CARIBBEAN COASTAL AND MARINE TOURISM: COPING WITH CLIMATE CHANGE AND ITS ASSOCIATED EFFECTS

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Abstract: *Coastal and marine tourism in many parts of the Caribbean is a significant source of revenue and tourism is the leading economic sector as a whole. On the Caribbean islands, effectively all tourism development has occurred in the coastal areas, where the beaches are the principal attraction.*

Relatively few of the most intensively developed resorts have beaches broader than about 30 meters at high tide, and qualitative assessments show that most of the world's sandy shorelines are in retreat. This situation is likely to get worse, in part, because ocean level rise, a possible ancillary effect of climate change, has risen by about 15 cm (1/2 foot) during the past century. Both the increasing warming (about 0.5 ° C past 100 years), possibly due, in part, to the build up of anthropogenic trace gases in the atmosphere, and the increasing level of the seas are projected by computer modelers to increase over the next several decades. With this prognosis, several shore areas of the Caribbean may suffer increasing adverse effects, both to the environment and to the economy.

Tourism is a big business. The United States Department of Commerce reports that it is the fastest growing industry worldwide. They also predict that by the turn of the century tourism will likely be the world's number one industry. Already, however, coastal and marine tourism in many parts of the Caribbean is a significant source of revenue and is the leading economic sector in the Caribbean as a whole (UNIDO, 1987). Latest available estimates place annual revenues at $7.3 billion (Caribbean Tourism Organization, 1989; *Figure 1*). Throughout the Caribbean islands, effectively all tourism development has occurred in coastal nearshore areas, where the beaches are the principal attraction (Gable and Aubrey, 1990).

Research assessments indicate that about 70% of the world's sandy shorelines are experiencing erosion (Bird, 1985; Bird, 1987); this is particularly true for the Caribbean region where relatively few of the most intensively developed resorts (tourist facilities) have beaches broader than about 30 meters at high tide.

This data is important because of the current environmental hypothesis of global climate change, a premise that presents far-reaching, multi-disciplinary scientific challenges. While changes in climate are the norm, increasingly man has become an agent of that change. Consequently, environmental problems associated with the potential impact of climate changes are an important concern for governments and planners in the Caribbean region.

Projected changes in global and regional climate during the next 50 or so years are likely to be controlled by changes in the concentrations of radiatively active gasses such as carbon dioxide, methane, chlorofluorocarbons, tropospheric ozone and water vapor. These trace gases individually and collectively change the radiative balance of the atmosphere and may cause a rise in global mean surface air temperature by trapping more heat near the Earth's surface. As a consequence, climatologists generally agree that significant global warming is likely. Moreover, most climatologists are now convinced that the warming of the past century - about 0.5° C (Karl *et al.*, 1989) - is not the result of faulty interpretation of climate records such as the progressive warming due to urban growth (Kerr, 1989).

The concomitant global warming from anthropogenic trace gasses already disbursed in the atmosphere from man's industrialization and agricultural practices will likely mean significant, though uncertain, changes in regional climate. The major problem facing the marine and adjacent coastal areas will result from the additive effects of environmental modification associated with climate change coupled with current environmental stress.

The present and projected use of coastal and nearshore areas of the Caribbean region for economic development, tourism, fisheries and mariculture, waste disposal, mining of non-living resources, harbor development and municipal growth (USAID, 1987) highlights the urgency of adopting policies to deal with projected impacts resulting from climate change.

This paper reviews selected tourism-oriented economies, discusses coastal areas in the Caribbean already experiencing environmental degradation, and addresses the ramifications of anticipated climate changes on these and other areas in the Caribbean. What strategies (planning) ought to be taken, considering the magnitude of uncertainty that exists in the projections of global climate change, is also addressed.

Physical and Cultural Attributes

The Caribbean Sea, an arm of the Atlantic Ocean, is bounded by the West Indies on the north and east, South America on the south and the isthmus of Central America on the west. The Caribbean connects with the Gulf of Mexico to the northwest through the Yucatan Channel. It includes an area of 1,019,500 square miles. Several oceanographic and atmospheric currents pass through in an east-west direction. Contained within the "Caribbean region" is the largest concentration of small developing countries in the world (UNIDO, 1987). The "Caribbean Basin" is comprised of 33 countries (plus additional territories) within and around the Caribbean Sea (UNIDO, 1987), (see: *Tables 1* and *2*).

The Caribbean countries display diversity of character and form, though they collectively face similar (climate change) and inter-related (climate change and the nearshore environmental stress) problems. Their resource base - particularly for the island entities - is limited in scale and scope, yet some of the most productive and complex ecosystems found in the world exist in the Caribbean coastal zone (UNIDO, 1987; USAID, 1987).

The economic importance of coral reefs, beaches, seagrass beds, mangrove forests, and coastal estuarine ecosystems derives mostly from their linkage to other resources, especially coastal tourism and fisheries (USAID, 1987). These coastal and marine habitats contribute a large percentage of income, especially to the Greater and Lesser Antilles economies. Recent economic performance of many Caribbean countries depicts tourism, construction and agricultural production (bananas) as the leading sectors in gross domestic product (GDP), particularly in the smaller, less-developed economies in the region (UNIDO, 1987).

