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Adapting to Climate Change in Pacific Island Countries: The Problem of Uncertainty

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Summary. — This paper investigates the problem of scientific uncertainty and the way it impedes planning for climate change and accelerated sea-level rise (CC & ASLR) in Pacific Island Countries (PICs). The paper begins by discussing the problems CC & ASLR poses for PICs, and it explores the limitations of the dominant approach to vulnerability and adaptation. Next, the paper considers the way scientific uncertainty problematizes policies aimed at adaptation to CC & ASLR. It argues that the prevailing approach, which requires anticipation of impacts, is unsuccessful, and the paper proposes a complementary strategy aimed to enhance the resilience of whole island social-ecological systems. Recent developments in the theory and practice of resilience are discussed and then applied to formulate goals for adaptation policy in PICs. © 2001 Elsevier Science Ltd. All rights reserved.

Key words — adaptation, climate change, Pacific Islands, policy, resilience, uncertainty, vulnerability

1. INTRODUCTION

Few environment and development problems rival climate change and accelerated sea-level rise (CC & ASLR) in terms of degree of scientific uncertainty. Attention has been devoted to reducing the uncertainties in likely parameters of future climate change, however, the resolution of Global Climate Models offers little at present for regional assessment of future impacts (IPCC, 2000). Scientific and triangulated anecdotal evidence strongly suggests recent changes in sea levels, weather patterns, fisheries and agricultural productivity in Pacific Island Countries (PICs) (Burns, 2000; Hay, 1997; SPREP, 1999). More changes are anticipated, but their precise magnitude, timing and location are uncertain. These uncertainties about the overall impacts of CC & ASLR are magnified many times over due to incomplete knowledge of individual ecosystems, patterns of causality and interaction between ecosystems, and patterns of causality and interaction between social and ecological systems. Moreover, in addition to uncertainty about what is reasonably expected to occur, PICs must also prepare for unforeseen effects (surprises). The inability to predict surprises has been termed a form of "ignorance" by Smithson (1989).

These issues of uncertainty and ignorance confound decision making at a time when the adaptation process must begin. As the Director of the South Pacific Regional Environment Programme (SPREP) expresses it: "government will be very reluctant to develop policies based on uncertain results" (Tutangata, 1997, p. 5). But, uncertainty about results is unlikely to be reduced in the near future, and in any event absolute certainty is impossible. Nevertheless, for reasons of efficacy and resource availability, planning must begin now, but insofar as adaptation policy remains premised on the assumption that the impacts of CC & ASLR can be predicted, policy will by necessity be hampered by uncertainty. Governments will rue investing scarce resources in expensive solutions to meet impacts which may not materialize and whose magnitude is uncertain (uncertainty of impact), even assuming that such solutions would be effective should the impact eventuate (uncertainty of effective solution). So, decisions must be made in the face of uncertainty (Jones, 2000; Leary, 1999; Yohe & Dowlatabadi, 1999). This paper argues that

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until impact predictions become more certain, an alternative approach, called a strategy of resilience, is better able to inform CC & ASLR-response policy.

This paper investigates the problem of scientific uncertainty and the way it impedes planning for CC & ASLR in PICs. The paper begins by discussing the problems CC & ASLR poses for PICs, and it explores the limitations of the dominant approach to vulnerability and adaptation. Next, the paper considers the way scientific uncertainty problematizes policies aimed at adaptation to CC & ASLR. It argues that the prevailing approach, which requires anticipation of impacts, is unsuccessful, and the paper proposes a complementary strategy aimed to enhance the resilience of whole island social-ecological systems. Recent developments in the theory and practice of resilience are discussed and then, applied to formulate goals for adaptation policy in PICs.

2. CLIMATE CHANGE AND ACCELERATED SEA-LEVEL RISE IN PACIFIC ISLAND COUNTRIES

The islands of the Pacific are particularly vulnerable to CC & ASLR (Brookfield, 1989; Nurse *et al.*, 1998). The extent of vulnerability of PICs to global forces is contested (see, for example, Bertram & Watters, 1985; Briguglio, 1995; Hau'ofa, 1993; Selwyn, 1980), and the category "island" masks some substantial geographical and cultural differences within the South-West Pacific. Nevertheless, insofar as Pacific Islands have a high ratio of shoreline to land area they are highly susceptible to damage from rising sea levels. Furthermore, in that PICs generally have a narrow economic base focused on primary production, are located in a highly dynamic ocean–atmosphere interface, have limited ecological carrying capacity, are scattered over a vast ocean area, and have rapid rural–urban migration to centers situated on the coastal margin, then PICs would indeed seem to be physically vulnerable to CC & ASLR. Of all PICs, the four atoll states of Kiribati, the Marshall Islands, Tokelau and Tuvalu are particularly vulnerable as their fresh water reserves are limited to a shallow subsurface lens which is susceptible to depletion in drought and susceptible to contamination from salt water. Further, the height of atolls above sea-level rarely exceeds two meters, which makes them highly susceptible to wave damage. The particular vulnerability of these atoll states raises the possibility of the first extinction of a sovereign state due to environmental change.

Recent research shows that average sea-level across the Pacific region has been rising at 2 mm per year for the last 50 years (Hay, 2000). Recording of sea-level has only been carried out since 1994 so long-term trends are hard to discern. Short-term variations in sea level within the region are significant, with sea levels rising by as much as 25 cm in the western Pacific in intense La Nina events (Delcroix & Rual, 1997). Temperature records for the region show an increase in mean surface temperature of 0.2% per decade this century (Salinger *et al.*, 1995). The most recent study has estimated that, given emissions of greenhouse gases up to 1995, a 5–12 cm rise in sea-level is inevitable (Jones, 1999). The study suggests, however, that even if all countries met their Kyoto Protocol commitments, and if all emissions of greenhouse gases ceased after 2020, a sea-level rise of 14–32 cm is likely. Although still highly uncertain, recent research indicates that even with a doubling of atmospheric CO_2 concentrations, there may be no change in the frequency of tropical cyclones, but they could be some 10–20% more intense, creating potentially catastrophic impacts from waves, storm surges and wind (Jones, Hennessy, Page, Walsh, & Whetton, 1999).

