# Building resilience to climate change through adaptive management of natural resources

Emma L. Tompkins and W. Neil Adger

January 2003

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**Emma L. Tompkins[1] and W. Neil Adger[1,2]**

1. Tyndall Centre for Climate Change Research

2. Centre for Social and Economic Research on the Global Environment

School of Environmental Sciences
University of East Anglia
Norwich, NR4 7TJ, UK

Email: e.tompkins@uea.ac.uk

**Abstract**
Emerging insights from adaptive ecosystem management and new institutional economics suggest that building resilience into both human and ecological systems is the optimal way to deal with future surprises, or unknowable risks. But do these emerging insights have implications for policies and strategies for responding to anthropogenic climate change? We review perspectives on collective action for natural resource management and use insights from this area to inform our understanding of climate response capacity and to demonstrate the importance of social acceptance of strategies that build social and ecological resilience. All societies need to enhance their response capacity to face future climate impacts that could lie outside their experienced coping range. The challenge, posed at both the scale of local natural resource management and at the scale of international agreements and actions, is to promote adaptive capacity in the context of competing sustainable development objectives. This theoretical argument is illustrated by an example of present day collective action for community-based coastal management in Trinidad and Tobago.

**Introduction**

The full weight of scientific evidence suggests that the climate is changing and that human activities are exacerbating natural changes in the climate (summarised in IPCC 2001), even if the range of changes, the probability of the range future climate change, nor the global distribution of the impacts are less apparent (Schneider, 2001). What is clear is that there will be winners and losers from climate change. The question is therefore how do we minimise the short term and long term costs from anthropogenic climate change? The answer to us lies in response measures that bring together integrated conservation and development concepts and that consider holistic response as opposed to mitigation or adaptation. Adaptation is the action of responding to experienced or expected impacts of changing climatic conditions to reduce impacts or to take advantage of new circumstances. Adaptation is not about returning to some prior state, since all social and natural systems evolve, and in some senses co-evolve with each other over time.

A decade of research on climate change vulnerability shows us that inevitably it is the poor and the most vulnerable who suffer the impacts of changing environmental conditions (e.g. Downing, 2003; Adger et al., 2001; Smit et al., 2001; Ribot et al., 1996). What emerges is the recognition that sustainable development must central to any climate change response measure.[1] We argue that building resilience, which involves increasing the ability of a system (social and ecological) to withstand shocks and surprises and to revitalise itself if damaged, offers the prospect of a sustainable response. Some natural and social systems have a natural ability to bounce back from adverse circumstances, whereas others have to learn how to become resilient. We focus on elements of decision-making, networks and institutions within the process of how to build resilience in both social and ecological systems.

Ideas of 'integrated' conservation and development have sprung from many fields (for a review see Brown, 2002). The core factors in integrating conservation and development are the engagement of resource stakeholders in developing management strategies as a means of building a constituency for the resource management problem, raising awareness of the development consequences and generating support for decision making (e.g. for coastal resources see Olsen 1993; O'Riordan and Ward 1997; Brown et al., 2002). Such approaches offer pathways for vulnerable communities to engage in developing response policies and ensuring that there is 'headroom for change' in those policies; they are often most effectively implemented through social institutions at the local level and collective action. Despite some criticism of this 'community based resource management' approach due to its lack of consideration of ecosystem heterogeneity and intra-community dynamics (see for example Agrawal and Gibson 1999; Leach et al. 1999), the role of collective action and inclusionary processes may offer some solutions at the local level for tackling rural vulnerability associated with climate change. Indeed the ability to engage community level stakeholders in resource management might determine the success or failure of a climate change response. The importance of community engagement has also been seen a means of reducing vulnerability in the area of disaster planning. This can be seen in the use of the disaster cycle framework which promotes:

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[1] In the IPCC efforts, for example, this recognition of sustainability is manifest in the attempts in the Third Assessment Report to give guidance to all the scientific assessment on how to incorporate 'development, equity and sustainability' (Munasinghe, 2000). Such efforts had, in the eyes of many participants, uneven influence in the findings.

mitigation, preparedness, response and then recovery, see for example (Abramovitz et al. 2001; Cutter et al., 2000).

