A framework for managing environmental vulnerability in small island developing states

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Introduction

The natural environments of small island developing states (SIDS) are thought to be vulnerable to a range of natural and anthropogenic hazards that operate to damage them at rates and intensities above those found elsewhere around the globe. It is expected that, because SIDS are small and their human and natural environments have a limited capacity to absorb shocks, tend to have few refugia and may be less differentiated, the effects of hazards are more pronounced and cause greater damage than they would in other parts of the world.

It is this tendency to more substantial damage that sets SIDS apart from most other countries. Their greater vulnerability in turn translates into greater impediments to sustainable development and, more recently, the realisation that the current sustainable development paradigm may be inapplicable to them. It is becoming increasingly clear that a new SIDS paradigm for sustainable development is needed.

The nature and terminology of vulnerability

The natural environment is unequivocally the life support for all human systems. Far from being a luxury available only to those who can afford it, successful environmental management will increasingly become the basis for the success or failure of the economies and social systems of entire countries.

The topic of environmental vulnerability is concerned with the *risk* of damage to the natural environment of a country. For the natural environment, the entities at risk, termed *responders*, include ecosystems, habitats, populations and communities of organisms, physical and biological processes, energy flows, diversity, genes, ecological resilience and ecological redundancy. Each of these responders may be affected by natural and anthropogenic hazards, the risk of which may vary with time, place and human behaviour. The complex nature of vulnerability has required the development of vulnerability theory to provide a framework for logical development and measurement.

The theory identifies three elements of vulnerability: the risk of hazards occurring, and the intrinsic resilience and extrinsic resilience to hazardous events. The risk associated with hazards is dependent on the frequency and intensity of events that may adversely affect the environment. The intrinsic resilience of the environment refers to the innate characteristics of a country that make it more or less able to cope with natural and anthropogenic hazards. For example, Nepal is intrinsically invulnerable to sea-level rise, regardless of the worldwide level of risk. Extrinsic resilience results from external forces acting on the environment and describes the ecological integrity or level of degradation of ecosystems. The underlying assumption is that the more degraded the ecosystems of a country (as a result of past natural and anthropogenic hazards), the more vulnerable they are likely to be to future hazards.

Risks to the natural environment include any events or processes that can cause damage, including natural and human events and processes, such as the weather and pollution. Natural and human hazards affect the environment in interactive ways. For example, the effects of cyclones on natural communities are worse where marine and shoreline ecosystems have been degraded by pollution and overharvesting. High levels of natural disturbance can drive

populations of organisms down to low levels or make their populations more variable. This makes the risk of local extinction, as a result of other hazards, more likely. The frequency and intensity of natural disturbances cannot be separated from the effects of human disturbances and has to be incorporated in the concept of environmental vulnerability.

Environmental challenges facing SIDS

SIDS are subject to most, but not all, of the range of environmental hazards found across the globe. The most important natural environmental challenges for SIDS have been extensively reviewed in *GEO-2000 Global Environment Outlook* and the Caribbean, Pacific islands and western Indian Ocean environment outlook reports (UNEP 1999 a, b, c, d).

These documents identify serious risks to the environmental integrity of SIDS in all three geographical regions that focus on the responders of land, forests, biodiversity, fresh water, marine and coastal areas, and atmosphere (Table 1). The most common basic features of SIDS that are thought to lead to their greater environmental vulnerability include: geographic isolation, ecological uniqueness and fragility, rapid human population growth, limited land resources, a high dependence on marine resources, exposure to extremely damaging natural disasters, low economic diversification, and exposure to external and global changes in climate, trade and markets (SPREP 1992, Thistlethwaite and Votaw 1992, UNEP 1999 c, d).

The environmental challenges facing SIDS are the result of interactions between these basic characteristics, and some of the environmental hazards common in many countries around the globe. The primary challenges fall into five main groups:

1. natural hazards and intrinsic resilience;
2. internal low-intensity, extensive anthropogenic hazards;
3. externally driven, high-intensity anthropogenic hazards;
4. global climate change; and
5. acquired vulnerabilities or extrinsic resilience.