It has been argued that sea-level rise is a mid- to long-term problem for PICs, and that the more immediate problem is the impact of enhanced climatic variability (for example, stronger hurricanes and storm surges and more frequent and severe droughts) on island systems already stressed by unsustainable development (see Brookfield, 1989; Burns, 1999; Lewis, 1990; Olsthoorn, Maunder, & Tol, 1999, and on drought see Meehl, 1996). Both climatic variability and sea-level rise threaten the habitability and sovereignty of Pacific Islands, however, the focus has been largely on sea-level aspects and as a consequence the issue of climate impacts has not received the research and policy attention it deserves.

Pessimism should not prevail, as there are good reasons to think that even the atoll states can adapt providing they achieve a high level of systemic sustainability.The critical issue is that to persist in the face of CC & ASLR, PICs need to achieve a degree of sustainability probably unprecedented in any modern state, in a biophysical and economic environment which in many respects allows little room for error, and in a very short space of time (they have a much shorter window of opportunity for change than larger and wealthier states). This is the real policy challenge of what is called "adaptation."

The United Nations Framework Convention on Climate Change (UNFCCC) contains two articles which require the assessment and reporting of vulnerability and adaptation (V & A) measures: Article 4—Commitments, and Article 12—Communication of Information Related to Implementation. At the 1999 Fifth Conference of Parties to the Convention, 10 PICs submitted their National Communications. [1] PICs have been very diligent in their reporting commitments to the UNFCCC and the Kyoto Protocol. Their intention is to demonstrate that the Framework Convention and Protocol's provisions are possible. Further, being good citizens in the UNFCCC process gives PICs greater moral standing and subsequently, more leverage in negotiations. This is undoubtedly the correct strategy, because despite even the best adaptation measures, the problems CC & ASLR pose to PICs can ultimately only be ceased or ameliorated by emissions reductions, starting first in developed countries.

3. VULNERABILITY

Historically, there have been competing definitions of vulnerability, and competing approaches to vulnerability assessment. In the field of hazards research, this has tended to impede the realization of a common language of vulnerability, and subsequently a common methodological approach to vulnerability assessment and response has not emerged. The concept of vulnerability is not amenable to succinct definition. Cutter (1996), for example, identifies 18 definitions from the hazards literature alone. As a result, vulnerability tends to be used inconsistently in practice as suggested in Hay and Sem's (1999) recent appraisal of the aforementioned Pacific Islands National Communications, where it was noted that the concept was understood differently among reports. In the most general of terms, vulnerability refers to the potential for loss (Cutter, 1996). More specific definitions qualify the potential for loss by factoring in (a) the likelihood of exposures, (b) susceptibility to damage, and (c) capacity to recover.

Broadly speaking, the hazards literature suggests that vulnerability stems from location and social disadvantage (lack of power), often simply manifested as income poverty (Cutter, 1996). This lack of power reduces access to resources and in turn narrows the range of options available to groups in times of stress (see Adger, 1999; Adger & Kelly, 1999; Blaikie, Cannon, Davis, & Wisner, 1994). These insights, although coming from the field of hazards study, are relevant to the problem of CC & ASLR, the principal difference being the temporal scale of change (rapid for hazards and incremental for ASLR). Given that exacerbated temperature and rainfall variability and increasingly severe cyclones may well be the most immediate threat to the persistence of island social-ecological systems, preparing for disasters is equally preparation for climate change.

In the South-West Pacific some very good work has been done in the area of vulnerability assessment, predominantly in terms of the likely response of biophysical processes to rising sea-levels (Aston, 1997; Mimura, 1997; Yamada, Nunn, Mimura, Machida, & Yamamoto, 1995; Holthus, Crawford, Makroro, & Sullivan, 1992; Nunn, Ravuvu, Balogh, Mimura, & Yamada, 1994; Nunn & Mimura, 1997). These studies have substantially advanced knowledge about the impacts of climate change and sea-level rise, and they act as consolidation points from which subsequent investigative phases can be launched in a more purposeful and co-ordinated manner. [2] A complementary approach is to focus on social vulnerability as explained by Adger (1999) and Handmer, Dovers, and Downing (1999), and a number of recent papers have called for greater efforts at combining biophysical and social elements into a single vulnerability assessment process (Klein & Nicholls, 1999; Warwick, 2000; Wheaten & MacIvor, 1999).

Because it is the habitability of the islands that is the penultimate policy concern, then the thresholds beyond which people can no longer remain on their islands require investigation (on thresholds see Jones & Pittock, 1997). So there is a need to engage in assessment of the vulnerability of whole island systems where the full gamut of biophysical, social, and biophysical-social interactions are taken into account. This requires vulnerability assessment to shift from the study of the parts to a study of the whole, a profoundly interdisciplinary challenge. At present, given the gap between actual and required information, given our ignorance of biophysical and social system exchanges, and given that the larger the scale of analysis the more complex and cross-scale is the system, a comprehensive and reliable national-scale vulnerability assessment would be extremely difficult, although efforts should still be made.

So, as a planning tool, the utility of existing vulnerability and adaptation assessments is limited due to a high degree of uncertainty and ignorance. There are also well-founded doubts about the effect of continually scripting Pacific Islands as "vulnerable" and by implication "weak" and "powerless" (Campbell, 1997).

4. ADAPTATION

Not unlike vulnerability, there are different definitions of adaptation. In its broadest sense, adaptation means "modification" or "fitting to suit." In the context of climate change, adaptation is taken here to mean the task of modifying ecological and social systems to accommodate CC & ASLR so that these systems can persist over time. The issue of adaptation can be reduced for policy purposes to include (a) modifying systems to accommodate long-term incremental changes (what is referred to here as "adaptation" proper), and (b) modifying systems to enable them to absorb and respond to short-term changes without passing critical threshold limits and so flipping into alternative states of equilibrium (what shall be referred to here as "resilience"). For the purposes of policy making the distinction should not be overemphasized as the changes needed to improve adaptive capacity are similar to those necessary for resilience. The critical "flip" for PICs is the threshold point beyond which the system is no longer able to support most or all of the population (islands become uninhabitable). Such a critical flip clearly falls within the UNFCCC's reference to "dangerous" interference with the climate system (Article 2, UNFCCC, 1992).