In complex natural systems management integrated approaches are also valuable, particularly in closely coupled systems involving human activity with direct implications for ecosystem health (see for example Cicin-Sain 1993; Olsen 1993; Turner et al. 1999; Abramovitz et al. 2001). Ecosystem management, for example, "integrates scientific knowledge of ecological relationships within a complex socio-political and values framework towards the general goal of protecting native ecosystem integrity over the long term" (Grumbine 1994). Promoting resilience is therefore directly dependent on the recognition of community engagement in resource management particularly in areas where communities rely on ecosystem health for their own well-being or livelihoods, as a means of preserving ecosystem integrity (Folke et al., 2002).

Integrated conservation and development approaches that include collaborative resource management would appear to be central to reducing vulnerability and increasing resilience to improve the well-being of those societies and ecosystems dependent on natural resources. In many situations, where full knowledge about a system does not exist and optimum productivity is not an obtainable goal, an iterative management process that is informed and evolves through an ongoing learning process is about the best that can be achieved. Adaptive management not only pursues the goal of greater ecological stability, but also that of more flexible institutions for resource management (Walters 1986; Holling 1978).

Some combination of adaptive management of social and ecological systems may provide a basis on which social and ecological resilience could be built. However adaptive approaches require flexibility within the management framework to adapt and change as new information and understandings become available. The ecosystem concept requires that the complexity of the ecosystem is accepted, that planning takes place over the appropriate spatial and temporal scales in line with ecosystem changes and that the interactions of human behaviour with the environment are considered.

We argue that an adaptive ecosystem management approach can improve the resilience of people and the environment and reduce vulnerability. Under such an approach an evolving management process for the entire system is developed through an iterative learning process. This paper explores the potential for this approach through a case study of a rural community reliant on coastal resources. Further research would be needed to determine whether this approach would apply equally well to social and ecological situations that may not be mapped onto defined ecosystems. We would expect a priori that the determinants of resilience and vulnerability to external perturbations are common to many resource situations (e.g. Peluso et al., 1994; Adger, 2000; Cutter, 1996; and examples in Adger et al., 2002; Pelling 2002)
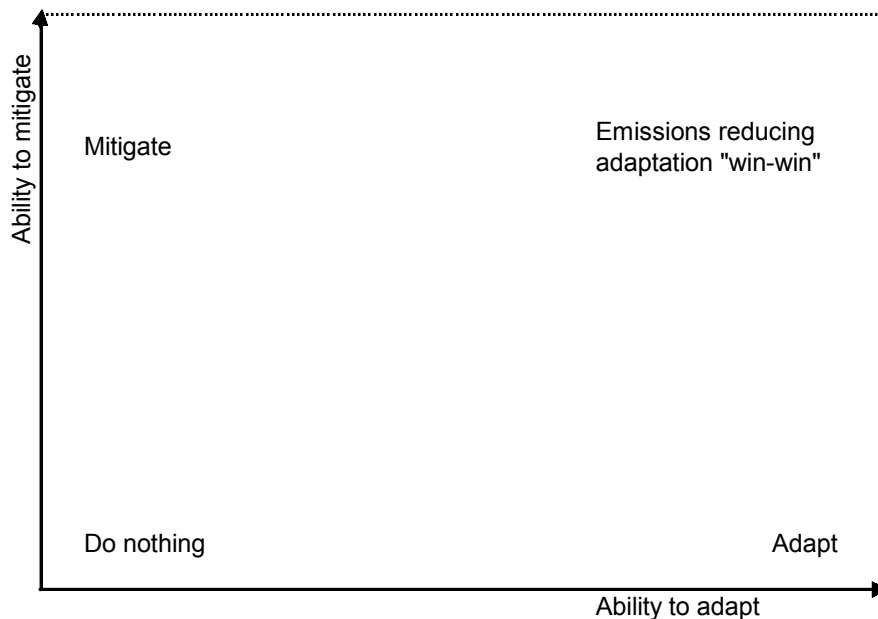
Using the case study in Trinidad and Tobago, one community's ability to respond to environmental change is investigated. This paper focuses specifically on the role of collective action in building community resilience, in creating a more integrated policy development process, and in enabling the decision making processes to become more responsive to changing environmental pressures and developmental needs.

