VULNERABILITY OF SMALL STATES TO SEA LEVEL RISE:
SEA-DEFENCE, ADJUSTMENT, AND PREPAREDNESS;
REQUIREMENTS FOR HOLISTIC NATIONAL
AND INTERNATIONAL STRATEGIES.

James Lewis
Datum International
Fellow in Development Studies
University of Bath
101 High Street Marshfield nr
Chippenham SN14 8LT
England UK
VULNERABILITY OF SMALL-ISLAND STATES TO SEA-LEVEL RISE.

Sea-defence, adjustment, and preparedness; Requirements for holistic national and international strategies

Summary

Uncertainty prevails regarding climate change and its implications, but within small-island states with wide ranging characteristics, social and economic vulnerability to the effects of hazardous events is likely to become increasingly important. It will not be a normally benign sea that rises, but incidence of storms and cyclones can be assumed to increase with tropical sea-surface temperatures. The proportional socio-economic impact of tropical cyclone disasters makes these of crucial significance to small and small-island states. Sea-defences do relatively little (and may not be feasible at all) relevant to the damage caused by tropical cyclones and some sea-surges. Social and economic adjustments are required to parallel technological measures; and disaster preparedness "longstops" must be further developed as a matter of urgency. Seemingly small measures must not be displaced by images of ultimate massive catastrophe. International and by-lateral measures are required to take account of migration and "ecological refugees". National administrative organisation may require modification to take appropriate account of this most crucial of environmental phenomena.

Uncertainty

Uncertainty prevails with regard to global-warming, climate-change and their implications. For example, since the field missions for the Commonwealth Secretariat were undertaken only a year ago, with a range of half-a-metre to one-and-a-half metres projected sea-level rise, projections are now less dramatic. Historical perspective reminds us that in any case, temperatures
have increased before - within living memory - and have cooled again (Golden: 1989). The scientist who first predicted the "greenhouse effect" (***) more than twenty years ago, is now more conservative about its implications (Miller: 1989). Uncertainty with regard to climate change and its implications calls for common sense applications of natural hazards research and management.

This paper takes as its basis an acceptance that global temperatures and sea-levels may be rising; and sympathises with the Maldives Government view that if we wait for precise forecasts, opportunity may be lost for the taking of timely measures which may be crucial. But further, if we allow forecasts and projections of an ultimate rise in sea-levels, however far away in time, to dominate with their image of catastrophe, we will be less able to bring ourselves to do anything about the interim now. We have to proceed with the matter in hand.

Island small-state variety

Characteristics of "small-island states" show more differences than similarities. Some are essentially single islands (Barbados; Sri Lanka); some are pairs of Islands (Malta; Western Samoa); and others are groups and archipelagoes of several islands (Tuvalu), hundreds of islands (Tonga); or thousands of islands as here in The Republic of the Maldives.

***
A greenhouse is essentially a temperate 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 be understood in equatorial climates. It is therefore not a term used hereafter in this paper.
Some groups of islands (Cooks) have less land area than even the smallest single islands (Niue). Most island states are multi-island; in some, component islands are spread over vast distances (Cooks, Tonga, Tuvalu), whereas others are more closely arranged (Seychelles; Solomons). Some island states may be close to continental neighbours (Maldives; Sri Lanka); others may be thousands of miles from the nearest continental capital (Western Samoa). Though the capitals of different island states may be separated by vast distances, their outlying islands may be close neighbours (Tonga\Fiji).

There are generally four types of island according to composition and origin (McLean 1980a). "Continental islands" are those that have separated from major continental land masses; "volcanic islands" are the tips of volcanoes built up from the ocean floor by volcanic action; "low coral islands or atolls" are coral reefs whose growth has kept them at the surface after the volcanoes upon which they were founded sank beneath the sea; and "elevated coral islands" are atolls or other coral reef structures that have been lifted above the ocean surface, leaving a hard limestone platform. (There are also intermediates between and combinations of these different island types). Some islands and groups of islands are mountainous (Dominica) and some may contain active volcanoes (Savo\Solomons; Niua Fo'ou and Kao\Tonga). Many
island groups comprise a variety of island types (Cooks; Tonga). A few island groups are entirely of atolls: Kiribati; The Maldives; Tokelau; and Tuvalu, for whom sea-level rise may be especially threatening.

In addition to "island states" (and protectorates and dependencies) are those islands and island groups which are a national part of continental states, such as the Lacadive, Nicobar, and Andoman Islands (India) and islands off Kenya, Malaysia, Sierra Leone and Tanzania, for example.

