The Vulnerability of Small Island States to Sea Level Rise: The Need for Holistic Strategies

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There is uncertainty about climate change and its socioenvironmental implications, but the vulnerability of small island states to hazardous events is likely to become increasingly significant. It will not be a normally benign sea that rises but the incidence of storms and cyclones can be assumed to increase with tropical sea-surface temperatures. The proportional socioeconomic impact of tropical cyclone disasters makes these of crucial significance to small islands and small island states. Sea-defences are of little use (and may not be feasible at all) against the damage caused by tropical cyclones and some sea-surges. Social and economic adjustments are also required to parallel erosion control; and disaster preparedness "longstops" must be further developed as a matter of urgency. Apparently small measures must not be displaced by images of ultimate, massive catastrophe; adjustments may serve other functions in society as well. International and bilateral measures are required to take account of migration and "ecological refugees" and national administrations may require modification to take appropriate account of this most crucial of environmental phenomena.

INTRODUCTION

There is uncertainty about global-warming, climate-change and their implications. Temperatures have increased within living memory and cooled again (Golden, 1989). The same scientists who first predicted the "greenhouse effect"[1] are now more conservative about the consequences of its increase (Miller, 1989). "Best estimates" now are of a 1.1 to 1.9 °C global mean temperature rise and a 17 to 26 cm sea level rise before the year 2050 (Commonwealth Secretariat, 1989). These values are projected to rise steeply beyond that date to suggest sea levels much higher in the longer term.

In assuming that global temperatures and sea-levels are rising, I sympathise with the view of the Maldives Government that to wait for precise forecasts may hinder interim measures which could be crucial. Further, forecasts of an ultimately catastrophic rise in sea-levels should not be allowed to dominate thinking to the extent of disabling seemingly small counteractive measures.

Some small island states are essentially single islands (e.g. Barbados and Sri Lanka);

others are groups and archipelagoes of several islands (e.g. Tuvalu), hundreds (e.g. Tonga); or thousands, as in the Maldives. Some islands and groups of islands are mountainous (e.g. Dominica) and some may contain active volcanoes (e.g. Savo Solomons, Niua Fo'ou and Kao/Tonga). Many island groups comprise a variety of island types (e.g. The Cooks and Tonga). Others, for which sea-level rise is especially threatening, consist entirely of atolls and reef islands (e.g. Kiribati, The Maldives, Tokelau and Tuvalu).[2]

NATURAL HAZARDS AND THE VULNERABILITY OF ISLAND STATES

It is not simply that a benign sea will rise rather more quickly than it has done in the past. The first effects will be of sporadic and intermittent currents, tides and storms riding upon and within a raised sea. A rising sea level is a phenomenon of global warming which will also raise sea and air temperatures, the interaction of which can generate tropical cyclones. Thus global warming is likely to lead to an increased incidence of storms and tropical cyclones in some regions (Commonwealth Secretariat, 1989; Warwick, 1989). Small islands can easily be missed by tropical cyclones which proceed to inundate continental shorelines. The incidence may be no higher for island states (although some frequencies are impressive), but one tropical cyclone can entirely overwhelm one island state after another. The "natural disasters" of small states and small populations cannot compete in size with those of continental countries but it is the often overwhelming proportional impact of disasters in small states that gives reason for special concern.

Tropical cyclones have been the cause of most disasters leading to high proportional losses in the island-states. Hurricane "Bebe" (1972) seriously affected Tuvalu, Tonga and Niue, and 95 per cent of housing on Funafuti (Tuvalu) was destroyed (Gilbert and Ellice Island Colony, 1972). Hurricane "David" (1979) destroyed 80 per cent of Dominica's housing stock. Hurricane "Allen" (1980) caused very severe damage to Barbados, St. Vincent, St. Lucia, Jamaica, and the Cayman Islands (Lewis, 1980). Over one fifth of housing in Tonga was destroyed by Hurricane "Isaac" in March 1982, together with 90 per cent of coconuts, breadfruit and bananas, and half the yam and cassava crops (Lewis, 1982). One fifth of Jamaica's housing was destroyed by Hurricane "Gilbert" (1988) and 500,000 people were made homeless — almost one quarter of the national population. "Hugo" (1989) has done the same for Montserrat.