We conclude that it is important to build resilience through the extension and consolidation of social networks, both at the local scale and at the national, regional or international scale. Social acceptance of any adaptation strategy is critical and such strategies need to be responsive to the changes that occur in both the environment and society. In this regard, institutional division of response measures into mitigative and adaptive may not be a useful separation of issues and in fact may prevent emissions reducing adaptations to take place. Hence management approaches need to be: iterative, to take account of new knowledge and information; flexible, to include the new knowledge as it becomes available; inclusionary, to enable collective actions to feed into the decision making process; and holistic, to take into account the whole spectrum of options that are available to individuals and communities.

**Resilience and adaptive capacity**
Deciding how to respond to the threats from climate change is in many ways another version of the larger sustainable development question. What development options are available to us that enable us to become more resilient to environmental change while contributing to the resilience of future generations? The climate change literature broadly splits the response options available to decision makers into adapt or mitigate. Adaptation refers to the actions that people take in response to, or in anticipation of projected or actual changes in climate, to reduce adverse impacts or take advantage of the opportunities posed by climate change. Mitigation on the other hand refers to actions taken to prevent, reduce or slow climate change, through slowing or stopping the build up of greenhouse gases in the atmosphere (Hulme 2002).

A holistic approach might be to consider a wider set of options that would be contained in a 'response space', see Figure 1 (related to the idea of 'adaptation space' proposed for example by Berkhout (2002)). A response space contains the full set of options available to decision makers and includes combinations of 'adaptation' and 'mitigation' responses. The response space for individuals, communities or nations is limited by its ability to adapt and ability to mitigate. Ability is determined by institutional structures; individual behaviour and lifestyles; micro level private sector behaviour; and national macro-economic conditions.

The chart has the following labels:
- Y-axis: Ability to mitigate
- X-axis: Ability to adapt
- Top-left: Mitigate
- Top-right: Emissions reducing adaptation "win-win"
- Bottom-left: Do nothing
- Bottom-right: Adapt

**Figure 1 Responses to climate change**

The response options might include: the do-nothing option for those with no ability to adapt or mitigate; the 'win-win' option that describes a situation of adaptation that offers mitigating benefits; as well as just mitigation or adaptation. Using this conceptualisation provides decision makers with a wider range of response options, including these 'win-win' responses, i.e. adaptive responses that are also mitigating responses. Such responses might be changing crop mixes to include more carbon-sequestering plants that are more resilient to the changing climate. Another example might be a switch to renewable energy sources on small islands. These 'win-win' options offer additional benefits, such as in this case, reduced reliance on imported fossil fuels, thereby releasing foreign exchange for adaptation measures.

Knowing the full range of options is the first step. The next step involves expanding the set of options available to different communities or societies. The response space can therefore be expanded through increasing ability to adapt or mitigate, which can be achieved through building resilience. Development actions based on strengthened social and ecological resilience enhance abilities both to adapt and to adopt new practices to mitigate climate change, and hence ultimately promote sustainability (see also Folke et al., 2002; Carpenter et al., 2001).

Resilience traditionally referred to the single state equilibrium of an ecosystem, where emphasis was placed on resistance to disturbance and speed of return to the equilibrium state (Pimm 1984). It was thought that environmental perturbations, such as groundwater reduction or habitat fragmentation occur gradually over time and ecosystems respond in a smooth and continuous manner (Vitousek et al. 1997). More recent studies have shown that many different types of environmental change can trigger sudden shifts in ecosystems to alternative states; these events can be part of a continuous trend or a one off event (Scheffer et al. 2001). Thus the definition of resilience has altered as it has become clearer that ecosystems have multiple equilibria, that non-linear changes occur and that there are threshold effects where rapid transformation occurs (Nystrom et al. 2000). Definitions of resilience now

consider stability as a central concept, and tend to refer to the magnitude of disturbance that can be absorbed by a system before it moves from one state to another (Holling 1995). Ecosystem management approaches that increase ecosystem stability rather than control the environmental disturbances are thus being promoted as a means of increasing ecological resilience (Nystrom et al. 2000; Scheffer et al. 2001).

Social resilience is used in some senses the ability for positive adaptation despite adversity (Luthar and Cicchetti 2000). In other words social resilience is the ability of groups or communities to adapt in the face of external social, political or environmental stresses and disturbances (Adger 2000). Three general characteristics of social systems may need to be present to enable societies to be resilient, notabl: the ability to buffer disturbance, the capability to self-organise and the capacity for learning and adaptation ( Carpenter et al., 2001; Trosper 2002).