Natural hazards and island-state vulnerability

It will not be only a benign sea that, we are advised, will rise rather more quickly than it has done in the past. First effects of a rising sea will be sporadic and intermittent, caused by currents, tides and storms as each of these rides upon and within a sea which is higher. A raised sea level is a phenomena of global warming which will also raise sea and air temperature, the two energy sources of tropical cyclone generation (see Box No 1).

Small islands can easily be missed by tropical cyclones which proceed to inundate continental shorelines. Their incidence may be no higher for island states (though some frequencies are impressive), but one tropical cyclone might wholly subsume one island state after another — and we can watch on our television screens as it does so.
Tropical cyclones (hurricanes and typhoons) originate in the oceans where surface temperatures reach 26 degrees C (76 F) to supply an abundance of water vapour and where small areas of low atmospheric pressure may have formed. The warm sea provides the overlying atmosphere with a continuous supply of energy and moisture, first to generate a tropical cyclone and then to maintain its powerfully destructive potential. Often hundreds of kilometres in diameter, tropical cyclones follow accustomed tracks, travelling at an average speed of 15-25 kilometres per hour (Britton: 1985b). It has been unusual for tropical cyclones to affect latitudes within 15 degrees North and South.

Each tropical cyclone has its own characteristics, but those that contribute to destructive powers are: WINDS in excess of 63 kph circulating round a relatively calm eye, clockwise in the southern hemisphere and anti-clockwise in the northern hemisphere; SEA SURGE, a bulge in the sea surface caused by low atmospheric pressure. Cyclonic winds push the bulge ahead of the storm so powerfully that an opposing shoreline causes the sea to rise upwards and flood inland. Where this occurs at or near high tide, the sea surge will be most damaging. Some sea-surges may travel the length of a section of coast. The height of surges above high tide level, though often little more than a metre or so, may be a more serious 3-4 metres, while 7-8 metres may be reached in extreme cases (Oliver: 1985): HEAVY RAINFALL may cause flooding to inland areas.
In a world predisposed towards magnitude, small states and small populations have little chance to create "natural disasters" to compete in size with those which occur in continental countries. It is the often overwhelming proportional impact of disasters in small states that is reason for special concern.

Tropical cyclones have been the cause of disasters most responsible for high proportional losses in the island states. Hurricane "Bebe" in 1972 seriously affected Tuvalu, Tonga and Niue, and 95% of housing on Funafuti (Tuvalu) was destroyed (Gilbert Is: 1972). Hurricane "David" in 1979 destroyed 80% of Dominica's housing stock. Hurricane "Allen" in 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% of coconuts, breadfruit and bananas, and half the crops of yams and cassava (Lewis: 1982; see Box No 2). One fifth of Jamaica's housing was destroyed by Hurricane "Gilbert" in 1988 and 500,000 people were made homeless - almost one quarter of the national population.

Most of these (and some other) small states can expect to be in the path of a tropical cyclone perhaps two or three times a decade - but often more frequently. Experience encourages an acceptance of sea hazards where absence of experience might actually raise perceptions of vulnerability. It might be said
Box No 2

Hurricane "Isaac" in March 1982, wrought catastrophic damage to most of Tonga. Sustained wind speeds were 150 kph, gusting to 200 kph. Cocanut palms were blown over, broken, or stripped of their foliage. Twenty-two percent of housing was destroyed, the Ha'apai island sub-group being worst hit. On Tongatapu, the hurricane coincided with high tide, causing sea-flooding up to 300 metres inland of the northern shore and in the streets of the capital Nuku'alofa. Overall, there were six deaths and total damage assessed at US$20 million of which 40% was to building (Lewis: 1983a).

In the Ha'apai Island sub-group, all 20 houses on Matuku Island (population 150) were destroyed; 87% on 'O'ua and 74% on Mo'unga'one, all one-village islands. In half of the villages of the Ha'apai Group, the proportion of destroyed dwellings was over 70%. The sea swept over 'Uiha Island and through 'Uiha village, carrying with it, houses, animals, chickens, trees and debris and the island changed its shape. The Ha'apai Islands lost 72% of their housing stock (nearly three-quarters); the Vava'u Group lost 29% and Tongatapu 12.5%. A total of 3,044 houses were destroyed - 22% of the national total.

Sea-surge flooding at Nuku'alofa caused most severe damage in the area known as Sopu. Mostly at or below sea-level, the area was occupied by "spontaneous" settlers (from Ha'apai).
that were the Maldives regularly affected by tropical cyclones, the sea flooding which unusually occurred in 1987 would not have been the cause of the ripples that have resulted in this important conference!

