rcc.rures.net>>.

### **3.1 Engendering reflexive adaptation in a local organization: Grasshoppers**

Grasshoppers is a Carmarthenshire based dairy farmers group with 20 members. It was established in 1999 to explore what they know as the New Zealand grazing system. This extensive production system differs from dominant intensive dairy practices in the UK in that a higher return is derived from a lower overall production, as costs and inputs are minimized. This happens through a combination of conserving hay for the winter, turning cattle out earlier in the spring and calving once rather than twice a year. The system results in little or no spending on winter feed and reduced labour costs. Critically, members of Grasshoppers have consistently been able to sell milk at profit in a market characterized by production losses, leaving them able to reinvest in alternative or complementary businesses.

Through changing their production practices, the members of Grasshoppers, as a group, have demonstrated an ability to adapt proactively to significant challenges to their economic and social well-being. The resulting mode of practice is probably better adapted to climate warming than conventional dairy production in the UK, but under the abrupt climate change scenarios of this research, there would be substantial challenges

to be faced. The proven capacity of the group to facilitate individual adaptive capacity offered an opportunity to explore the role of institutions and social learning in adapting to climate change, experienced through environmental and market variability and change.

Group activities centre on monthly farm visits where members scrutinise each other's management strategy. This scrutiny, which extends to farm accounts, and the shared understanding of how to implement and exploit the New Zealand system has developed over time and is now rooted in a culture of inter-personal trust. This has fostered social learning and joint innovation. Trust enables honest criticism of one another's businesses, something which group members contrast with other farmers communication. Grasshoppers members expressed a strong and well developed shared identity. New members are recruited by invitation, reinforcing the shared and distinct group identity. Critically, membership does not focus directly on joint commercial activity. Members were more concerned with sharing knowledge, improving practice and mutual support in meeting the challenges of the New Zealand system, than with sharing more tangible resources.

For some, the opportunity cost of maintaining their membership of Grasshoppers was high. Membership discussions took time and energy – reflexive cultures require more work to maintain than those built on received wisdom. One response was to include family in Grasshoppers events to break-down conflict between commitment to family and Grasshoppers. Here the boundaries between canonical and shadow organization breaks down, as business, fraternal and family relationships are reconciled. However, while the learning culture within Grasshoppers arose through trust, it depends on

exclusion too. Potential members who can not cope with the group culture were expected to leave.

Thus, in Grasshoppers, inter-personal trust based in a shared history underwrites quality control for learning between individuals. Trust has built up over time to extend beyond core Grasshoppers business, blurring the boundaries between the shadow and canonical systems of Grasshoppers. Such a deep culture of reflexive learning helped to avoid the trap of groupthink, and the group's values center on a capacity to take risks, challenge individual perceptions and modify practices, the essence of reflexive adaptive capacity. This was perhaps best exemplified by the stated willingness of members to move from the New Zealand system to other solutions, and indeed to dissolve Grasshoppers in favour of some other organisational focus/form, if the economic or environmental consequences of abrupt climate change required it. Group members were very optimistic about their ability to adapt to future challenges of abrupt climate change, or indeed other unexpected and sudden events. When pressed, they ascribed this to the confidence gained from the group having successfully negotiated a major adaptation in farming practices in the past by taking on the New Zealand system.

The willingness of members to change embedded practices to achieve important life objectives, even to leave dairy farming, is important – evidence for a value-based adaptive capacity fostered within the group. It stands in contrast to many other farmers who feel stuck, unable to make or even see the changes they need to remain viable. Furthermore, that the members of the group were happy to view Grasshoppers as something transitory points to the importance of the informal relationships fostered there. The formal group was useful for the moment, but not necessary of itself. This suggests that the relationships giving rise to Grasshoppers as a learning culture might

prove a valuable social resource in forming other groups or informal associations oriented towards addressing future challenges. This adds weight to the argument that measuring adaptive capacity needs to consider not just the number of voluntary associations in a society but also the nature of the personal relationships that underpin them (Pelling and High, 2005).

### **3.2 Shadow spaces as vertical pathways for adaptive capacity between local and regional organizations: the Environment Agency**

The Environment Agency provides a regulatory framework and informational resource for local actors in the rural economy and is thus a potential facilitator of local adaptive capacity. This case study explores the place of shadow spaces in the construction of vertical pathways for social learning across organizational boundaries that build adaptive capacity.