So are social systems resilient in the face of climate change over time? Clearly individuals and communities are adapting to climate change in the same way that they have dealt with climate variability throughout history (Adger and Brooks 2003; Haberly and Lusty, 2000; Trainter et al., 2000), and that adaptive capacity exists within communities to different degrees in responses to sudden changes in environmental conditions. Not all adaptations are sustainable and there is recent historical evidence that large-scale, systematic changes in global climate have had profoundly negative consequences for many societies in the past (Keys, 1999; Cullen *et* al., 2000; de Menocal, 2001). But collective response and institutional resilience remains the dominant factor in sustaining adaptation. When faced with contemporary climatic perturbations in the Canadian artic, the Inuvialuit people of Sachs Harbour have been making short term adjustments in the face of climate change over the past decades (Berkes and Jolly 2002). Their adaptations include switching hunted species and changing the timing and methods of hunting. Flexibility within cultural traditions and networks make other forms of adaptation possible for this community, such as food sharing networks and intercommunity trade. The Berkes and Jolly study also find that newly evolving co-management institutions are creating linkages across scales, local, regional, national and international and hence transmitting local concerns to a wider audience and also being able to draw on the same wider community for assistance and advice.

Many of the lessons from long term adaptations are also apparent in resilience in the face of other unpredictable natural hazxards. In New Zealand, after the eruption of Mt Ruapehu, it was found that self-efficacy, a sense of community and problem-focussed responses were good predictors of community resilience (Paton et al. 2001). Most importantly Paton et al. recognise the importance of the nature of social relationships as a factor that can enhance resilience. The lessons from these studies are context-specific but they do establish some broad criteria by which to assess the adaptive capacity of communities. The nature of relationships between community members is critical, as is the access to and participation in the wider decision making process (Adger, 2003.

In communities where there is less cohesion, for example one where there is more central planning of community life, it may be that another important factor is the structure of the governance institutions. In other areas, such as coastal zone

management the expansion of social networks has been noted as an important element in developing more robust management institutions (Tompkins et al. 2002). More specifically, drawing on (Cox 1998) networks can be explored in terms of the access to power and representation that they provide to participants (networks of engagement) and the support they offer to participants in vulnerable positions (networks of dependence). The expansion of spaces of engagement appears to be critical to enhancement of resilience in communities being affected by, or likely to be affected by climate change.

The question is then, how can communities enhance their networks of association, most importantly, their spaces of engagement? Local groups and individuals often feel their powerlessness in many ways, although none so much as in the lack of access to decision makers (Brown et al. 2001a). In this paper we propose that building successful collective actions, possibly in the form of co-management arrangements for natural resources can enhance the resilience of communities, as can maintaining ecosystem services and ecosystem resilience. The latter can retain or even expand the possibilities for adapting to climate change.


**Institutions for integrated and inclusive approaches**
Collective action is the co-ordination of efforts among groups of individuals to achieve a common goal, when individual self-interest would be inadequate to achieve the desired outcome (Olson 1965). Co-management is one form of collective action whereby resource stakeholders work together with a government management agency to undertake some aspect of resource management. Many examples exist where forms of collective action have been attempted with varying degrees of success, for example in fisheries management (Lim et al. 1995), coastal zone management (Sandersen and Koester 2000), and watershed management (Ravnborg and Guerrero 1999).

In principle the concept of collective action seems to offer one solution to resource management, however, by working together, by consolidating spaces of dependence, and by working with the government, to expand spaces of engagement, stakeholders may in fact be building community resilience to better cope with climate change impacts. In practice there are several threats to successful implementation of collective action associated with the design of institutions, the nature of the group, and the nature of the resource (Agrawal, 2001; Brown et al., 2002) as well as indicidual strategic behaviour. Self-interest will generally drive individual behaviour and the outcome will be free riding behaviour and possible overuse of the resources. Free riding' behaviour is not, however, the logical outcome of collectively managed resources (see for example White and Runge, 1995).