So, adaptation is a long-term process of learning and adjusting, a process which has historically been co-evolutionary between social and environmental systems, and where learning and adjustment has not been sufficient or sufficiently rapid, systems have failed (see Berkes & Folke, 1998). In broader terms, the ability of social and ecological systems to adapt to changed circumstances is the essence of evolution (Smil, 1993). Seen in these terms, adaptation is hard to grasp because it demands system-wide analysis and intervention.

At the international policy level, adaptation remains a somewhat slippery concept. Parry and Carter (1998), principal authors of the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations, seem reluctant to define adaptation, simply stating it as "response to the effects of climate change" (p. 30). The IPCC Regional Impacts Report does not define adaptation *per se*, but defines adaptability as:

> The degree to which adjustments are possible in practices, processes, or structures of systems to projected or actual changes of climate; adaptation can be spontaneous or planned, and can be carried out in response to or in "anticipation" of changes in conditions (Watson, Zinyowera, & Moss, 1998, p. 496).

Note the emphasis on "anticipation," which will be discussed later in this paper.

The most straightforward and policy-useful definition of adaptation comes from Campbell and de Wet (1999), who define it as: "Those actions or activities that people, individually or in groups, take in order to accommodate, cope with or benefit from the effects of climate change" (p. v). This definition is preferred here, because it essentially does away with the cumbersome and problematic issue of autonomous as opposed to purposeful adaptation (the latter being called, rather unhelpfully "adaptation strategies" by the IPCC guidelines). [3] This is not to say that understanding the natural response of systems (autonomous adaptation) to environmental change is unimportant, but rather that policy can do little to control these things, and that it is not prudent to build a response to CC & ASLR which relies on processes that are uncertain to occur. Further, trying to find the line between automatic and purposeful social behavior raises a host of intellectually intense, and for policy purposes distracting, questions about the respective influences of biology and culture on human behavior. In any event, the bulk of the literature on adaptation focuses on purposeful adaptation, usually in terms of government policy. This may change after the Third Assessment Report of the Intergovernmental Panel on Climate Change to be released in 2001.

This difficulty with the classification of adaptation is but one of the problems associated with the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations (Carter *et al*., 1994, now widely available now in Parry & Carter, 1998). These guidelines are a seven-step generic framework for assessing vulnerability to climate change and are designed to be applicable both natural and social systems. An important, albeit incidental problem with pursuing the IPCC guidelines is that they avoid larger questions about the motives for, and consequences of, the international community shifting its attention to vulnerability and adaptation without having yet committed to mitigation of greenhouse gases. If it is found (or even if it is likely to be found) that for developed countries the costs of adaptation are less than the costs of mitigation, then, this may well mitigate against ratification and implementation of the Kyoto protocol. Of course, if as a consequence of this broader benefit–cost exercise, developed countries takes the option of nonmitigation in favor of domestic adaptation because it is deemed to be cheaper, PICs will suffer. Thus, while it would be unwise for PICs to ignore issues of vulnerability and adaptation, this should not serve to downgrade the importance of mitigation (a point repeatedly stressed by the Alliance of Small Island States). In short, the motives for the vulnerability and adaptation (V & A) process may not be all benign; as is often the case, necessity can be the mother of deception.

The principal problem with the IPCC Technical Guidelines for Assessing Climate Change Impacts and Adaptations as they relate to PICs is that they are based on evaluation criteria and procedures used in developed countries which have then been generalized to apply to all countries (Carter, 1996, p. 33). As a result, the guidelines assume the presence of well-developed resource management institutions, and a large quantity of high-quality information feeding into an established and robust decision making process. These are not yet present in most small islands states. As a consequence, when applied to Pacific Island Countries the IPCC guidelines generate substantial uncertainties, and solutions are not offered as to how to manage these. Approaching the problem of decision making about adaptation from alternative paradigms of science such as ecology, systems theory, and more generally from the social and policy sciences, acknowledges and reveals different approaches to the problem of uncertainty in adapting to CC & ASLR.

5. UNCERTAINTY

Scientific studies seeking to anticipate the impacts of climate change in PICs generally acknowledge uncertainties, and policy makers are increasingly drawing attention to the difficulties of making decisions in the face of these uncertainties. Despite this general, if diffuse awareness, there has been little effort systematically to classify, examine and manage uncertainty. Uncertainty is defined here as imperfect knowledge of an event's probability, magnitude, timing and location. Insofar as the future cannot be known with certainty, any attempt to prepare for the future is characterized by uncertainty. In this sense "a modicum of uncertainty is a universal condition," and it is important to recognize that uncertainty about the future cannot be reduced to zero—what Wildavsky calls "the principle of irreducible uncertainty" (Wildavsky, 1988, p. 4).

In the case of CC & ASLR, the problem of uncertainty is enormous due to the nature of the problem which is (a) cross-scale (from global climate processes to microbial transformations); (b) temporally complex (impacts are happening today and will still be happening in a 100 years time, they will also unfold in non-linear ways); (c) spatially complex (systems are nested and interact in complex ways); (d) highly interconnected (it is difficult to think of a biophysical or social process/system which will not be affected). Further, there is uncertainty not merely about impacts, but also about the likely effectiveness of any anticipatory response. Climate change, then, scores highly on all attributes which determine a difficult policy problem (Dovers, 1995). Nevertheless, univocal scientific evidence will not be forthcoming in the near future. Decisions must be made today in order to maximize choices and minimizing suffering in the future. Policy makers in PICs are therefore trapped in a Catch-22 situation, they need to move toward adaptation now, but uncertainty about impacts obfuscates the necessary form of any such movement. This in turn generates the problem of potential regret, which is the social (and hence political) risk that comes from committing scarce resources to meet impacts whose magnitude is uncertain.

It makes sense to gauge the extent of uncertainties before making policy. This requires recognizing that the problems facing decision makers in PICs stem not just from scientific uncertainty, but also from what is more accurately called "ignorance" (Smithson, 1989;

Dovers, Norton, & Handmer, 1996; Dovers & Handmer, 1995). Whereas uncertainty stems from not knowing the specific form of anticipated impacts, ignorance is simply not knowing. The specific use of the term ignorance here has no association with its historical use in a denigrative discourse on Pacific Islanders to justify colonial administration. Rather, ignorance is used here to explain the problem of not knowing about surprise impacts which by definition cannot be anticipated. There is little doubt that, given the complex spatial, temporal, cross-scale and connective nature of climate change, it is impossible to anticipate all impacts (ignorance), and hence impossible to design perfect responses. So, not only does policy have to plan for anticipated events whose specific form is uncertain (uncertainty of impact), and design strategies whose effectiveness will be uncertain (uncertainty of effective solution), it also has to have some capacity to minimize suffering and avert disaster from events whose very existence is impossible to predict.