Tropical cyclones and accompanying sea-surges are, in addition to flooding, most obviously the recurrent natural hazards to be exacerbated by a rise in sea levels. There is some value however, in not separating these from other natural hazards to which many island and small states are subject. Volcanic eruptions, earthquakes, and periods of drought will continue, in spite of if not because of global warming and sea-level rise. The incidence of these must continue to be taken into account within measures for vulnerability reduction and survival strategy. The interrelationships between one disaster and socioeconomic vulnerability to the next of the same or different "kind" are often of crucial consequence (Lewis: 1984a). Many island states are prone to a variety of hazards (eg Tomblin: 1981; for earthquakes, volcanoes, and hurricanes in the Caribbean). Tonga has earthquakes, floods, and droughts, as well as frequent severe hurricanes - and five active volcanoes, two of which are inhabited islands. From Western Samoa with volcano, earthquake and hurricane, there is one account of the latter two occurring at the same time! Sea-level rise will not only be reflected in the consequences of sea-related hazards, but socially and
economically the effects of all hazards in any small state will be compounded.

**Coastlines and the effects of rising sea-levels**

Unlike most continental countries, coastlines entirely surround islands and island states. Physical vulnerability to the sea is thus an expression of coastline extent. Coastline length is not solely a function of island size; "long-narrow" islands having more coastline to land area than "round" islands. Though coastlines are a source of hazard, they are also a source of food, transportation and often of preferred level land for agricultural and physical development. 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).

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

- Reduced island size (due to sea encroachment and to coastal erosion)
- Reduced shore length and changed shoreline (in consequence of the above)
- Decreased ground water (lens) capacity (Concomitant with reduced landform area)
Increased exposure of freshwater and vegetation to salination (wind-borne salt and sea water in porous ground)

- Reduced food production (less land area and increased salination)
- Increased incidence (atmospheric warming) and penetration of tropical cyclones and sea-surges
- More extensive and longer lasting food shortages
- Increased risk of malnutrition, environmental health hazards, and epidemics (cholera; typhoid; schistomiasis)
- Movement of human settlements from coastlines
- In-country migration from low to high islands (with consequent increases on high islands of population density)
- 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, C: 1989)

Sea defences

**EXAMPLE 1**

Where urban land is intensively occupied for industrial or commercial purposes and land lease values reflect this use, an example based upon Nuku'alofa, Tonga, (Lewis: 1988 (b) suggests that foreshore construction of sea defences, with some associated land reclamation, may be cost effective. Estimated costs of sea defence construction based on local examples amounted to T$7million (US$5.9million); minimum lease values gained came to
T$16.5 million (US$9.1 million); and estimated losses without
sea-defences, due to sea level rise inundation in three
representative areas of the capital (only) totalled T$23.5
million (US$19.9 million; this last calculation based on Nunn:
1988).

Occupying a low-lying promontory between the ocean and an inland
lagoon, Nuku'alofa is conveniently located to 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, under German and Japanese aid,
and in direct response to the flooding caused by Hurricane
"Isaac" in 1982 (ie 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 will thus be only slightly reduced, and destruction,
damage and injury wrought by high winds will be unaffected.
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 of up to 15 metres 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% (Ball: 1973). An enormous ridge of coral-reef rubble appeared overnight, 19 kilometres long and up to 4 metres high, along the ocean facing coastline of Funafuti and enclosed a new inland lagoon. One fifth additional land area was added to Funafuti (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 (other much smaller construction resists 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: 1988 (b)).

Tuvalu's landforms (see Box No 3) create extensive coastlines; although the land area of Funafuti is 2.5 square kilometres, its
The total land area of Tuvalu's nine islands is 25 square kilometres. Areas of each of the nine islands range between one and a half and five square kilometres. Tiny Niulakita (not permanently inhabited) is 41 hectares, less than half a square kilometre.

Nowhere do the Tuvalu's islands rise more than four and a half metres above mean sea level; most land being much lower. Records of recent high tides show parts of Funafuti to be prone to sea-flooding twice a year. These low atoll islands are entirely of porous coral rock; where inland they reach or are lower than sea level, sea water ponds and rises and falls with the tides. This is most evident in the extensive borrow pits which remain from World War II airfield construction.