Empirical evidence of successful collective actions for natural resource management, such as White and Runge (1995) and Berkes et al. (1989), has contributed to the development of a set of general pre-conditions for successful collective action (Olson 1965; Sandler 1992; Steins and Edwards 1999). Assuming that there is a link between the functioning of social networks and adaptive capacity, then these pre-conditions could also be the pre-conditions for more resilient communities. There are three principles for collective action on which there is broad agreement: smaller groups tend to be more successful than larger groups; the more equitable the

distribution of endowments among members the more chance of success; failures of collective action can be overcome by the introduction of selective benefits and alternative institutional design. Underpinning these principles are the concepts of social discourse and the need for integration of diverse stakeholders' interests into collective decisions (Davos 1998). The literature on inclusionary and participatory planning for resource management supports these lessons (see for example Owens 2000), recognising that the barriers to community or individual action do not lie primarily in a lack of information or understanding alone, but in social, cultural and institutional factors.

Making decisions about what to do about climate change is complicated due to the existence of uncertainty about the size and distribution of the possible impacts, and the risks attached to making maladaptive decisions. However complexity and uncertainty about the impacts of decisions characterise decision making in fisheries management, pollution control, coastal zone management, flood control and others. The reality of management in these and other areas is that much of it takes place in the face of risk and uncertainty. The different fields have each taken their own approaches to handling risk and uncertainty, however in recent years consistent themes have arisen from them, notably the roles of 'adaptation' and 'integration'.

Recognising the importance of learning from errors within past management process may generate new responses based on stakeholders' needs. Such learning-based or adaptive management systems are widely supported (see for example Kay and Alder, 1999; Turner et al., 1999; and Sorensen, 1997). Similarly integrated approaches are increasingly being promoted. The concept of 'integrated' policy is a recurrent theme in a wide range of resource management literature, including animal pest control, coastal zone management, rural development, forest management, health policy and planning, land use planning and climate change, see for example (Lawrence 1997; Sorensen 1997; Pinkerton 1998; Wainwright and Wehrmeyer 1998; Allen et al. 2001; Jones 2001; Peattie et al. 2001). Ultimately this integration needs to be both horizontal and vertical.

Horizontal integration refers to cross-sectoral harmonisation of policy and practice relating to resource management, and vertical integration refers to the different scales of governance, from local to international, involved in management. Equally important are the management structures that exist and the potential for change within those structures, whether they are institutions, property rights or communities.

Rational decision making, whereby problems are identified, goals and objectives are defined, alternatives considered, decisions made, plans implemented and then evaluated is the usual structure for natural resource management. An adaptive social-ecological system management approach may provide an alternative approach that can bring together the lessons learned at the community and government level through collective actions, social networks and integrated ecosystem management approaches. For example, Imperial (1999) suggests that ecosystem management approaches should: recognise the complexity, interconnectedness and dynamic character of ecological systems; be suited to local conditions; incorporate people who are affected by or who affect the ecosystem; work across administrative boundaries; and emphasise interagency co-operation and the need for organisational change. The bringing together of the natural and social sciences within such an integrated policy

framework, coupled with a learning-based management system, may increase ecological and social resilience and hence increase ability to respond to climate change.

**Adaptive social-ecological system management for natural resource management in Trinidad and Tobago**

The difficulty in moving towards more resilient communities and ecosystems is twofold. First, experience suggests that there is an incompatibility of current governance structures with those we suggest are necessary for promoting social and ecological resilience. Inclusive institutions and sharing responsibility for natural resources goes against the dominant hierarchical institutional forms of government throughout the world. Second, adaptive ecosystem management overturns some major tenets of traditional management styles which have in many cases operated through exclusion of users and the top-down application of scientific knowledge in rigid programmes.

This section outlines an experience in promoting new forms of governance to promote resilience in Trinidad and Tobago. It has to be noted that the resilience objectives (either social or ecosystem) are not explicit in the laws and institutional changes or in the evolving community-based initiatives. Nevertheless, the need to promote sustainability in the present day resonates with the concepts of resilience and adaptation to climate change.