Most of these small states can expect to be in the path of a tropical cyclone perhaps two or three times a decade and often more frequently. Experience encourages an acceptance of sea hazards while lack of experience might actually raise perceptions of vulnerability. It might be that, had the Maldives been regularly affected by tropical cyclones, the flooding of 1987 would not have resulted in the historic 1989 conference on Sea Level Rise held at Male', Maldive Islands, in November 1989![3]

Tropical cyclones and accompanying sea-surges are, in addition to flooding, recurrent natural hazards which are liable to be exacerbated by a rise in sea levels. There is some value, however, in *not* separating these from other natural hazards — especially in small islands. Volcanic eruptions, earthquakes, and periods of drought will continue, regardless of global warming and sea-level rise. The incidence of these events must therefore continue to be taken into account when planning for vulnerability reduction and survival. The inter-relationships between one disaster and vulnerability to another often brings crucial consequences (Lewis, 1984a). Many island states are prone to a variety of hazards (see Tomblin, 1981, for earthquakes, volcanoes, and hurricanes in

the Caribbean). Tonga alone has earthquakes, floods, and droughts, as well as frequent severe hurricanes — and five active volcanoes, two of which are inhabited islands.

Sea-level rise will not only be reflected in the consequences of sea-related hazards, but will also increase social and economic vulnerability to other hazards. Measures to reduce social and economic vulnerability will be required. A healthy and self-reliant population, for example, is more likely to survive the effects of flooding or storm, and to proceed effectively with its rehabilitation than an unhealthy one.

COASTLINES AND THE EFFECTS OF RISING SEA-LEVELS

Vulnerability to the sea is a function of coastline length, but coastline length is not solely a function of island size. Long, narrow islands have more coastline to land area than round islands. Coastlines also change according to the level and behaviour of the sea. Extensive erosion is likely to be a more pervasive and permanent phenomenon as storm activity increases and sea levels rise (McLean, 1980b). Though coastlines are susceptible to hazard, they are also a source of food, transportation and often of sought after level land for agricultural and physical development. Increased development in coastal areas and increasing storminess and sea level will both exacerbate vulnerability until appropriate countermeasures are instituted.

Overall, the effects and consequences of rising sea levels are likely to be (Lewis, 1988a):

- reduced island size (due to sea encroachment and coastal erosion) leading to
- reduced shore length and changed shoreline;
- decreased ground water (lens) capacity (concomitant with reduced landform area);
- increased exposure of freshwater and vegetation to salination (due to wind-borne salt and sea water in porous ground);
- reduced food production (less land area and increased salination);
- increased incidence and penetration of tropical cyclones and sea-surges;
- more extensive and longer lasting food shortages;
- increased risk of malnutrition, environmental health hazards, epidemics (e.g. cholera, typhoid and schistosomiasis);
- movement of human settlements from coastlines (where possible);
- in-country migration from low to high islands (with consequent increases in the population density of high islands);
- in-country migration to urban centres (for the achievement of apparent security);
- emigration between countries from low islands to higher land;
- increased demand for emigration to continental countries and consequent "ecological refugees" (Tickell, 1989).

SEA DEFENCES

Case 1

Where urban land is intensively occupied for industrial or commercial purposes and land lease values reflect this use, foreshore construction of sea defences with some associated land reclamation may be cost effective. In Nuku'alofa, Tonga (Lewis, 1988b) estimated costs of sea defence construction amounted to T$7 million (US$5.9 million); minimum lease values gained came to T$16.5 million (US$9.1 million); and estimated losses without sea-defences, due to inundation in three representative areas of the capital (only) totalled T$23.5 million (US$19.9 million).[4] Occupying a low-lying promontory between the ocean and an inland lagoon, Nuku'alofa could be surrounded on three sides by sea-defences meeting the higher

ground on the fourth side on the western edge of the capital. There seems as yet to be no visible evidence of "flooding from within" by high tides percolating through porous rock. Most of the island of Tongatapu is raised hard limestone.

Some recent sea-defence construction and land reclamation has been completed on the ocean side, with German and Japanese aid, and in direct response to the flooding caused by Hurricane "Isaac" in 1982 (i.e. not to sea level rise projections). Nuku'alofa accommodates a fifth of Tonga's population, as well as being the seat of Government and of the Tongan Royal Family. Completed sea defence construction may impede future sea surges where they occur again at the same place, but will not entirely prevent inland flooding. National hurricane damage due to flooding would thus be only slightly reduced, and destruction, damage and injury wrought by high winds will be unaffected.

Case 2

Hurricane incidence for Tuvalu is much less than for Tonga; but in October 1972 (six years before independence) Hurricane "Bebe" and its associated sea-surge, riding on an exceptional spring tide, sent a series of waves up to 15 m high onto Funafuti and other islands. Virtually all houses were destroyed and government buildings were damaged beyond repair. Five people were killed and copra production fell by 80 per cent (Ball, 1973). An enormous ridge of coral-reef rubble appeared overnight, 19 km long and up to 4 m high, along the ocean-facing coastline of Funafuti and enclosed a new inland lagoon. As a consequence, the land area of Funafuti increased by 20 per cent (Baines and McLean, 1976). Similar banks appeared on other islands, notably Nukufetau.