Tiny though Tuvalu's island land areas are, most island landforms are divided again many times as the atoll rim dips below sea level and reappears forming even tinier motu, in many places no wider than roadway width. The lagoons that are surrounded by these islets may be up to twenty kilometres across - dividing and separating land and its communities whose fragile existence in a massive and powerful ocean is at once graphic and extraordinary.
The total shoreline length is about 54 kilometres (McLean 1980a). Similar ratios apply to all of seven other islands. So narrow is the land that there are few places where sea defences would have anything to protect but the back of sea defences on the other side – especially after the ravages of the construction process! Sea defence construction is only feasible if the land itself were to be reformed to create more cost effective formations (i.e., nearer circular). Moreover, porosity would make necessary the raising of land that sea defences contained. Sea defences would effectively destroy what they set out to protect. Even if structurally practicable, technically possible, and economically feasible, social and cultural life as it has been, would not be possible. Tiny, sensitive, and gentle Tuvalu would be transformed into "citadels-in-the-sea" (Lewis: 1988b \ Lewis: 1989).

Adjustment

The construction of sea defences would itself be one kind of adjustment; but "adjustments", in the now classical sense of natural hazards research (commenced a quarter of a century ago e.g., Burton, Kates and White: 1968), emphasises rearrangement or alteration in human behaviour, as distinct from manipulation or "protection" – seemingly enabling human activities to proceed as before (implied by "disaster prevention"). Sea defences represent the technological approach to hazards; but social adjustments
must be additionally and crucially incorporated as a part of all social and economic activities.

Sea level rise for most small states will not commence a new set of implications and discrete events separable from everything else; it will exacerbate conditions that are already apparent or which are already a 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. Management for each of these is not new, but overall, requires adjustment for such a formidable and pervasive range and incidence of environmental hazards. Hazards must come to be managed as an integral part of administration in all sectors of government, not made the exclusive domain of a separate department - absolving the others of their crucial responsibilities.

Sectoral adjustments directly related to foreseeable effects of rising sea levels require that the imagery of possible future catastrophe should not be made to preclude seemingly minor measures taken on behalf of interim real conditions. In other words, resist the view that because its all going to sink below the sea (uncertain), its not worth doing anything (hazards will continue in any case) ! If it is to be the end of the twenty-first century before a rise of 20 - 140 centimetres has been achieved (UNEP: 1988), then there is a hundred years at
least in which to implement a wide variety of adjustments to
seas\$ at that level (Lewis: 1989).

Some "adjustments" may already have been appropriately commenced
on account of perceptions not yet related to sea-level rise
scenarios. For example, in Tuvalu, 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 not so
immediately vulnerable to salt water. Similarly, because of
endemic flooding, new housing will shortly be required by
regulation to have its floor raised off ground level - a return
to the traditional form and eminently appropriate where flood
risk is on the increase.

In Tonga, although population in Nuku'alofa (the capital) has
increased, partly by the same process the population of many of
the Tongan islands has decreased overall by 17% in ten years.
Estimates of land to be lost to a maximum 1.5 metre sea level
rise (now regarded as greatly in excess of expectations) to the
year 2025, are estimated as only 5% (Lewis: 1988b) albeit of the
most occupied coastal areas. Especially as migration is likely to
continue, a rise in sea level is not going to increase at all the
population densities in most of the Tongan islands. Social
adjustment in the islands, in a sense, has already begun but
urban social adjustments in the capital remain a requirement of the policy makers. Other island group small states may be experiencing the same phenomenon.

In addition to those involving agriculture and housing (above), adjustments proposed for Tuvalu (Lewis: 1988b) include improved rainwater conservation and management; health and environmental health programmes; filling in of the 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).

Such adjustments serve not only to protect from initial impact of events (storms, hurricanes; flooding; etc), but to reduce social and economic vulnerability to the effects of hazardous events - which are likely to increase. A healthy population for example, is more likely to be self reliant, to survive flooding or storm, and to proceed with its rehabilitation more effectively than an unhealthy population. 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 less likely to produce debris that can become a danger to people. Locally maintained water and food
<table>
<thead>
<tr>
<th>Sector</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td>Building form eg raised floors; construction quality and maintenance</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Diversity and innovation</td>
</tr>
<tr>
<td>Water</td>
<td>Improved water conservation and management</td>
</tr>
<tr>
<td>Health</td>
<td>Environmental health programmes: eg vermin and insect eradication; birth control</td>
</tr>
<tr>
<td>Works</td>
<td>Coastal erosion protection; development planning and control</td>
</tr>
<tr>
<td>Environment</td>
<td>Conservation of naturally protective features eg: reefs and mangroves; environmental impact assessments</td>
</tr>
<tr>
<td>Communications</td>
<td>Hazard and disaster warnings</td>
</tr>
<tr>
<td>Education</td>
<td>Schools programmes at all levels</td>
</tr>
<tr>
<td>Training</td>
<td>Public and government sector training and information programmes</td>
</tr>
<tr>
<td>Disaster preparedness &amp; manuals; stockpiles; emergency funds</td>
<td>Forecasting; warning; organisation; plans; Long term implementation of planning, funding; counselling; health; housing; employment.</td>
</tr>
</tbody>
</table>
supplies are crucial for self reliant survival (Lewis: 1981). Issues of global warming give long awaited emphasis that natural hazards are environmental phenomena and are better included as a part of, not separated from, environmental strategies. The extent and severity of "natural disasters" of whatever kind will be reduced and contained by these and other crucial adjustments.