A comprehensive uncertainty and ignorance management strategy begins with a formalized and systematic examination of ignorance and uncertainty, termed an "ignorance audit" by Dovers and Handmer (1995). The ultimate utility of an ignorance audit is that it systematically identifies what is known (and with how much certainty), and what is generally less known, for the purposes of making decisions about adaptation. It also suggests what can be better known for the purposes of more informed decision making in the future. In this way, the balance of the mix between the scientific information and the political considerations which inform any decision (and nondecision) about adaptation is thus revealed more clearly. [4] Further, by identifying what can and cannot be known in the future, an ignorance audit identifies decisions that can realistically be deferred while future additional information is gathered (and how long it might take to deliver that information). In this latter sense, an ignorance audit serves as a consolidation and review of research activities, enabling co-ordination and refocusing of areas for further research.

A better understanding of the extent of ignorance and uncertainty leads to more appropriate policy selection. On impacts for which there is a high degree of certainty of occurrence (such as future droughts due to El Niño in the western Pacific), and a high degree of confidence in the effectiveness of the response strategy (warning systems, improved water resource management, greater diversification of food supplies, etc.) adaptation strategies can be pursued with confidence and social impediments to implementation addressed with vigor (on El Niño in Papua New Guinea, see WMO, 1999). On issues where there is moderate uncertainty (such as the effect of warming of oceans and increasing carbon dioxide concentrations in oceans on coral reefs), but potential to reduce this by further study, decisions could be postponed for a determined period of time (on reefs and changes in oceans see Kleypass *et al.*, 1999). On issues where there is high uncertainty (such as the impact of climate change on cyclone frequency and intensity), and particularly if high uncertainty is found to be generic and ubiquitous, alternative policy options should be pursued (on climate change and cyclones see Jones *et al.*, 1999; Olsthoorn *et al.*, 1999).

6. UNCERTAINTY AND POLICY

In PICs a "no regrets" approach to making decisions about adaptation in the face of uncertainty prevails. This entails favoring strategies which will yield benefits regardless of whether CC & ASLR should occur. This makes eminent sense, not least because it presumably entails the pursuit of sustainable development, which, as argued in Section 2, is vital if PICs are to persist in the face of CC & ASLR. Nevertheless, implementing sustainable development still involves making decisions in the context of uncertainty (Dovers *et al.*, 1996). To some extent regrets are unavoidable because of limited resources, limited time, ignorance and uncertainty. Deciding among options is precisely the business of deciding what is best, and by implication what is foregone now and in the future. So what may seem to be a good decision with "no regrets" now may nevertheless bring substantial regret if it means forgoing an option which history shows would have been more successful. At the heart of this issue is the tradeoff between limited resources and future needs, and the realization that having no regret is still to some extent contingent on certainty about the future.

A widely advocated approach to dealing with uncertainty is the precautionary principle, which became prominent in global environmental change after the 1992 Rio Declaration. The Rio Declaration stated the precautionary principle as: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (Principle 15, UNCED, 1993). The UNFCCC also adopts the same basic definition at Article 3.3, but places greater emphasis on the "cost-effective" element (UNFCCC). [5] Dovers *et al.* (1996, p. 1149) state that the precautionary principle has three basic implications: (a) uncertainty should not delay implementing protective measures; (b) anticipatory and preventative measures (forward planning) should replace reactive measures; and (c) the burden of proof should shift to those proposing development. The precautionary principle is not without substantial operational difficulties, largely emanating from the subjective nature of interpreting its key terms of "full scientific certainty," "irreversible damage" and "cost effective" (Dovers & Handmer, 1995). Ultimately, these difficulties will not be resolved by science, but by politics (Dovers *et al.*, 1996). So, in terms of adaptation in PICs, the precautionary principle, like "no regrets" measures, is the formalization of common sense. [6] It offers little guidance to policy makers at the "coal-face" of adaptation other than to advise against inaction. This is not to say that the no regrets and precautionary approaches are invalid, but they do not resolve the dilemmas of decision makers.

The concept of adaptive management (AM) is increasingly being promoted as an approach to policy which is better able to manage and accommodate uncertainty and complexity. AM is an iterative feedback and learning-based approach to policy (Berkes & Folke, 1998). The essence of AM is "management as experiment," where management exercises are seen not as final solutions, but as probes to learn more about the system (Dovers & Mobbs, 1997, p. 41). AM therefore, entails a shift away from certainty as a prerequisite for policy and from the assumptions that final solutions are possible and problems are discrete. Instead, AM is premised on the assumption that organizations and institutions can learn in the same way that individuals do, and models of AM are increasingly based on models of community learning and adaptation to environmental change (Berkes & Folke, 1998). Despite its innovative nature and emphasis on process more than product, AM is by no means a comprehensive solution to the problem of adaptation to CC & ASLR in PICs. AM is most useful for the management of small and reasonably discrete biophysical systems and it (arguably) carries with it a Western bias toward technical expertise, whereas adaptation in PICs involves island-scale and extremely complex non-Western social and ecological systems responding largely to endogenous changes. More work is necessary to harness the potential of AM for the purposes of adaptation to climate change and accelerated sea-level rise in PICs.