Table 1 Summary of main environmental challenges affecting the main GEO categories of responders in the three SIDS regions

Responders	Main challenges
Land	• Pollution • Land and soil degradation • Shortage of land • Mining • Radioactive and chemical contamination • Land titles
Forests	• Deforestation • Forest conversion • Mining • Logging • Loss of traditional controls • Fire/drought
Biodiversity	• Highest marine diversity • Extensive coral reefs • Sensitive/fragile ecosystems • Endemic species • Critically threatened biodiversity • Extinctions • Species introductions
Fresh water	• Water shortages

	• Limited ground water • Saltwater intrusion • Limited surface water • Losses from distribution networks • Drought • Pollution/eutrophication/poor sanitation
Marine/coastal	• Many low-lying areas • High focus on coastal zone • Nutrients (sewage, erosion, fertilisers and eutrophication) • Solid waste disposal • Sedimentation (deforestation, mining and logging) • Physical alteration to reefs, beaches, wetlands, mangrove beds and watercourses • Loss of critical habitats • Coastal erosion and stability • Cyclones, storm surges and tsunamis • Overexploitation of resources, particularly using destructive fishing
Atmosphere	• Air quality a problem in larger urban areas • Climate change and El Niño
Cross-cutting	• Climate change (changes in temperatures, winds, storms, floods, landslides and droughts) • Sea-level rise • Loss of entire or parts of islands • Population growth • Urbanisation • Loss of traditional systems and changing expectations

Note, these challenges are listed by category for convenience but, in reality, most of them are interactive and could not be considered in isolation.

Challenge 1: natural hazards and intrinsic resilience

Natural disasters such as cyclones can affect an entire small island state, leaving nowhere to supply seed organisms, stage human recovery operations and supply resources while the country recovers. This, in turn, can lead to greater damage to an environment that must still be used during recovery to supply human needs. In larger countries, it is likely that only a small area of the country will be damaged by natural disasters at any one time, so that refugia and alternative supplies are always available. In SIDS, these natural hazards most commonly include cyclones (Antigua and Barbuda, Jamaica, Tuvalu and Vanuatu), coastal floods, river floods, drought, tsunamis, earthquakes, volcanoes (Montserrat) and fires associated with El Niño droughts (Samoa) (UNEP 1999c).

The intrinsic characteristics of a country have a bearing on how resilient it is to the hazards that threaten its environment. For example, countries with larger and higher land areas are likely to be less sensitive to encroaching seawater from cyclones, tsunamis and sea level rises. Such inherent characteristics are normally unchangeable, and are an important consideration in the overall vulnerability equation.

Challenge 2: internal low-intensity, extensive anthropogenic hazards

Rapidly increasing human populations, the loss of traditional systems of resource management, changes in land and sea tenure, and changing lifestyle expectations have resulted in widespread but relatively low-intensity (extensive) ecosystem damage in SIDS. Most SIDS are not involved in heavy industries that produce concentrated or very toxic wastes which can be spread over a wide area (for example, chemical and nuclear pollution). However, they may be involved through the actions of multinational companies (for example, in mining or logging) as dumping or testing grounds for toxic materials, or incidentally

through global changes in climate. Few SIDS are heavily involved in highly mechanised and intensive systems of farming.

Most of the internally generated human effects in SIDS are connected with the deforestation or conversion of forests, relatively low-toxicity pollution (for example, agricultural chemicals and sewage), the overexploitation of resources, and increasing urbanisation. The damage caused by these activities tends to be widespread over the small area available, resulting in losses of resilience, ecosystem integrity and character, and biodiversity, often without producing obviously highly degraded areas. The damage, some of which may be unrecognised, is subtle, and results from activities spread across the population base, leaving few areas undamaged. For example, overfishing is seen as a major threat in most Pacific SIDS (World Bank 1999), and Samoa's rate of deforestation approaches 2 per cent per annum (GOWS 1994).

Challenge 3: externally driven, high-intensity anthropogenic hazards

The natural environments of many SIDS are subject to damage from transboundary hazards, and the activities of other governments and multinationals. Their relative isolation has seen SIDS become sites for nuclear testing, wars and the dumping of toxic wastes. For example, in the Pacific there are problems with current stockpiles of persistent organic pollutants, entire islands that have been contaminated by nuclear residues, and islands on which the natural ecosystems have been disrupted by wartime activities (for example, borrow pits on Funafuti, Tuvalu).