**Disaster preparedness**

Whilst *disaster prevention* is defined as "measures designed to prevent natural phenomena from causing or resulting in disaster or other related emergency situations", *disaster preparedness* is action designed to minimise loss of life and damage, and to organise and facilitate timely and effective rescue, relief and rehabilitation in cases of disaster (UNDRO c1976). Disaster preparedness is essentially for disasters that cannot be avoided and which are likely to happen, in spite of adjustments or measures implemented as disaster prevention.

Likelihood of an increase in the incidence and severity of tropical cyclones, and increases in sea flooding, demands as a matter of urgency, overall upgrading of the effectiveness and scope of disaster preparedness programmes, in addition to "adjustments" (Table 1). Preparedness is concerned with forecasting and warning, organisation for and management of disaster situations, including preparation of operational plans.
and manuals, 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 (Table 1).

Currently however, preparedness measures are being implemented nationally and locally largely by units, offices or "desks" separate and apart from other departments of government - or by "non-government". This may result in a perception of those other departments being absolved of their responsibilities with regard to hazards: nothing could be further from the reality because, in effect, preparedness measures by one hand are being directed at disasters which are in part the result of vulnerability brought about by activities perpetrated by another hand (of the same government!).

The Brundtland Report (WCED: 1987) called for environmental implications of development projects to be placed within the remit of sectors responsible for those projects; so it would best be for the social and economic adjustments to environmental hazards. Sea-level rise, and its attendant phenomena, suggest a measure of hazards that can no longer be contemplated as an unlikely set of discrete events that might upset normal day to
day affairs; sea-level rise brings a set of conditions so all embracing as to be the normal (Hewitt: 1983). "Normal" however, has to be assessed not for an erroneously homogenous group of "small states" - but by each small state according to its own characteristics and its own interpretations of hazardous uncertainty in its context of myriad geographic, topographic, and cultural variety (above).

Additionally, preparedness measures on account of sea level rise require international and bi-lateral expansion to take account of migration and evacuation.

Migration, emigration, and evacuation

Migration amongst islands 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 also in in Fiji for example - in Suva and on the island of Kioa which is owned by Vaitupu Island (Tuvalu). These pioneer emigrant communities could be regarded as the cultural and social base and precedents for continued emigration; now, to reduce pressure on already impressive
population densities, and for 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).

Development assistance

Tuvalu, for example, receives development assistance from the Canada, the EEC, Germany (FRG), New Zealand, United Kingdom, and USA. The environmental dimensions and implications of development assistance take on an enhanced significance with regard to sea level rise and associated natural hazards. Development assistance will be required to support and to take account of protective construction for sea defence and control of coastal erosion; adjustments in agriculture, housing, food and water supply, health and environmental health programmes; disaster preparedness projects to take account of communications and warning requirements; and training and education in all of these aspects to convey information, to assist understanding, and to develop practical skills.

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 our 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; inter-relationships count for more than convenient separation of issues, sectors, or regions; holistic and systemic, not reductionist problem solving and management are required for this most crucial, as with all other, environmental issues (Lewis: 1987).

REFERENCES

NOTE: This paper was written before the publication of the Report of the Commonwealth Expert Group on Climate Change and Sea level Rise: "Climate Change; Meeting the Challenge". Commonwealth Secretariat. September 1989.


Lewis, James: "The economic and social effects of natural disasters on the Least Developed and Developing Island Countries: with special reference to Antigua and Barbuda; Republic of Cape Verde; Comoros Federal Islamic Republic (and Mayotte); Republic of the Maldives; and Western Samoa. Report to UNCTAD IV, Belgrade. 1982. (UNCTAD\TD\B\961).


Tickell, Crispin (Sir): "Environmental refugees; the human impact of global climate change" The NERC Annual Lecture; June 1989.


Wells, Sue; Edwards, Alasdair: "Waving, not drowning? - sea-level rise and coral island nations" New Scientist (Forthcoming).