A radically alternative strategy to handling uncertainty comes from Wildavsky (1988), who offers not so much alternative criterion for decision making, but rather an overall strategy which has resonance with AM. Wildavsky distinguishes between the conventional approach to future problems which are uncertain, which he calls "anticipation," and a strategy of resilience. Much of the literature on vulnerability and adaptation to CC & ASLR advocates a strategy of anticipation, particularly the IPCC guidelines. The anticipatory strategy involves "picking winners," which entails guessing which problems are likely to emerge and implementing presumably (but by no means certainly) effective responses. The principal difficulty with an anticipatory strategy is that the possibility of regret due to bad guessing or ineffective response is high. More subtly, but no less importantly, committing resources to adapt to uncertain future dangers can actually make the future more dangerous by displacing basic strategies which enhance adaptability (like education and poverty reduction), and by decreasing the size of the future resource base from which the community will need to draw on in times of crisis. [7]

So, anticipatory strategies are prone to regret and can create vulnerability to surprises. Anticipatory strategies are characterized by the centralization of power, a lack of flexibility, and an inability to engage in policy learning. They tend to prevail because of: habit; vested interests (such a scientific bias, bureaucratic influence, and political pressures); benefit-cost accounting systems which favor optimizing resources now by discounting future benefits and costs; and the extension of largely linear and positivist epistemologies, (including neoclassical economics) traditionally concerned with stability and steady yields, into the realm of policy. A strategy of anticipation and response is only appropriate when there is certainty about the anticipated danger and certainty that the intended solution will effectively curtail that danger. When these criteria cannot be met, which is often the case when considering the impacts of climate CC & ASLR, then a strategy of anticipation should be abandoned and an alternative strategy of resilience pursued.

The resilience approach emphasizes the capacity to cope with uncertainty and surprises while maintaining overall system persistence. For Wildavsky (1988), resilience is about learning from error how to bounce back in better shape. A strategy of resilience involves building up institutional structures and human resources as these are the first and last requirements of a system able to absorb, learn from, and modify itself to changes. A strategy of resilience entails developing coping capacity which is arguably a better approach to adaptation given scientific uncertainty.

7. THEORIZING RESILIENCE

The beginnings of a contemporary theory of resilience can be traced to a paper by C.S. Holling, published in 1973, which defined resilience as "the persistence of relationships within a system" and "the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling, 1973, p. 47). This ecological approach to the concept has developed over time, and has more recently been applied to policy through the notion of AM (see, for example, Berkes & Folke, 1998; Gunderson, Holling, & Light, 1995; Handmer & Dovers, 1996; Holling, 1978; Holling, Berkes, & Folke, 1998). The significance of Wildavksy's (1988) book *Searching for Safety* is that he interprets various understandings of resilience and communicates these in terms familiar to social science. The study of disasters also talks of resilience (see, for example, Blaikie *et al.*, 1994; Handmer & Dovers, 1996; Mortimore, 1989). Further, there are nascent parallels with these bodies of work and Murray Bookchin's ecophilosophical rationalization of unity in diversity (1982).

In terms of CC & ASLR in PICs, it is important to recognize that the pursuit of resilience is integral to the development of adaptive capacity. This is because, as a general if not near-universal rule, an integral feature of resilient systems is an ability to learn from, and reorganize to meet, changed conditions. In short, a resilient system carries with it the essential qualities for adaptation. Mortimore has argued the point in the following way: "the extension of the idea of resilience from ecosystems to human systems directs emphasis away from a futile search for equilibrium to the strengthening of social adaptive behaviour" (Mortimore, 1989, p. 217). Resilience is most often cast in terms of response to impacts which are essentially negative in nature, however, a society which is flexible and able to shift rapidly is also able to exploit any positive opportunities that might arise in an uncertain future.

A focus on resilience stands in contrast to the traditional emphasis in environmental and economic policy on the principles of stability and anticipation. These principles very much inform the study of vulnerability and adaptation to climate change, not least because the social science most involved in this process is neoclassical economics, which is itself dominated by the principle of predictable (and increasing) yields. In the main, resource management policies are also anticipatory and emphasize stability, seeking to secure steady and predictable yields (Holling *et al.*, 1998). Holling's study posits, however, that resource management practices which seek steady yields restrict the natural fluctuations in a system, and this tends to increase the likelihood of the system to flip into an alternative equilibrium state in the face of surprises. So, conventional resource management practices tend to decrease the ability of a system to persist in the face of surprises (decreases resilience). [8] The critical issue here for PICs and the case of CC & ASLR is that extraordinary endogenous changes are occurring and are certain to continue, so adaptation policies which seek to maintain steady-yields would seem to be increasingly prone to invoke system failure. Thus, a sectorally-based approach to adaptation which seeks to intervene in key sectors to secure steady-yields despite future climatic changes is probably counterproductive in the long term. This implies a shift from sector-based planning to system based planning (from a focus on the parts to a focus on the whole), and from resource management to sustainability. [9]

Ecological research identifies a number of traits that characterize system resilience, although it should be noted that this is somewhat contentious. [10] There are at least six principles of resilient systems (Watt & Craig, cited in Wildavsky, 1988, p. 112). First is the homeostasis principle, which holds that the system is maintained through feedbacks between its components. These feedbacks signal changes, drive responses, and enable learning. Resilience is enhanced when feedbacks are transmitted effectively. The second principle is the omnivory principle, which holds that external shocks are mitigated by the diversification of resources and the diversification of the means by which resources are delivered. Thus, the more diverse the resources and the more diverse the means of delivery, the less likely it is that the supply of vital items will falter. In this way, a crisis of supply in one place does not trigger a crisis in other (overly dependent) places. The third principle is the high flux principle, which holds that the faster the rate of movement of resources through the system the more resources will be available at any given time to help cope with perturbation, and hence, the more resilient the system. The fourth principle is the flatness principle, which refers to the number of hierarchical levels relative to the base in an organization, and holds that the greater the number of participants higher in the system (the more top-heavy), the less resilient a system. Overly hierarchical systems are less flexible and hence less able to cope with surprise and adjust behavior. The fifth principle is the buffering principle, which refers to the surplus or slackness in the system, and holds that a system which has a capacity in excess of its needs can draw on this capacity in times of need, and so is more resilient. Finally there is the redundancy principle, which holds that a degree of overlapping function and redundancy in a system permits the system to change by allowing vital functions to continue while formerly redundant elements take on new functions. Redundancy also allows for interchangeability when one part fails to perform.

Approaching resilience from the perspective of social-ecological systems, Folke, Berkes, and Colding (1998) explore the characteristics of resource management practices based on traditional ecological knowledge, practices which they argue enable a high degree of resilience. There are therefore, clear linkages between social and ecological resilience (Adger, 2000). Some of the strategies of resilient traditional social-ecological systems Folke *et al.*, identify are (p. 418): monitoring of changes in ecosystems and resource stocks; management of landscape patchiness; constant re-interpretation of signals in systems; integration of knowledge; carrying and transmission of folklore/intergenerational transmission of knowledge; geographical transfer of knowledge; and community-wide assessments.