Transboundary problems can also take the form of pollution (waters from the Amazon are affecting marine ecosystems in Trinidad), the uncontrolled or inappropriate migration of refugees to already crowded islands, and problems with migratory fisheries stocks (for example, tuna in the Pacific). In many SIDS, external interests have moved into the country and harvested both renewable and non-renewable resources, sometimes only paying a fraction of a fair resource rent, and leaving behind a legacy of environmental damage and social disorder. For example, in Papua New Guinea, most of the country's forests have been logged by companies from Australia, Japan and Malaysia, mostly using poor logging practices that have damaged forests, and caused erosion and sediment run-off into waterways, wetlands and the sea.

Mining and gas and oil extraction in that country are thought to have affected aquatic environments (Hunnam et al 2001). The active mines produce large quantities of waste materials, which are dumped into rivers or find their way to the sea through run-off. It is likely that the Bougainville crisis is at least partly attributable to disputes over the distribution of benefits, including the bearing of environmental costs. Most Pacific SIDS are subject to poaching of their tuna stocks by distant fishing nations, and have little capacity for effective surveillance and enforcement of exclusive economic zones.

Challenge 4: global climate change

Climate change and its associated effects are really a special case of challenge 3 hazards, those driven by external influences, but have been separated here because their effects operate over different periods than the other challenges. The main hazards associated with climate change pose serious threats to all of the world's small island states (IPCC 2001). The risks are highest for SIDS — which contribute least to global emissions of greenhouse gases — because they have a limited capacity to mitigate, and adapt to, the predicted changes, such as:

- sea-level rises,

- increases in climate-related natural disasters, and
- changes in climate and climate variability (UNEP 1999c, IPCC 2001).

The most significant and immediate challenges for SIDS are likely to be changes in rainfall regimes, soil moisture budgets and the speed and direction of prevailing winds, and short-term variations in sea levels and patterns of wave action (IPCC 2001). These changes are expected to have highly interactive flow-on effects in every aspect of the natural environments of SIDS.

Challenge 5: acquired vulnerability or extrinsic resilience

All of the above hazards can lead to further environmental vulnerability when a hazard causes damage and reduces the resilience of the environment to future hazards. This has been termed extrinsic resilience because it is concerned with *acquired vulnerability*. For example, a coral reef damaged by cyclones for three successive years is likely to be more vulnerable to damage if another cyclone were to hit in the fourth year, than it would if it had time to fully recover. Similarly, the same reef would be more vulnerable if it also had a history of damage by pollution.

Managing vulnerabilities and building resilience

For SIDS to address these challenges and thereby manage their environmental vulnerability, they will first need to fully identify its components and establish suitable measures of those components. The environmental vulnerabilities of SIDS vary from country to country. Clearly, the approaches and instruments for dealing with these different vulnerabilities will vary, and will include a combination of measurement and assessment, management within the country, building internal resilience, using multilateral environmental agreements (MEAs), and international assistance (Table 2).

Table 2 Summary of main approaches to managing vulnerability and building resilience for the five environmental vulnerability challenges facing SIDS

Challenge	Repeated measurement/ assessment	Internal management	Building internal resilience	Multilateral environmental agreements	International assistance
1. Natural hazards and intrinsic resilience	Y	N	Y	N	Y/N
2. Internal anthropogenic hazards	Y	Y	Y	Y/N	Y
3. External anthropogenic hazards	Y	Y/N	Y	Y	Y
4. Global climate change	Y	N	Y	Y	Y
5. Secondary vulnerability/extrinsic resilience	Y	Y/N	Y	Y	Y

Y = yes, N = no, and Y/N = yes and/or no respectively.

Measurement or assessment of vulnerability

The first step in attempting to manage the vulnerabilities of SIDS is to identify all aspects of vulnerabilities, and measure or assess these repeatedly. To be sustainable, the future of SIDS must be based on a symbiotic relationship with the natural environment. Where, in the past, environmental management was separated from the concerns of economies, it must now become an integral part of the economic, social and cultural systems of each country, and has to be accounted for at this scale. Attempts have been made to do this over the past few years by developing criteria for ecologically sustainable development (Heinonen et al 2001), and

general conceptual frameworks for sustaining the Earth's life-support systems (Daily 1999). These attempts, though valuable, tend to focus on processes rather than outcomes, can be cumbersome to evaluate or implement, and may not easily allow for auditing the effectiveness of the measures being taken. They are not focused on 'ensuring the future' (Tonn 2000).