Coastal management in Tobago has been controversial and contested for over 30 years. The struggle to find balance between the drive for development and the need for conservation has left decision makers in an uncomfortable position. Pushed from one side by a population demanding job opportunities and improvements in the quality of life, the government has developed the tourism industry. However, it is pulled on the other side by the need to manage fish stocks; conserve the 'natural' heritage for current future generations; maintain the quality of the environment for both residents and tourists; manage waste disposal and maintain the natural coastal defences provided by the coral reefs and mangroves to protect the island from storm and wave damage, see for example (Goreau 1967; Laydoo et al. 1987; IMA 1995; THA 1999). The contested objectives for one popular part of the coast, the Buccoo Reef area, have proven difficult to resolve.

In response, action research over the period 1997–2000 (detailed in Brown et al. 2001) proposed that social and ecological resilience could be enhanced by including stakeholders for the Buccoo Reef area in an inclusive and sectorally and vertically integrated decision making process. This process, termed 'trade-off analysis' involved identifying and engaging key stakeholders; identifying their interests and objectives for the resource; engaging them in a process of information dissemination and dialogue to explore their preferences for managing the area; collecting and analysing economic, social and ecological data to understand the impacts of different future scenarios on important criteria; data analysis; resolving conflicts that existed and finding areas of agreement among them, see (Brown et al. 2002).

The process brought together a mix of community stakeholders from different spatial areas, different socio-economic backgrounds and areas of employment with

government stakeholders from different sectors, including tourism, fisheries, land use planning, town and country planning, economic planning and education. The cross-sectoral, multi-scale stakeholder engagement ensured that the diverse actors who influence or who are affected by the complex human-ecosystem interactions in the coastal zone had the opportunity to participate in the decision making process. The process itself was iterative, with stakeholder preferences being elicited and fed into a multi-criteria model and then the results reported back to the stakeholders who had the opportunity to explore their preferences further through group discussions. These processes ensured that the decision-making system was flexible enough to include new information and changing preferences about coastal management decisions.

The bringing together of the physical and biological systems through a multi-criteria analysis model with the human-behavioural soft systems through stakeholder engagement and conflict resolution was an important part of the integrated adaptive management strategy.

Specifically it is the soft systems that both Berkes and Jolly (2002) and Paton et al. (2001) suggest are critical elements of community resilience. In the Tobago context it social learning, which refers to the process of behavioural and knowledge learning by individuals in social environments through interaction and deliberation, brought about a consolidation of the local spaces of dependence and an expansion of spaces of engagement (Tompkins et al. 2002). This consolidation was achieved by numerous factors that reduced the barriers to communication. These included reducing the transaction costs of communication and social learning among institutions and communities (Glasbergen 1996); providing a forum for deliberation; openness and sharing information; as well as positively-reinforcing feedback. One of the outcomes of this process was the creation of a cohesive multi-stakeholder group which reached the conclusion that better resource management solutions could be found by working with each other and with the government. In effect co-management of coastal resources offers institutional arenas whereby social learning between government agencies and resource management groups can occur and where such synergy can promote sustainable utilisation (McCay and Jentoft, 1996; Berkes, 2002).

The application of this inclusive and integrated trade-off analysis process brought about two critical changes at the community level and in the government level. First the various groups of previously conflicting stakeholders were mobilised to take both conservation and development actions together, as they recognised that they had more power as a group than as individuals. Prior to the establishment of the group few of the group members communicated with each other. The groups' cohesion introduced the potential for more flexible localised adaptive responses to environmental change. Open lines of communication meant that small modifications in behavioural norms at the community level could be instigated through group processes rather than through more formalised institutional change. One example of this was in the decision of boat using stakeholder in the area to be more careful in their use of oil and gas in the marine area to reduce spillage. This decision was taken in response to a discussion within the group that oil and gas spills in the marine area were a problem. The creation of the multi-stakeholder group immediately solidified the group's space of dependence and on this base grew the possibility of developing a more formalised co-management arrangement with the government decision makers.

The second critical change arose as the multi-stakeholder group also realised that by jointly speaking with a single coherent message increased their chances of being heard by the decision makers. Conversely, the decision makers found that active support by the multi-stakeholder group enabled them to initiate changes in the management process without fear of making unsupported and hence unsuccessful resource management decisions. The integration of the stakeholders into the decision making process expanded the stakeholders' space of engagement, which in itself provided them with the incentive to continue to work together.