From the perspective of the study of natural disasters, a number of strategies enable systems to both absorb and recover from sudden changes, and to learn from and adapt to changed conditions. As well as designing slackness, redundancy and speed of supply into social systems (respectively the buffering, redundancy and high flux principles) as identified by Handmer and Dovers (1996), and the decentralization of decision making (the flatness principle) as identified by Blaikie *et al.* (1994), other strategies which enhance resilience to disasters include: mobility, including ability to relocate temporarily and permanently; diversification of supply of food, fiber and income (the omnivory principle); mobilizing social networks and systems of redistribution (the whole insures the parts); alleviation of absolute poverty; learning from past events and changing practices; transmission of knowledge across space and time; experimentation and innovation; and sustainable intensification of resource use (after Adger, 1999; Blaikie & Brookfield, 1987; Blaikie *et al.*, 1994; Burton, 1996; Handmer & Dovers, 1996; Mortimore, 1989).

There are lessons to be learned from environmental philosophy as well. For example, in his discussion of Social Ecology, Bookchin (1982) stresses the value of ecological and social diversity and complexity, which he says create multiple sites for creativity and innovation, which in turn increase the sum of potential choices available to a system. He notes that freedom (which for the purposes of this paper can be crudely read as capacity to adapt) is a function of diversity. This diversity-creativity-solutions analysis is not dissimilar to Wildavsky's reasoning that ignorance and uncertainty are best investigated by numerous small, individual institutions exploring possible dangers, and this is in turn one possible strategy for pursuing AM.

8. BASES OF RESILIENCE IN PICs

The social-ecological systems of the Pacific Islands have historically been able to adapt to environmental change. While there have been instances of considerable population decline due to environmental change such as at Rapa Nui (Bahn & Flenley, 1992), sufficient evidence exists to show that people have maintained habitation of the Pacific Islands during periods of substantial exogenous and human-induced environmental changes, although adaptation was at times traumatic (see Kirch, 1997; Nunn, 1999, 2000). Considerable resilience to (short-term) hazards has also been documented (Campbell, 1990; Firth, 1959; Lessa, 1964; Marshall, 1979; Rappaport, 1963). Campbell argues that Pacific Island societies have historically had a range of practices that made them resilient to climate extremes, and that since colonization these have been modified to suit changed political and economic circumstances (Campbell, 1990, 1998). It is these attributes which the following section briefly describes before moving on to discuss the implications of resilience for climate change adaptation policy in the South-West Pacific.

Climate extremes have a severe impact on the Pacific Islands, and it is the possibility of increased frequency and/or intensity of these that now most concerns policy makers. In recent times, the 1997–98 El Niño caused widespread drought and subsequent famine in the islands west of the international dateline, with agricultural losses in Fiji valued at US$65 million, and some 260,000 people in Papua New Guinea placed in a life-threatening condition due to depleted food supply (WMO, 1999). In the same period, there was an increased frequency of tropical cyclones east of the international dateline. The Cook Islands experienced 17 tropical cyclones, the most recorded in a season (WMO, 1999). Cyclones are particularly problematic and have caused massive financial losses; cyclone Ofa which struck Western Samoa in 1990 caused US$110 million worth of damage, as did cyclone Kina which struck Fiji in 1993 (Campbell, 1990; Olsthoorn *et al.*, 1999). In addition to wind damage and damage from increased rainfall and flooding, cyclones induce storm surges which can reach up to six meters in height, far in excess of the maximum height of atolls. For example, in 1987 a cyclone and storm surge struck Tokelau, bringing waves that swept across the islands and flooding of up to a meter on the island of Fakaofo (Hooper, 1990). These surges will be greater if superimposed on elevated sea-levels, and greater still if cyclone intensity increases due to climate change (Olsthoorn *et al.*, 1999). Successful adaptation to climate change requires understanding and enhancement of people's strategies to prepare for, respond to and recover from extreme events such as these.

Social interaction across space, at a variety of scales, is integral to past and present coping strategies in Pacific Islands. In his excellent study of cyclone response in the Banks Islands of Vanuatu, Campbell locates the pre-colonial resilience of people in well-established and complex sets of political and social interactions among the island group (Campbell, 1990). Forms of interaction included marriage, trade of food surpluses and the circulation of shell money. The production of a food surplus and the exchange of this surplus was important to establishing relationships of reciprocity between islands. Exchange of material tended to correspond to the diverse resources of the islands, so that each island maximized its ecological advantages and offset its deficiencies through trade. In times of need, such as after a cyclone, communities would assist each other through the redistribution of food, and at times through the dispersal of people to other islands. More recently, but on a smaller scale, considerable migration within home islands was observed in Samoa and Tokelau during cyclone Ofa (Fauolo cited in Campbell, 1999; Hooper, 1990). This requires good social relations with "neighbors" (see Torry, 1979). Unlike contemporary processes of disaster relief, interisland mutual assistance in the Banks Islands was "within the control of local decision makers" (Campbell, 1990, p. 419).

Diversity across space emerges as a key theme of resilience. For example, in addition to storage and preservation of food, food security in the Banks Islands, Vanuatu (Campbell, 1990), and in many places in Papua new Guinea (Clarke, 1977; digim'Rina, 1998; Mogina, 1999) is maintained through planting a diverse array of plants in gardens, and through biodiversity in the immediate environs which provides "famine foods" when gardens fail. Social diversity within an area, but with some cohesion maintained by reciprocity (as is the case in the Banks Islands), is also important for resilience to climate extremes. So, Campbell writes of the Banks Islands:

> By maintaining a diverse range of crops the likelihood that all species in any one location would be heavily damaged was reduced. The same principle applied at the regional level, to an even greater degree. Not only did different islands in the Banks Group vary in terms of their main staple, they were also sufficiently dispersed so that it was extremely unlikely that all islands would suffer equally (1990, p. 408).

Thus, the "chains of dependency" between communities provided resilience to sudden shocks (Boyden, 1987).