Culturally, the peoples of the Caribbean are a mix of African, Asian, European and Native American. *Tables 1* and *2* provide selected socioeconomic and demographic data concerning the island and continental countries and territories in the Caribbean Basin. Most of the smaller island states have economies that are based on tourism, including the distinctive micro-states of the British Virgin Islands, Cayman Islands, Anguilla, Montserrat and the Turks and Caicos. In addition, Antigua and Barbuda, the Bahamas, Barbados, the Netherlands Antilles and the United States Virgin Islands (USVI) among others rely heavily upon income from tourists. As a consequence, in some cases, the influx of tourists during the northern hemisphere winter season is large enough so that when averaged out tourists outnumber the year round residents. This situation could lead to a loss of indigenous cultural identity and may overshadow any monetary benefits (Bastin, 1984). Nevertheless, tourism and the needs of tourists has already led to the modification of the coastal and marine habitats and, when coupled with anticipated changes in climate, could present unfamiliar and costly problems.

Nature of Environmental Problems

Virtually all of the independent nations bordering the Caribbean Basin are developing countries. For many Caribbean countries and territories the major source of revenue is coastal/nearshore tourism. As a consequence of human economic activities (including tourism), degradation of the marine and coastal environment is being felt basin wide (Rodriguez, 1981; Goudie, 1987). Although problems associated with environmental degradation may be confined primarily to the coastal areas of most countries, their effects are more widespread due to patterns of water circulation, prevailing wind systems, nearshore bathymetry and terrestrial topography. Limits to how quickly natural ecosystems can respond to the combination of climatic changes when juxtaposed upon present environmental degradation is of especial concern (Gleick, 1989).

Mangroves are an important resource throughout the Caribbean because they aid in nutrient removal, control local mean water levels and flow direction, and act as sediment baffles, spawning grounds, nurseries and feeding habitats for traditional and commercially important finfish and crustaceans. The prevalent practice of mangrove 'clear cutting' and filling for land and fuel results in increased siltation and eliminates the shoreline stabilization these forests provide particularly during severe storms.

Other current environmental problems, particularly in the eastern Caribbean, include the use of coral reefs as a raw material for the making of cement and aggregate. Dredging for the construction of engineering works such as jetties, for example, as well as other developmental works has led to the destruction of some coral reefs. Moreover, the recent discovery of mass bleachings on Caribbean coral reefs may be related to global warming trends through higher seawater temperatures (Porter *et al.*, 1989) and may be an early indicator of climate change (Goreau, 1990). The general decaying of most of the coral reefs in the Caribbean Basin from over-fishing, pollution, sedimentation from nearshore erosion, and physical destruction due in part to the dragging of ship anchors and plundering for souvenirs - may have reduced the capacity of coral reefs to endure temperature changes (Bunkley-Williams and Williams, 1990). The additional

	Land Area (sq km)	Population (est.)	Per Capita Income $
Anguilla	91	7.019	1.914
Antigua and Barbuda	442	77.093	2.063
Aruba	193	64.418	N/A
Bahamas	13942	235.000	10.430
Barbados	431	254.000	4.925
Bonaire	288	11.000	6.390*
British Virgin Islands	153	12.000	6.246
Cayman Islands	260	22.000	18.200
Cuba	114.524	10.400.000	1.590
Curacao	444	147.000	6.390*
Dominica	751	81.200	1.265
Dominican Republic	48.442	6.720.000	455
Grenada	344	113.000	1.231
Guadeloupe, St. Martin & St. Barthelemy	1,780	336,538	4,170
Haiti	27.749	5.400.000	372
Jamaica	11.292	2.360.000	1.068
Martinique	1.080	333.275	3.670
Montserrat	102	13.000	4.030
Puerto Rico	8.897	3.380.000	5.299
St. Christopher and Nevis	269	44.600	1.930
St. Lucia	238	128.000	1.289
St. Maarten, Saba & St. Eustatius	68	27,680	6,600
St. Vincent & the Grenadines	389	134.000	840
Trinidad & Tobago	5.128	1.200.000	3.042
Turks & Caicos	430	12.000	1.680
U.S. Virgin Islands	342	106.000	7.811

Source: The World Bank Atlas, 1988.
UNIDO, 1987, World Almanac, 1989

* Netherlands Antilles

Table 1: Selected statistics on Caribbean island countries and territories.