Respondents were active within the Environment Agency in seeking to undertake institutional modification as acts of adaptation. Yet the constraints that arise through formal institutions on personal and collective adaptive behaviour could be difficult to renegotiate where they originate.

Institutions, as rules, can both constrain and enable adaptation. As a constraint, they check individual and collective behaviour (North, 1990). In the Environment Agency respondents expressed this tension as a stress between personal and professional agendas, made particularly difficult when the constraining institutions originated beyond an individual's influence, often higher up the hierarchy of control so that the costs of renegotiation were exorbitant in personal and professional terms. An alternative locus of adaptive opportunity arose through the informal social life of organisations, and

can be fostered, for example through casual discussion or spontaneous email debates (Benner, 2003).

One respondent noted the principal concern with using information sourced from the shadow system was the difficulty of making transparent judgments on the appropriateness and veracity of information where there were no formal controls on quality. This was perceived to be particularly relevant for climate change where the contexts that shaped past experience may no longer have the same relevance making professional judgment an important element in evaluating received information. Part of the answer to this lies in interpersonal and professional trust decreasing the transactions costs of accessing information and entering into action. One respondent expressed a preference for working with or acting on information received from colleagues from whom past information had proven reliable. Seeking to maintain a reputation for trustworthiness was explained as costly, and risk aversion as a merit for those active in the shadow system in this organizational context.

Respondents were active within the Environment Agency in seeking to undertake institutional modification as acts of adaptation. The core personal skills identified as being required for working the shadow system to influence canonical behaviour included: communication skills, formalizing viewpoints, bridging between organizations and cultivating a personal network where professional and personal trust were the basis for influencing.

Building adaptive capacity through pathways for learning with wider stakeholders, and especially the public had its costs, there was a difficult balancing act between efficiency and building adaptive capacity through, for example the ability of line staff to undertake

their work without too much interruption. This tension was well demonstrated by the establishment of a call center. While being appropriate under the logic of efficiency (through taking scientific officers away from direct contact with the public), this innovation was counter to the alternative logic of adaptive capacity (through the loss of vertical linkages) between the Agency and local organizations.

A key challenge of sanctioning pathways for building adaptive capacity through the shadow system was the difficulty of measuring impact. This made it difficult for the canonical system to reward positive influencing behavior extending from the shadow system, and acted as a dis-incentive for individuals active in the shadow system. But a lack of visibility is a defining attribute of the shadow system and one that enables experimentation and risk taking. This touches on the need to find (and constantly review) the right balance between the shadow and canonical systems within organizations: to build adaptive capacity in a way that does not overly compromise other organisational imperatives (Shaw, 1997). The challenge for building adaptive capacity through the shadow system is to find ways to manage in relation to it, rather than attempt to take control of it. Of particular concern is the task of incentivising positive shadow activity while leaving enough space for it to operate. This might be done by developing job descriptions that can reward individuals who use their skills in creating and maintaining informal relationships in the shadow system, but also requires overcoming the difficulties inherent in reporting on tacit, contingent activities to managerialist organisations.

### **3.3 Shadow spaces as nodes for reflexive adaptation in an organisational network:**

#### **The Welsh Polity**



Devolution has opened the opportunity for regional approaches to the building of local adaptive capacity. In Wales, the institutions of the Welsh Assembly and the associated Assembly Sponsored Public Bodies play this role. In addition to formal structures, the Welsh Polity benefits from a strong sense of identity amongst its agencies and officers, grounded in distinctive characteristics such as a culture of consultation and regional individuality, along with the opportunities for institutional innovation and reform that devolution has brought. These cultural values influence risk management in the canonical system, which places emphasis on public consultation. For example in Towyn, a town that experiences periodic flooding, local communities were involved in decision-making on flood risk management that precipitated a move away from a blanket ban of flood plain development to the negotiation of locally acceptable levels of risk.

A culture of consultation was also reflected in a strong shadow system that facilitated inter-agency communication and collective, informal adaptive capacity. Respondents reported that the shadow system was more effective than official structures in communicating information. Inter-agency response to unplanned for events was recognized to have benefited from informal networks because reactive adaptation required rapid communication, not just horizontally between chief executives of different agencies, but also between those at the coalface. Informal institutions also reduced the effort of affecting action in others, where there was a common understanding of urgency a simple phone call could allow exchange of information or release resources.