Over the last decade, the United Nations Environment Programme, the Asian Development Bank and the regional environmental organisations working with SIDS have gone a long way towards identifying the main hazards and sensitivities affecting the natural environment through state-of-the-environment reporting. The documents that resulted (UNEP 1999 a, b, c, d; ADB 2000) provide an excellent starting point for identifying and assessing countries' main vulnerability problems.

Attempts have been made to provide measures of vulnerability in rating or index form for climate change and sea level rises (Pernetta 1990, IPCC 1991, IPCC 1992, Downing 1992), and human impacts on the environment (Ehrlich and Ehrlich 1991, UNEP 1998). More recently, through the South Pacific Applied Geoscience Commission (SOPAC) and its collaborators, the Pacific island countries have developed a comprehensive vulnerability index and profiles for the natural environment. The environmental vulnerability index (EVI) is among the first tools now being developed to focus environmental management using vulnerability rather than the state of the environment, by working at the same scales at which environmentally significant decisions are made, and by concentrating on outcomes.

EVI uses 54 *smart indicators* to assess the vulnerability of the environment at the scale of entire countries (Table 3), because it is at this level that major decisions are made affecting the environment. If environmental conditions are monitored at the same time as those concerning human systems, there is better opportunity for feedback between them. The EVI has indicators that cover all major aspects of vulnerability, including the five challenges identified for SIDS. This index is undergoing testing and is expected to be released later in 2002.

Table 3 List of indicators of the environmental vulnerability of a country being tested by SOPAC and its collaborating countries and experts

No	Indicator	Subindex	Category	No	Indicator	Subindex	Category
1	Sea temperature	REI	Met	28	Loss of natural cover	REI	A
2	High winds	REI	Met	29	Tourists	REI	A
3	Dry periods	REI	Met	30	Waste water	REI	A
4	Wet periods	REI	Met	31	Production wastes	REI	A
5	Heat spells	REI	Met	32	Waste treatment	REI	A
6	Cold spells	REI	Met	33	Oil spills	REI	A
7	Volcanoes	REI	G	34	Toxic industries	REI	A
8	Earthquakes	REI	G	35	Vehicles	REI	A
9	Tsunamis	REI	G	36	Sulphur dioxide	REI	A
10	Land area	IRI	CC	37	Fertilisers	REI	A
11	Fragmentation	IRI	CC	38	Pesticides	REI	A
12	Isolation	IRI	CC	39	Fisheries stocks	REI	A
13	Vertical relief	IRI	CC	40	Degradation of land	EDI	A
14	Lowlands	IRI	CC	41	Fresh water	EDI	A
15	Coastal vulnerability	IRI	CC	42	Subsurface mining	REI	A
16	Endemics	IRI	CC	43	Surface mining	EDI	A
17	Pathogens	REI	B	44	Terrestrial reserves	EDI	A
18	Potential for introductions	REI	B	45	Marine reserves	EDI	A
19	Introductions	EDI	B	46	War and civil unrest	EDI	A
20	Endangered species	EDI	B	47	Legislation	EDI	A
21	Extinctions	EDI	B	48	Sanitation	EDI	A
22	Natural vegetation	EDI	B	49	Genetically modified organisms	EDI	A
23	Intensive farming	EDI	B	50	Shared borders	IRI	CC
24	Fisheries	EDI	B	51	Fragmentation of vegetation	EDI	A
25	Coastal settlements	EDI	A	52	Migratory species	REI	B
26	Population density	REI	A	53	Icesheets and glaciers	EDI	G
27	Population growth	REI	A	54	Slides	REI	G

Indicators are characterised in terms of subindex and broad category to allow for better identification of sources of vulnerability as follows: REI = risk exposure subindex, IRI = intrinsic resilience subindex, EDI = environmental degradation subindex (extrinsic resilience), Met = meteorological, G = geological, CC = intrinsic country characteristics, B = biological, and A = anthropogenic influences (the full text for each indicator may be found in Kaly et al 2002).

Internal management

Certain aspects of vulnerability are amenable to management within SIDS through the normal channels of policy, legislation, political will and public cooperation, while there are some that are not (see Table 2). Natural hazards (for example, cyclones) and intrinsic sensitivities (for example, low elevation), challenge 1 vulnerabilities, are generally not under the control of governments or people and cannot be managed by them. These are aspects of a country's vulnerability that have to be lived with, though effort can and should be put into building resilience to their effects. A similar situation can occur with externally induced vulnerabilities, such as climate change or sea-level rise (challenge 4) and many challenges 3 and 5 vulnerabilities. For example, apart from negotiating with responsible governments, SIDS are generally unable to directly influence the global emission of greenhouse gases or prevent pollution from migrating across borders into their jurisdictions.