The processes of colonization and subsequent globalization have seen a steady increase in the spatial range of interaction between Pacific Islands and the rest of the world. Colonization undermined the ability of Banks Islanders to cope with climate extremes, particularly through structural changes wrought by the imposition of a market economy and its impacts on agricultural and biological diversity and interisland exchanges (Campbell, 1990). The contemporary form of colonization—globalization—is less imperialistic and more technical and economically-oriented, but continues the process of opening up the islands to the forces of capital. Globalization, however, at least offers the promise (which may be false) of greater development opportunities and autonomy from colonial dependency. The "chains of interdependency" among island groups such as the Banks Islands have been substantially weakened as Campbell (1990) documents, and have been replaced by linkages to places further afield. Perhaps the shift is best understood as the replacement of chains of interdependence and mutual assistance with more indeterminate, potentially destructive and certainly more instrumental chains of dependence. Thus, Campbell writes of the Banks Group that:

> Whereas the nexus of traditional coping systems was community-island–island group, it has now become community-island–international.... Unlike the traditional systems of exchange, where potential recipient communities exerted control over response through the production and manipulation of surpluses and the maintenance of obligations with potential donors in an integrated and interdependent system, no such reciprocity exists in the current process (Campbell, 1990, p. 420).

Since the 1950s there has been substantial migration away from the Pacific Islands—particularly the Polynesian Islands—to rim countries such as Australia, New Zealand and the United States. In 1996, there were some 600,000 people living in the Cook Islands, Niue, the Samoas, Tuvalu, Tokelau and French Polynesia, and some 400,000 migrants from these places living in the Pacific rim (Bedford, 2000). Most migrants maintain strong spiritual ties with their ancestral homelands, and this has led to the formation of complex meta-societies of groups with common identities living in different places, and engaging in transnational exchanges of finance, materials, labor and culture. One aspect of this transnational economy—the remittances of goods and money from migrants to their homelands—is now an important contemporary form of mutual assistance that seems to enhance the resilience and adaptability of the Pacific Islands to economic change, but also at times to environmental change (the overall impact of remittances is a subject of some debate, see Bedford, 2000 for a review). In response to the damage caused by cyclone Ofa in 1990, for example, substantial sums of money and goods were remitted to Samoa by Samoans living in New Zealand (Campbell, 1999). Nevertheless, the linkages between migration and environmental issues are not as straightforward as many would suggest; they seem to be neither entirely negative nor entirely positive, and are context-specific (see Locke, Adger, & Kelly, 2000). More research on the overall environmental benefits and costs of migration in the Pacific Islands is necessary. It remains a robust conclusion, however, that through migration "transnational economic and social relationships" have developed in Polynesia, and these are the most important new factors in the resilience of Pacific Island people to global forces.

9. IMPLICATIONS OF RESILIENCE FOR POLICY

From this discussion of resilience some key implications for policy emerge. In general, a strategy to develop the social and organizational capabilities of PICs will ensure their persistence over time. A tentative list of policy goals can be proposed, assuming that the overall policy objective with respect to CC & ASLR in Pacific Island Countries is the persistence of island social-ecological systems indefinitely. These broad policy goals can be summarized as focusing on information, communication, education, economic policy and institutional design.

A first-order priority, consistent with the social-ecological system practices identified by Folke *et al.* (1998), and consistent with AM, is to increase the availability of information necessary to understand the state of the biophysical and social environment. This is a task for research in both the biophysical sciences and social sciences. Baseline data sets and monitoring of key indicators are necessary to develop sensitivity to change. Equally important, however, is the capacity to distribute this and other forms of information in all directions throughout the society, not just in directions dictated by the presence of centralized and upper-echelon management. This means developing the physical infrastructure for communications, but also utilizing regular social practices of information exchange. This is a task for the state, society and also the media. Specific programs to encourage horizontal and vertical exchanges in social systems may be required, for example, formalized regular meetings of village leaders on specific issues such as disaster planning or state of environment reporting.

An ability to learn is central to the ability to respond and adapt to change. In that, broadly educated societies seem to more resilient to environmental change, education policy is a key to adaptation. In the realm of technical capability, the answer need not lie exclusively in formal training in state-sanctioned and external learning institutions. For example, scientists are required but not all research work requires a university degree; it is as important to have a large number of people capable of reading equipment as it is to have a few technical experts able to interpret the data. Further, one need not have a degree in sociology to monitor basic changes in social conditions. Developing these technical skills necessary for resilient island systems may be as much about giving opportunities and responsibility to people as it is about training. In addition, it is important that policy makers themselves learn from past adaptive behavior in their own social and ecological systems, and from the successes and failures of past policies.

The need for resilient and adaptable social-ecological systems also has implications for economic policy in PICs. The omnivory principle strongly suggests investment in transport infrastructure to enable rapid transfer of resources wherever and whenever necessary. In the case of extremes events, better infrastructure will also enable rapid movement of people away from disaster areas. Equally important is the need to diversify sources of supply from outside the island system, including sources of training, of information, of technology, of raw materials and of finance. Part of the agenda here is to diversify trading relations and to seek out new donors and financiers. This does not imply acceptance of the free trade agenda and associated liberal economics, as these are increasingly being seen to be counterproductive to systemic sustainability, not least because they maximize productivity and expropriate all surplus production necessary for system buffering (Bayliss-Smith, 1991; Bosselmann & Richardson, 1999). The buffering principle suggests a need for purposeful accumulation (savings) of various forms of capital such as financial resources, food, fuel, fiber, and genetic diversity. This is necessary both as contingency planning for short-term perturbations, but also as "capital" to "fund" future adaptation-oriented developments.

In terms of development, the variable vulnerability of groups within PICs suggests targeting employment and sustainable development programs at the most disadvantaged people in the most disaster-prone places (see Blaikie *et al.*, 1994, Cutter, 1996). More generally, while development has a strong tendency to undermine ecosystem resilience, the wealth it confers paradoxically tends to enhance resilience, particularly when it is equitable and when it leads to enrichment of the state. Thus, a long-term goal of sustainable development is essential, but a focus on the least developed (most vulnerable) should be an immediate priority. The understanding of "social vulnerability" therefore, becomes essential to policies for resilient and adaptable Pacific Island societies (see Adger, 1999, 2000; Handmer *et al.*, 1999).