Thus the social learning between agents involved in co-management in the Tobago case enhances general resilience. But does such action and the emergence of these institutions constitutes adaptive capacity in the context of climate change? From the example in Tobago it appears that inclusionary and integrated coastal management contributes to adaptive capacity in two ways. First the networking social capital can act as a resource in coping with weather extremes. Although Trinidad and Tobago only rarely experience hurricane landfall, many of the individuals with responsibility for disaster planning are the same individuals who now work more closely to promote marine protected area management. The existence of the networks themselves therefore promotes adaptive capacity.

Second, the sustainable management of resources promotes the resilience of the natural systems on which the population of Tobago depends. For coral reef ecosystems, for example, it is clear that high sea surface temperature events such as those experienced in ENSO years, and which may become more frequent over time with climate change, pose a threat to their continued widespread existence in tropical coastal waters (Reaser et al., 2000).

Flexible decision-making processes that can accept new information and be modified on the basis of this information are also important elements in building resilience. Such learning based processes are anathema to the usual forms of governance which tend to follow a more rigid decision making process, however, perhaps institutional flexibility is an area that requires developing further.

Community participation in decision making about natural resources can be beset by a myriad of problems, and may not always be in the best interests of either the targeted community or the natural resource being managed (Cooke and Kothari 2001). Indeed, the creation of strong spaces of dependence, empowered communities and high self-reliance will not necessarily lead to environmental health improvements (Tacconi and Tisdell 1992). This may be particularly relevant in the case of climate change where those experiencing the impacts will not necessarily be causing the impacts, although the findings of Berkes and Jolly (2002) adds credence the idea that it is important to build resilient communities so that they are able to adapt to the coming changes.


**The way forward**
Ecological resilience at first thought does not seem compatible with social resilience; one concept focuses on environmental conservation, the other on social development. The means of enhancing both social and ecological resilience may in some cases be found in supporting communities in traditional management approaches where there has been identified and continued success in resource management in the face of

environmental change. In other cases it may be found through creating new institutions for resource management through collective action. The way to achieve this may be through the application of adaptive ecosystem management that evolves through learning-based integrated resource management. Building community resilience through the expansion of the networks of dependence and engagement could facilitate this type of learning based management.

The way forward in building resilience to climate threats requires a three pronged approach: cement localised spaces of dependence; expand spaces of engagement; and avoid being tied to specific response paths through the implementation of flexible learning-based management.

Climate change stakeholders may need to find ways to strengthen their spaces of dependence to support them in the face of change, but also to expand their spaces of engagement to enable them to find a wider support network, in the form interaction with regional or national government, or international agencies. Social resilience in this context is promoted through at least two distinct networks:
·   networks and community relations of individuals and groups operating to cope with variability and change in everyday decision making, and
·   wider networks of individuals or groups who may be able to influence the decisions that are being made at the local scale.

The use of integrated and adaptive ecosystem approaches may promote the expansion of these networks, and hence enhance social resilience. Similarly there must be sustained enhancements to ecological resilience, although again this may be achievable through the application of either traditional community-based adaptive responses that have proved successful in supporting ecosystem stability in the face of past environmental change, or through learning-based management. Both of which require adaptive systems and governance structures that can change and develop as new information and understanding is introduced.

In the area of adaptation to climate change, clearly, the nature of the relationships between stakeholders at the community level will determine their immediate response to climate change risks. However it is their networks that enable individuals to engage in the wider decision environment that will affect their longer term resilience. The existence and the usefulness of these networks are determined by institutional as well as social factors.

At the community level, reducing the barriers to communication through sharing information and positively-reinforcing feedback are important elements in consolidating networks of dependence. This could be promoted through collective action, whereby stakeholders work together to find areas of commonality on which they can work to provide support to the wider group. At the institutional level, integrated institutional structures may be better able to support the inclusion of climate stakeholders in decision making processes, and to ensure that their needs can be addressed by as wide an audience as possible. Providing spaces for deliberation within decision making processes can facilitate this as can opening up channels of communication and ensuring that all important stakeholders are engaged.

In both spaces of exchange we need to be sure that we can clearly identify the stakeholders and ensure that any adaptive management processes are directed towards

building resilience of both the social and ecological systems. This might mean encouraging the evolution of new institutions that are sensitive to the resilience of the ecosystems which they are managing, and that are specific to climate change issues.

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