Respondents were clear about why it was that a strong shadow system had emerged between agencies in the Welsh Region. These included the quality (the number of local

agencies in Wales is large enough to provide the basis for a network but small enough so that all members can know each other), and the frequency of interaction between staff from different agencies. Furthermore, it was felt that a high number of Welsh staff stay working in Wales throughout their careers facilitating the accumulation of strong personal relationships. Importantly the shadow system has received official sanction, it has been formal policy as part of the Welsh Assembly's commitment to integrated planning and sustainable development to build networks amongst different agencies. After five years, this policy is paying off through the accrual of personalised trust and social networks cross-cutting formal channels inter-and intra-agency communication. The shadow system has been further reinforced at the cultural level, by a desire amongst the Welsh Assembly to establish a policy identity separate to Westminster. This concept, called Team Wales, has succeeded in socialising a regional culture of self-identification contributing to the accumulation of trust and reciprocity between regional actors.

The thickness of the shadow system in Wales had been seen to have enabled proactive adaptation. Here the shadow system was a resource for innovation and for filling gaps in formal organisational practice. In one example, an initiative on health and the environment used the shadow system to bring people together on a relatively informal basis, this innovation has since become formalised. In a second example, an informally organised air quality forum facilitated the acquisition of a mobile air quality monitoring lab.

A prominent feature in past reactive adaptations based in the canonical system had been their conditioning through prior experience. The latter was a feature of both foot-and-mouth and the Sea Empress oil spill. Here pre-determined contingency plans provided a

framework for response but one that was based more on previous experience than on the scale and directions of the unfolding disasters. In both cases flexibility and a capacity to work outside the formal procedures of the canonical system were seen as an asset in timely and effective response. Shadow spaces provided capacity for reflexive adaptation in these unfolding crises. But the formal system also provided a pathway for solidifying new connections within and between agencies at the sharp end of a crisis, as demonstrated by foot-and-mouth. In this crisis some experts were initially reluctant to become involved in novel arrangements for collective response, but as co-management was seen to deliver results participation expanded building mutual respect between different agencies. In parallel, the shadow system provided a pathway for specific reactive adaptations. The scale and speed of the crisis overwhelmed established procedures and created a need to short-circuit normal decision making process. In response, the shadow system facilitated the movement of material and informational resources to support local actors. This example of institutional modification shows how fuzzy the boundaries between the canonical and shadow systems can be in practice, particularly in a fast moving policy context of reactive adaptation, and the need to understand more about their interaction in reactive adaptation.

The shadow system was recognized to have contributed to resilience in the Region through providing excess capacity, overlapping functions, increasing the speed of information and resource flow and enhanced horizontal governance. However, respondents did express concerns that activity within the hidden networks of the shadow system was less accountable and transparent than the canonical system indicating tensions between existing imperatives and those of adaptive capacity. It was also recognized that the shadow system could be a source of inequality between those

people, ideas or values inside and outside the network, and with respect to newcomers represented a cost in terms of time required to become established within the network.

#### **4. Adaptive Capacity and the Shadow System**

In 1991, O’Riordan and Rayner argued that new institutions are needed to support decision-making under the uncertainty associated with climate change. In 2006, Rayner complains that this agenda remains largely unmet. The challenge, according to Rayner, is to move from a recognition of the need for more public engagement in reflexive governance towards identifying those pathways through which multiple viewpoints and values can be brought into the decision-making arena to enable adaptive action. In the context of adapting to climate change, uncertainty over future directions and speed of change, and the myriad indirect pathways through which climate variability will become manifest in economic and social as well as biological and environmental systems means that fundamental institutional forms that can enhance generic adaptive capacity offer a sound basis for building adaptive capacity (O’Brien, 2006). The theoretical framework and empirical evidence above provide a mechanism for understanding the interaction of institutions in the creation of generic, reflexive capacity from which adaptation to stressors associated with climate change can arise.

While differences in the aims and structures of each organisation make comparison difficult, this work highlights the pervasiveness and relevance of the shadow system for social learning amongst local actors. Table 1 summarises key attributes of the two systems and their interactions that contribute to shaping adaptive capacity in the three case studies.