The most important institutional need is to enhance the participation of all people in research, in monitoring, in decision making, and in policy implementation so that to the greatest extent possible the whole of the island-system is involved in the management of the island's future. This is an area fraught with ethnocentric assumptions about equity and democracy, so ultimately it is the responsibility of the particular place to design institutions which fit their cultural and ecological circumstances. Enhancing participation may require developing capacity in communication, translation, teamwork facilitation and conflict resolution, again suggesting the importance of education and training.

At the broader regional scale there is a scope for designing and implementing a polycentric organizational structure (a Pacific Island climate change administrative system) with three not necessarily hierarchically-related levels: (a) regional, (b) national, and (c) local. The purpose of such a system would be to involve as many people as possible in various activities related to CC & ASLR. This is not to argue for the centralization of authority, as this has historically been part of the process that has undermined community resilience to climate extremes (see the earlier discussion). Rather, this argument here is for the distribution of power to those institutions and groups which are most capable of acting to enhance their own resilience. Conversely, this involves more than simply shifting authority downward, instead it involves locating authority in the regional, national, local and nongovernmental organizations in a co-ordinated and communication-rich system. In this schema, regional and national organizations are brokers, facilitators and funders of local-level climate change adaptation strategies. [11] Such a scheme offers the possibility of re-establishing mutually supportive relationships among local communities as they liaise on the common problem of CC & ASLR.

The South Pacific Regional Environment Programme is the obvious candidate for the principal authority at the regional level. At the national level there are two principal options, either expand on the Pacific Islands Climate Change Assistance Programme (PICCAP) country teams (Campbell and de Wet's 1999 proposal for National Climate Change Co-ordinating Teams), or expand on the Disaster Management Committees established as a result of the International Decade for Natural Disaster Reduction (IDNDR) (see Barnett, forthcoming; Campbell, 1999). At the local level, governing bodies based on the suitable administrative unit (most likely the village) could be established. Designing such a system should take account of existing organizations and linkages, and should identify key people. In addition to being a prerequisite for resilience in its own right, the proposed administrative system would be invaluable for a number of specific tasks related to adaptation: it could provide official nodes for supporting and organizing research in localities; it could provide clear lines of communication vertically—and with the development of regular forums—horizontally; it could provide a framework for monitoring changes and communicating findings which covers all social and all inhabited ecological spaces; it could provide channels and nodes for community education and awareness raising; it could bring a wide array of people into an integrated system, and so help foster the development of human resources.

In sum, these proposed broad policy goals aim to develop systems of purposeful exchange between informed social groups living in a social-ecological context characterized by a fair level of resource saving, a high degree of sensitivity to change, a capacity to learn, and a capacity to change. They have strong resonance with existing calls for capacity building, disaster planning, education and human development, however, it is important to stress the interdependence of these things as a requirement for coping with CC & ASLR. These goals are not merely steps toward adaptation, but are indeed the key ingredients of resilience and adaptation proper; in this sense capacity building *is* implementation. [12]

10. CONCLUSIONS

This paper has investigated the way scientific uncertainty impedes planning for adaptation to CC & ASLR in PICs. It has discussed the problems CC & ASLR poses for PICs, and it has exposed some of the limitations of the dominant approach to vulnerability and adaptation. The paper has considered the problem uncertainty poses for policy makers in the Pacific, and has argued that the existing approach which is based on anticipation of impacts restricts policy. Instead, the paper has proposed a complementary strategy of resilience. The paper then discussed recent developments in the theory of resilience, and considered the implications of this for adaptation policy in PICs. Broad policy goals were proposed. These may not be optimum solutions, but optimum solutions are only possible where uncertainty is small. Given scientific uncertainty, these goals confer a number of potential benefits compared to a strategy based solely anticipation of impacts: they are precautionary and no regrets in nature; they entail the investigation, reduction and accommodation of uncertainty and ignorance; they are more accommodating of surprise; they foster social and policy learning; and they are, for the most part, achievable within existing policy and development constraints.

NOTES

1. The 10 countries are: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Independent Samoa, Solomon Islands, Tuvalu and Vanuatu.

2. Overall, the vulnerability and adaptation process initiated by the Intergovernmental Panel on Climate Change (IPCC) has enormous value as an epistemic mechanism in that assessments allow diverse

communities of scientists and policy makers to focus their attention on a common topic to exchange information and engage in mutual learning.

3. A definitional dilemma made more complex by the inclusion of "tactical adjustments" as part of the "autonomous adjustments" category in the IPCC guidelines (Carter, Parry, Harasawa, & Nishioka, 1994).

4. By political I mean personal values and preferences, institutional values and preferences, and the full gamut of social factors that influence policy making. To the extent that an ignorance audit helps reveal the magnitude of these factors, it may also assist in stimulating the mediation of these factors as they influence decisions.

5. Which suggests that, as discussed earlier, certain parties to the Convention may indeed be postponing decisions until the relative costs of adaptation as opposed to mitigation can be assessed.

6. Its very presence speaks ill of the nature of global environmental diplomacy.

7. At the very least this suggests that one decision making criteria in the IPCC Guidelines should be the extent to which a decision maximizes future choice (the flexibility conferred by various options).

8. Holling (1973) gives the example of the trout fishery in Lake Michigan where steady-yield fishing activity stressed and undermined the resilience of the system so that when an (inevitable) surprise event occurred, the system collapsed (Holling, 1973, p. 9).

9. Dovers' definition of sustainability is particularly suitable to the concept of resilience. For Dovers, sustainability is "the ability of a natural, human or mixed system to withstand or adapt to, over an indefinite time scale, endogenous or exogenous changes" (Dovers, 1997, p. 304).

10. The rationale for drawing on ecological theory is not because this paper views social behavior as being driven by the same principles that drive ecosystem behavior, but because there are nevertheless some valuable analogies between ecological and social systems, and because, in any event, it must be recognized that social and ecological systems are not distinct domains, but are contingent upon each other.

11. This is the inverse of the present trend, noted by O'Tuathail, Herod, and Roberts (1998), whereby the state increasingly acts as a conduit for exclusively top-down implementation of the rules and requirements of the global economy. A similar scheme has been proposed for environmental security at the global scale (Barnett, 2001).

12. The UNFCCC sees capacity building as being about building the ability to implement the convention. This is not necessarily the same as building the ability of PICs to cope with climate change.

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