The most significant sea-defences in Tuvalu are thus those created by the sea itself (additional smaller rubble banks resist erosion of precious landforms). The "hurricane bank" on Funafuti now protects Vaiaku and 2,750 people, one third of the national population (in 1972 it was 850), the seat of national government, communications facilities, and the only usable airstrip in the country (Lewis, 1988b).

The coastline of Funafuti is 54 km, but its land area is only 2.5 km^2 (McLean, 1980a). Similar ratios apply to all of seven other islands. So narrow is the land that there are few places where sea defences on one side would have anything to protect but the back of sea defences on the other side — especially after the ravages of the civil engineering process. Sea defence construction would only be feasible if the land itself were to be re-formed to create more cost-effective formations (i.e., nearer to the circular). Moreover, flooding by porosity would make necessary the raising of the land that the sea defences contained. Even if they were structurally practicable, technically possible, and economically feasible, they would make present day social and cultural life impossible and transform Tuvalu into "citadels-in-the sea" (Lewis, 1988b and 1989). Sea defences would effectively destroy what they set out to protect.

ADJUSTMENTS

The construction of sea defences is one kind of adjustment; another emphasises the rearrangement or alteration of human behaviour (Burton, Kates and White, 1968). Sea defences represent the engineering approach to hazards, but social and socio-economic adjustments must be incorporated as a part of all social and economic activities.

For most small states, rising sea levels will not create new conditions but exacerbate those which are already part of environmental experience. Flooding, coastal erosion, and tropical cyclones are not new phenomena, though their incidence is likely

to increase and larger numbers of people are likely to be affected. Their management will therefore require a review of existing adjustments and preparation for a formidable and pervasive range and incidence of environmental hazards. Hazard management must be made an integral part of administration in all sectors of government, not the exclusive domain of a separate department (UNDRO, 1987), and thereby absolving the others of their crucial responsibilities.

Adjustments to the foreseeable effects of rising sea levels require that the prediction of possible future catastrophe should not preclude seemingly minor measures taken in the face of interim real conditions. In other words, the view that, because it is all going to "sink below the sea", it is not worth doing anything, should be resisted. If it will not be until the end of the twenty-first century before a rise of 20–140 cm has been reached (UNEP, 1988), then there is at least a century in which to implement a wide variety of adjustments to seas at that level (Lewis, 1989).

Some adjustments will already have been made for reasons not yet related to sea-level rise. In Tuvalu, for example, where salination of pulaka pits (mulch beds) has been increasing the deterioration of taro crops, sweet potatoes have been introduced which can be grown hydroponically in coral sand at ground level, thus making them less vulnerable to salt water. Similarly, because of frequent flooding, regulations will shortly be introduced requiring the floors of new houses to be raised above ground level — a return to the traditional form and eminently appropriate where flood risk is on the increase.

Although the population of the Tongan capital of Nuku'alofa has increased, the population of many of the Tongan islands has decreased overall by 17 per cent in the last ten years. In these islands the estimate of land that will be lost to a 1.5 m sea level rise is only 5 per cent (Lewis, 1988b), albeit of the most occupied coastal areas. As migration is likely to continue, sea level rise will not contribute to an increase in population densities in most Tongan islands. Social adjustment in the islands has, in a sense, already begun, but urban social adjustments in the capital have yet to be instituted. Other small island states may be experiencing the same phenomenon.

In addition to adjustments involving agriculture and housing, those proposed for Tuvalu (Lewis, 1988b) include improved rainwater conservation and management, health and environmental health programmes, the filling in of World War II borrow pits (to remove a health hazard and to release more land), stabilisation of the natural hurricane bank and increased and improved measures for the prevention of coastal erosion, including the conservation of naturally protective features such as mangroves and reefs (Table 1). These adjustments would not only give protection against the initial impact of hazardous events but also reduce social and economic vulnerability to their effects. The maintenance of housing and other buildings is as important as (and contributes to) environmental health management. A well maintained building is less likely to sustain storm damage and to produce debris that can become a danger to people. Locally maintained water and food supplies are crucial for self reliant survival (Lewis, 1981). Issues of global warming give long awaited emphasis to the argument that hazards are a natural component of the environment and are better included as a part of, not separated from, environmental management. The extent and severity of "natural disasters" of whatever kind will be reduced and contained by the wide ranging adjustments that will ensue.