**Table 1: Comparing experiences of adaptive capacity, learning and the shadow system by organisational scale and sector of operation**

	<b>Grasshoppers</b> [a local organisation]	<b>Environment</b> <b>Agency</b> [connected to the local though a vertical hierarchy]	<b>Welsh Polity</b> [connected to the local though networked oversight]
The relations or interface between the shadow and canonical systems.	Reinforcing systems of interdependence each providing legitimacy and value for the other. Core procedural elements of the formal system provide a common structure and aims for the group, while the overlapping of professional and personal trust provide a strong base for reflexivity, social learning and adaptive capacity and action.	A vertical shadow system connecting local actors with officials and policy makers in the Environment Agency.  The boundary was clearly identified but pervious. Informal influencing was sanctioned and strengthened through reputation and the use of boundary objects such as academic publications.	A horizontal shadow system connecting officers and local agencies in Wales.  The diversity of actors in the canonical network produced a complex array of shadow systems which varied in their vigour, transparency and membership

Skills needed	An open mind and commitment to the group.	Communication skills, an ability to bridge different professional and interpersonal communities.	Membership to shadow systems came with individuals having demonstrated professional competence and commitment to the idea of Team Wales
Tensions between social learning and other imperatives of the organisation	None surfaced, if other priorities emerged that required the break-up of the formal group it is likely informal interpersonal ties would survive.	Competing views on organisational aims were expressed through tensions with efficiency, stakeholder participation and transparency.	Risk aversion by some actors acted to slow social learning and institutional modification.
How were the impacts of the shadow system on adaptive capacity measured?	The health of the shadow system was an integral part of the health of this group and its capacity for social learning and reflexive adaptations. Consequently it was	Trust is used by individuals to inform judgements on the veracity of information received through the shadow system.	Shadow systems worked alongside canonical systems and had facilitated the timely and efficient flow of resources and information in

	very difficult to identify separate outputs for the formal and shadow systems.	Final outcomes could only be measured indirectly for example through the insertion of a lobbyist's text in formal policy statements.	response to past analogues of abrupt climate change.
Strategies for building communities of practice within the shadow system	Overt, new members join by invitation only. Strategic, new members should ideally bring additional networks and influence or ideas to the group.	Covert, based on personality as much as professional position.	Embedded in the canonical system through the concept of Team Wales, although those not buying into this idea or without personal connections could be excluded.

Local actors are at the sharp end of adaptation. A capacity for reflexive adaptation, both proactively and reactively, is a desirable attribute for sustainable local collectives and organisations. Grasshoppers was no exception. The canonical structures of a support organisation provided a framework around which thicker social ties based on informal but, strictly maintained, rules of conduct were woven. The closeness of the shadow and canonical systems in Grasshoppers was seen as an asset by members. Interpersonal trust and individual reputation built within one system informed practices in the other. This

created a dense social context for social learning supporting experimentation and contained risk taking. In other words a culture in which generic and reflexive capacity for proactive adaptation were nourished.

Elaborate informal systems of consultation within the Environment Agency have produced a relatively closed UK policy culture in which only preferred non-governmental groups are given access (Wynne et al., 2001). The evidence in this paper points to shadow systems operating at the local level with the potential to feed additional knowledge into canonical policy and practice. The shadow system enhanced capacity for vertical information flow with local actors, but was at times in conflict with reforms to the canonical systems (such as the call centre) that may provide greater efficiency for the organisation but erode the social ties of the shadow system and so cut off opportunities for reflexive adaptation and institutional modification. In the Welsh polity, the shadow system had a more horizontal form, reflecting the emphasis placed on inter-agency networking by the Assembly. Openness to social learning from the shadow system and raised adaptive capacity was demonstrated.

In all organisations, the shadow system worked on the basis of personalised trust, which provided a quality control function in this otherwise unregulated space. In the Welsh Assembly this was reinforced by a canonical culture of inter-agency and public consultation and a strong communal identity embodied in the concept of Team Wales. In spite of this, some organisations – in particular local government - were perceived to behave more conservatively and with more caution with respect to novel institutions arising from the shadow system around the Welsh Assembly. This indicates conflicting perceptions of ownership of the shadow system, and suggests that multiple communities of practice and associated value systems are in operation in the Welsh polity. This



makes it more challenging to work outside the canonical system and requires greater skills of negotiation and communication. But if the shadow system can be creatively engaged with this diversity opens possibilities for overcoming the tendency for organisations to process new challenges and develop adaptive strategy through pre-existing templates (adaptation through commend and control), rather than fully considering multiple alternatives (reflexive adaptation and institutional modification).