In contrast, challenge 2 vulnerabilities, the anthropogenic hazards to the natural environment generated in country, can be managed and balanced against the social and economic objectives of SIDS. They can be managed using commonly accepted tools coupled with a reliable feedback mechanism, which repeatedly measures a vulnerability and how the level changes as policy is implemented. Some externally driven and secondary vulnerabilities (challenges 3 and 5) could be managed in a similar fashion. This would apply to external interests utilising a country's resources (for example, in mining) and SIDS should examine their opportunities for reducing their vulnerabilities in those areas.

Building internal resilience

SIDS can decrease their environmental vulnerability to all types of hazards (challenges 1 to 5) by strengthening the natural environment, providing refugia for recovery or reducing some of the negative interactive effects operating between factors. Strengthening the natural environment can involve reducing stressors (for example, by better treating or disposing of sewage), allowing sufficient periods for recovery, or rehabilitating damaged areas (the last resort). For natural resources, allowing time for recovery might include ensuring that harvesting does not exceed the maximum sustainable level, not only to maintain the resource itself, but also the ecosystem of which it is part. Allowing natural ecosystems that have been damaged in the past to recover fully builds that system's resilience to future events.

Refugia in the form of protected areas are an excellent resilience-building mechanism for SIDS. Despite the obvious shortage of land area in many SIDS, their need to set areas aside is even more pressing than other countries'. Reserves help to attenuate diffuse pollution, preserve biodiversity and replenish the supply of organisms if those in surrounding areas become damaged or depleted (for example, marine reserves are said to improve fishing in non-reserve areas because they export adult and juvenile fish).

Multilateral and non-binding environmental agreements

Many SIDS are signatories to a large number of global and regional MEAs. Many of these remain poorly implemented in SIDS because of a lack of funding and capacity. MEAs cannot affect challenge 1 vulnerabilities, but can help to manage all other types of vulnerabilities and increase the environmental resilience of SIDS. Some of the more recent MEAs on biodiversity and climate change have been effective in developing appropriate environmental policies that operate to manage vulnerabilities generated inside and outside of a country (UNEP 1999c).

Many of the agreements have been effective in mobilising funding for increasing understanding within SIDS and, internationally, of the issues facing them. Although there are still many barriers to implementing MEAs in SIDS, it is clear that they are an important part of reducing vulnerability.

International assistance

All SIDS, as developing countries, receive some form of assistance from international and regional development organisations, donor governments, international development banks and non-government environmental organisations. There is a large potential within the relationship between SIDS and these organisations to examine and develop programs for addressing those aspects of vulnerability subject to action, and for general resilience building in country. All five types of vulnerability have at least some aspects that could be addressed by these relationships. For example, programs that focus on building the resilience of the natural environment and improving public awareness have the potential to reduce vulnerability to natural disasters. Vulnerability measures, such as the SOPAC EVI, would be valuable in this process because they would allow bilateral partners to identify the main environmental vulnerabilities within individual SIDS and act as an auditing mechanism, providing feedback between actions taken and results obtained.

Recommendations

It is clear that some of the environmental vulnerabilities of SIDS are intrinsic and cannot be influenced by human actions, while others could be managed at least in part by the SIDS' governments and people. Their burden of environmental vulnerability is, however, relatively greater than in other developing and developed countries because of their intrinsic characteristics. There is an urgent need to identify and measure all aspects of the special vulnerabilities of SIDS to ensure that development priorities and approaches are appropriate to the special conditions found there, and to ensure that these special vulnerabilities are taken into account in international processes (such as interventions).

It is therefore recommended that:

1. streamlined and permanent (periodic) mechanisms be established to collect environmental vulnerability data in all SIDS to form the basis of vulnerability management and resilience-building processes;
2. the EVI be completed as a mechanism for identifying and measuring environmental vulnerabilities in SIDS, and for monitoring changes in response to actions and over time;
3. mechanisms be established for taking SIDS' special vulnerability into account in regional and international processes, including adjustments and assistance as necessary;
4. the implications of SIDS' special vulnerability be re-examined in terms of sustainable development; and
5. public awareness and capacity be increased in SIDS in relation to the unique conditions of environmental vulnerability, and options for management and resilience building be discussed.

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