DISASTER PREPAREDNESS

The likelihood of an increase in the incidence and severity of tropical cyclones

TABLE 1
Examples of adjustments to sea-level rise and other hazards

Sector	*Measures*
Housing	— building form (e.g., raised floors)
	— construction quality and maintenance
Agriculture	— diversity and innovation
Water	— improved water conservation and management
Health	— environmental health programmes: (e.g., vermin and insect eradication; birth control)
Works	— coastal erosion protection; development planning and control
Environment	— conservation of naturally protective features (e.g., reefs and mangroves)
	— environmental impact assessments
Communications	— hazard and disaster warnings
Education	— schools programmes at all levels
Training	— public and government sector training and information programmes
Disaster preparedness	— forecasting; warning; organisation; plans and manuals; stockpiles; emergency funds
Evacuation management	— long term implementation of planning; funding; counselling; health; housing; employment

and increases in sea flooding demand, as a matter of urgency, overall upgrading of the effectiveness and scope of disaster preparedness programmes, as a component of "adjustments" (Table 1). Preparedness is concerned with forecasting and warning and with the organisation for and management of disasters. This includes the preparation of operational plans and manuals, the training of relief teams, the stockpiling of supplies, and the earmarking of necessary funds. Disaster preparedness measures are thus last in line, or longstops, in a necessarily holistic spectrum of measures to be implemented on account of rising seas and other hazards.

Currently, however, prepardeness measures are being implemented by individual departments of government (or by "non-government") in an uncoordinated way. This could result in other departments seeming to be absolved of their responsibilities with regard to hazards whereas, in reality, preparedness measures deployed by one agency are often directed at disasters which are in part the result of vulnerability brought about by the activities of other agencies of the same government.

The Brundtland Report (WCED, 1987) called for the environmental implications of development projects to be placed within the remit of sectors responsible for those projects. The same should be done for social and economic adjustments to environmental hazards. Sea-level rise and its attendant phenomena can no longer be regarded as an unlikely set of discrete events that might upset normal day to day

affairs. Sea-level rise brings with it a set of conditions so all-embracing that they must be considered normal (Hewitt, 1983). "Normal" however, has to be assessed not for an erroneously viewed homogeneous group of "small states" but by each small state according to its own characteristics, its own interpretations of hazardous uncertainty, and its own context of geographic, topographic, and cultural variety. Preparedness measures also require international and bilateral action to take account of migration and evacuation.

MIGRATION, EMIGRATION, AND EVACUATION

Inter-island migration within island states, and between islands of different island states, was traditional and normal up to the time of colonial administrations. Migration between the islands of Tuvalu continues on account of land and crop losses due to coastal erosion. Emigration is also traditional. There are many South Pacific island state communities in New Zealand and Tuvaluan communities in Fiji (e.g. in Suva and on the island of Kioa, owned by Vaitupu Island, Tuvalu). These pioneer emigrant communities have set cultural and social precedents for continued emigration, needed now to reduce population densities and to respond to the possible future implications of a rise in sea levels.

Emigration requires political acceptance, planning, funding, and administration to take account of services for counselling, health, housing, and employment (Table 1). On the other hand, evacuation is unlikely to be a realistic alternative. It is, in any case, an insensitive imposition on seemingly insignificant populations. There is ample evidence that many in the past have preferred to stay in (or have returned to) hazardous isolation, rather than face the unknowns of relocation (Bazin, 1970; Rogers, 1986).

DEVELOPMENT ASSISTANCE

Tuvalu receives development assistance from Canada, the EC, Germany (FRG), New Zealand, United Kingdom, and USA. The environmental and social dimensions of development take on an enhanced significance with regard to sea level rise and associated natural hazards, being required to support and to take comprehensive account of all adjustments (Table 1). The threat of rising sea levels requires a multisectoral and multidisciplinary approach. No single measure in any single sector or department can adequately respond. The hazards that rising sea levels imply have to be taken into account in all activities and deliberations. They cannot conveniently be allocated to special departments separated physically and administratively from everything else — because everything else is implicated. Hazards pervade all boundaries. Interrelationships count for more than the convenient separation of issues, sectors, or regions. Holistic and systemic, not reductionist, problem solving and management are required for this most crucial of environmental issues no less than for others (Lewis, 1987).

Notes

This article is a revised version of a paper presented at the Small States Conference on Sea Level Rise at Malé, Maldive Islands, in November 1989. It is partly based on my reports to the Commonwealth Expert Group on Climate Change and Sea Level Rise (Commonwealth Secretariat, 1989; Lewis, 1989a and 1989b).

1. A greenhouse is essentially a temporate zone glass construction to achieve longer growing seasons and/or higher temperatures for selected or delicate plants. Although atmospheric warming is a global phenomenon, the term 'greenhouse effect' appears not always to be understood in equatorial

climates. It is therefore not a term used hereafter in this article.

2. In addition to island states (and protectorates and dependencies) there are islands and island groups which are parts of continental states, such as the Lacadive, Nicobar and Andoman Islands (India) and Islands off Kenya, Malaysia, Sierra Leone and Tanzania.
3. See my report of this conference in *Disasters* 14:2, 1990.
4. The last calculation is based on Nunn (1988).

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