The challenge for the shadow system to make linkages beyond those underwritten by the canonical system was also found in the Environment Agency, although here respondents identified many personal skills that had been developed by the initiative of individuals who had recognised the additional leverage for influencing policy that the shadow system offered. This suggests there is a good deal of scope for fostering skills for working the shadow system to enable thicker social connections and trust to develop between agencies at the local and regional levels and thus build generic capacity for adaptation.

#### **4. Conclusion: implications for research and planning for adaptation**

The opportunity for understanding and building adaptive capacity to climate change through the interaction of the shadow and canonical systems has been neglected by academics and policy makers alike. Many of the attributes of social learning that can build capacity for reflexive adaptation in local organizations are reflected in work that has examined the role of institutions and social learning at the international and national scales in the management of global environmental risks (Haas and McCabe, 2001; Wynne et al., 2001). All scales benefit from the right balance between independence and oversight. At the international scale and in the context of mitigation, independence helps legitimate scientific expertise and contributions to policy formulation; at the local

level, independence can run much deeper with the shadow system providing a key resource for policy enactment and regulation as well as innovation and learning.

Using an institutional approach to develop indicators for local adaptive capacity also enriches our understanding of the role of institutions and the need to appreciate interactions of the shadow and canonical systems. Furthermore, the synthesis of social learning and institutional theory points towards two key pathways for adaptation that are indicative of generic adaptive capacity – institutional modification and reflexive adaptation.

Empirical evidence of these and other capacities for adaptation outlines in this paper make it possible to use the theoretical and analytical frameworks proposed to map adaptive capacities within as well as between organizations and locales. The approach opens real opportunities for comparative assessments of adaptive capacities across economic or social sectors of local and regional economies. Further work is needed to develop methodologies that can uncover institutional arrangements and adaptive capacities in a time efficient manner while retaining the sociological rigour of the methodology used in this exploratory study.

The policy implications of this work add weight to existing calls for greater awareness of the role of informal social interaction in the management of organisations and in policy regimes (e.g. Williams, 2002). More specifically the research raises questions for the policy communities concerned with local adaptation to climate change:

1. How might the shadow system be embraced inside local organisations without unduly compromising or being suppressed by established imperatives for efficiency, transparency and vertical accountability?
2. How might outputs of the shadow system and of building systems of quality control be measured so that the hidden nature of the shadow system is not compromised?
3. How might job descriptions and work guidelines be modified to support the development of personal and professional skills needed to work the shadow system? For example, by providing time in everyday work routines for social interaction that may take many years to build up into productive networks of exchange, and for adaptive outputs to emerge and for rewarding innovation in the shadow system?

**Acknowledgements.** The authors acknowledge the kind co-operation of respondents from the Environment Agency, Grasshoppers and the Welsh Assembly. Research was funded by the UK ESRC (RES-221-25-0044).

## **References**

- Adger WN, Arnell NW, Tompkins EL, 2005, "Successful adaptation to climate change across scales" *Global Environmental Change* **15** 77-86
- Argyris C, Schön D, 1996 *Organisational Learning II: Theory, Learning and Practice* (Addison-Wesley Publishing, Reading Ma.)
- Bakker K (ed.), 1999 *A framework for institutional analysis*. Working paper # 3, Societal and Institutional Responses to Climate Change and Climate Hazards:

- Managing Changing Flood and Drought Risk, Environmental Change Unit,  
University of Oxford
- Bateson G, 2000 [1972], *Steps to an Ecology of the Mind* (The University of Chicago Press: London)
- Benner C, 2003, "Learning communities in a learning region: the soft infrastructure of cross-firm learning networks in Silicon Valley" *Environment and Planning A* **35** 1809-1830
- Brown JS and Duguid P, 1991, "Organizational learning and communities of practice: Towards a unified view of working, learning and innovation" *Organizational Science* **2** (1) 40-57
- Bührs T, 2003 "From diffusion to defusion: the roots and effects of environmental innovation in New Zealand" *Environmental Politics*, **12** (3) 83-101
- Checkland P, Casar A, 1986, "Vickers' concept of an appreciative system: A systemic account" *Journal of Applied Systems Analysis* **13** 3-17
- Demeritt D, Langdon D, 2004, "The UK Climate Change Programme and communication with local authorities" *Global Environmental Change* **14** 325-336
- Drevenšek M, 2005, "Negotiation as the driving force of environmental citizenship" *Environmental Politics* **14** (2) 226-238
- Dyball R, Beavis S, Kaufman S, 2005, "Complex adaptive systems: constructing mental models", in *Social learning in environmental management: towards a sustainable future* Eds. Keen M, Brown V, Dyball R (Earthscan, London)
- Elwyn G, Greenhalgh T, Macfarlane F, 2001, *Groups: A Guide to Small Group Work in Healthcare Management, Education and Research* (Radcliffe Medical Press, Abingdon, Oxon)
- Goleman D, 1998, *Vital lies, simple truths* (Bloomsbury Publishing, London)

- Griffin D, Shaw P, Stacey R, 1999, "Knowing and acting in conditions of uncertainty: A complexity perspective" *Systemic Practice and Action Research* **12** (3) 295-309
- Grothmann T, Patt A, 2005, "Adaptive capacity and human cognition: The process of individual adaptation to climate change" *Global Environmental Change* **15** (2) 199-213
- Haas PM, McCabe D, 2001, "Amplifiers or dampeners: international institutions and social learning in the management of global environmental risks", in *Learning to Manage Global Environmental Risks: Volume I A Comparative History of Social Responses to Climate Change, Ozone Depletion and Acid Rain*, Eds. Haas PM, Jasanoff S, Rochlin G, (The MIT Press: Massachusetts) pp 323-348
- High C, Pelling M, Rengasamy S, 2004, *Local agency, adaptation and the shadow system: the institutional architecture of social learning in rural areas of the UK and India*, XI World Congress on Rural Sociology, Norway
- High, C., Pelling, M. & Nemes, G. (2005). *Understanding informal institutions: Networks and communities in rural development* invited paper for Transition in Agriculture Conference, Institute of Economics, Hungarian Academy of Sciences Budapest.
- High C, Slater R, Rengasamy S, 2006, *Are shadows dark? Governance, informal institutions and corruption in rural India* in Cheshire, L., Higgins, V. & Lawrence, G., Eds. *Rural governance: International perspectives*. Oxon, Routledge
- Hulme M, Jenkins GJ, Lu X, Turnpenny JR, Mitchell TD, Jones RG, Lowe J, Murphy JM, Hassell D, Boorman P, McDonald R, Hill S, 2002, *Climate change scenarios for the United Kingdom: The UKCIP02 Scientific Report*, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

- Hutchins E, 1996, "Organizing work by adaptation" *Organizational Learning*, Eds. Cohen M D, Sproull LS (Sage, London)
- IPCC, 2001, *Climate change 2001: Impacts, adaptation, and vulnerability* (Cambridge University Press, Cambridge)
- Ison RL, High C, Blackmore C, Cerf M, 2000, "Theoretical frameworks for learning-based approaches to change in industrialised-country agricultures", in *Cow Up A Tree: Knowing and Learning for Change in Agriculture: Case Studies from Industrialised Countries*, Eds. Cerf M, Gibbon D (INRA, Paris)
- Iwanciw JG, 2004, *Promoting social adaptation to climate change and variability through knowledge, experiential and co-learning networks in Bolivia*, ComunitAd, La Paz, Bolivia, <http://www.lapz.nur.edu/resiliencia>.
- Janis I, 1989, "Groupthink: The problems of conformity", in *Creative Organization Theory*, Ed. Morgan G (Sage Publications, London)
- Jarvis P, Holford J, Griffin C (Eds.), 1998, *The Theory and Practice of Learning*. (Kogan Page, London)
- Keen M, Brown VA, Dyball R, 2005, "Social learning: A new approach to environmental management", in *Social learning in environmental management: Towards a sustainable future*, Eds. Keen M, Brown VA, Dyball R, (Earthscan, London), pp 3-21
- Maturana H, Varela F, 1992, *The tree of knowledge - The biological roots of human understanding* (Shambala, Boston)
- Næss LO, Bang G, Eriksen S, Vevatne J, 2005 "Institutional adaptation to climate change: flood responses at the municipal level in Norway", *Global Environmental Change* **15** 125-138
- North DC, 1990, *Institutions, Institutional Change and Economic Performance* (Cambridge University Press, Cambridge)

- O'Brien K, 2006, "Are we missing the point? Global environmental change as an issue of human security" *Global Environmental Change* **16** (1) 1-3
- O'Riordan T, Rayner S, 1991 "Risk management for global environmental change" *Global Environmental Change* **1** (2) 91-108
- O'Riordan T, Cooper CL, Jordan A, Rayner S, Richards KR, Runci P, Yoffe S, (1998) "Institutional frameworks for political action", in *Human Choice and Climate Change: The Societal Framework*, Eds. Rayner S, Malone EL (Battelle Press, Ohio)
- Ostrom E, 1999, "Institutional rational choice", in *Theories of the Policy Process*, Ed. Sabatier PA, (Westview Press, Boulder)
- Pelling M, 1998, "Participation, Social Capital and Vulnerability to Urban Flooding in Guyana" *Journal of International Development* **10** 469-486
- Pelling M, High C, 2005, "Understanding adaptation: what can social capital offer assessments of adaptive capacity?" *Global Environmental Change* **15** (4) 308-319
- Pred A, Watts M, 1992, *Reworking Modernity: Capitalism and Symbolic Discontent* (Princeton University Press, New Jersey)
- Rayner S, 2006, "What drives environmental policy?", *Global Environmental Change* **16** (1) 4-6
- Rayner S, Malone EL, 1998 *Human Choice and Climate Change, Volume Four: What Have We Learned?* (Bettelle Press, Ohio)
- Schneider SH, 2004, "Abrupt non-linear climate change, irreversibility and surprise" *Global Environmental Change* **14** 245-258
- Senge P, 1990, *The Fifth Discipline – The Art and Practice of the Learning Organization* (Century Business, London)
- Shaw P, 1997, "Intervening in the shadow systems of organizations: consulting from a complexity perspective" *Journal of Organizational Change* **10** (3) 235-250

- Smit B, Burton I, Klein RJT, Wandel J, 2000, "An anatomy of adaptation to climate change and variability" *Climatic Change* **45** 223-251
- Smith D, 2004 "For whom the bell tolls: imagining accidents and the development of crisis simulation in organisations" *Simulation and Gaming* **35** (3) 347-362
- Stacey R, 1996, *Complexity and Creativity in Organisations* (Berrett-Koehler, San Francisco, CA)
- Surowiecki J, 2004, *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations* (Doubleday, London)
- Tompkins EL, 2005, "Planning for climate change in small islands: insights from national hurricane preparedness in the Cayman Islands" *Global Environmental Change* **15** 139-149
- Wang CL, Ahmed PK, 2003, "Organisational learning: a critical review" *The Learning Organization* **10** (1) 8-17
- Wenger E, 1999, *Communities of practice: Learning, meaning and identity* (Cambridge University Press, Cambridge)
- Wenger E, 2000, "Communities of practice and social learning systems" *Organization* **7** (2) 225-246
- West CC, Gawith MJ (Eds.), 2005, *Measuring Progress: Preparing for climate change through the UK Climate Impacts Programme* (UK CIP, Oxford)
- Williams P, 2002, "The Competent Boundary Spanner" *Public Administration* **80** (1) 103-124
- Willows RJ, Connell RK, 2003, *Climate Adaptation: Risk, Uncertainty and Decision-Making* UKCIP Technical Report (UKCIP, Oxford)
- Wisner B, Blaikie P, Cannon T, Davis I, 2004 [1994], *At Risk: Natural Hazards, People's Vulnerability and Disasters* (Routledge, London)



Wynne B, Simmons P, Waterton C, Hughes P, Shackley S, 2001, "Institutional cultures and the management of global environmental risks in the United Kingdom", in *Learning to Manage Global Environmental Risks*, Eds. Clark WC, Jäger J, van Eijndhoven J, Dickson NM (MIT Press, London) pp 93-113