	Land Area (sq km)	Population (est.)	Per Capita Income $
Belize	22.973	200.000	1.080
Colombia	1.138.914	30.600.000	1.430
Costa Rica	50.700	2.800.000	1.655
French Guiana	90.909	78.336	3.230
Guatemala	108.880	8.700.000	1.120
Guyana	214.970	750.000	557
Honduras	112.088	4.800.000	700
Mexico	1.978.800	83.500.000	1.950
Nicaragua	147.900	3.600.000	840
Panama	75.650	2.300.000	2.060
Suriname	142.709	400.000	2.920
Venezuela	912.050	18.760.000	658

Source: The World Bank Atlas, 1988.
UNIDO, 1987, World Almanac, 1989

Table 2: Selected statistics on Caribbean continental countries and territories.

stress of climate change presents a new dilemma for researchers and coastal zone managers. Additional problems include the use of fertilizers, pesticides and insecticides. The runoff from these chemicals into the marine environment poses serious threats. Organotins used in paints for yachts and other vessels presents a serious environmental threat to shellfish populations in coastal areas and may make their way into the food web through zooplankton and finfish posing a threat to man (Champ and Lowenstein, 1987).

Plastic debris in the Caribbean has been a recent environmental degradation. Wilber (1987) has found oceanically-derived plastic to be a common occurrence, particularly on the beaches in the Bahamas and the Antilles. Much of the plastic present in the marine environment is likely to be deposited on sandy shores (Wilber, 1987). In addition, floating tar and oil slicks, notably the recent spill into Christiansted Harbor on St. Croix, are fouling the Caribbean coasts and having a negative impact on tourism.

Increasing urbanization and industrialization are causing an increase in domestic sewage and industrial effluents, resulting in both direct and indirect impacts to adjacent marine waters (GESAMP, 1990; Capuzzo *et al.*, 1985). Because of poor or no sewage treatment plants, high counts of fecal coliform bacteria are often found on the beaches and adjacent waters, which, of course, has a negative impact on tourism. This problem is exacerbated by the continued promotion of tourism and the construction of expansive hotels behind the beaches. The carrying capacity for a particular area can be exceeded by untreated wastes from these hotels which creates serious and recurring health problems. Therein lies the quandary, where the undoing by tourism of the environmental quality that attracted visitors and the tourist industry is now an agent in the physical damaging of a location (Murphy, 1986). Therefore, proper planning for these facilities is critically important, particularly if development is to be sustainable.

The majority of Caribbean coastal lowlands and their adjacent coastlines presently experience extensive damage from erosion and inundation during storms. Most beaches exhibit signs of erosion mainly because of human social and economic activities such as the construction of jetties, groins and breakwaters that interfere with littoral processes. In addition, the removal of sand from beaches and streams for use as aggregate has caused considerable coastal erosion (Gable and Aubrey, 1990). Because of human activities, such as draining and reclamation, many natural coastal wetlands, marshes, lagoons and salinas have been permanently altered (adversely impacted). Add to these problems the potential rise in sea level and it becomes imperative to alter policies for sustainable tourism.

Enhanced relative sea-level changes (land subsidence) caused by underground fluid extraction, salinization of ground waters and deforestation are other basin-wide problems. While several of these environmental problems occur to varying degrees in some countries, they may not exist in detrimental form in others. In this review, however, differentiation has not been ventured. Environmental deterioration in developing countries in general however, continues at an ominous rate (Gleick, 1989). Moreover, because of present environmental stresses, the addition of another - climate change from global warming - is an unwelcome prospect.

Climatic Changes Due to Global Warming

Global change is caused by increased atmospheric trace gas loading from carbon dioxide, methane, nitrous oxide, tropospheric ozone, chlorofluorocarbons (freons), and water vapor, all of which absorb infrared radiation. Increases in these radiatively active atmospheric gases are due principally to their use in industrial developments such as refrigeration and air-conditioning, computer semiconductors and combustion of fossil fuels (Hall, 1989). Deforestation, however, contributes considerably to carbon dioxide buildup (Myers, 1988), and may even promote climate change (Repetto, 1990). The carbon dioxide buildup in the atmosphere increased from around 270-290 parts per million volume (ppmv) to about 355 ppmv - about a 20-25% expansion - from the turn of the century to the mid 1980's (Schneider, 1987). It has increased by more than nine percent during the last three decades (Rowland, 1988). The importance of these trace gases is related to their residence time in the atmosphere; many last for tens of years and their dispersal is global no matter where or what their source (Graedel, 1989).

Over the past century or so, the average global temperature rose by about 0.55° C, and the average and trend of temperature increase between 1958 and 1988 correlates closely with the growth in atmospheric carbon dioxide concentrations (Kuo *et al.*, 1990). If the buildup of these trace gases continues, a doubling of the concentrations of these "greenhouse" gases (relative to a pre-industrial atmosphere ca.1860) may occur as early as 2030 AD. This increase may produce a global rise of surface air temperature of 1.5° to 4° C (Sestini *et al.*, 1989). There is, however, a considerable lag time (generally 2 to 10 decades) before the warming appears, because of absorption of some of these gases into sinks such as the oceans (Cess, 1981; Bullister, 1989).

Forecasts of global climate changes are projected with General Circulation Models (GCM) using mathematical calculations and relationships. For tropical regions during the next century, extrapolated increases in mean temperatures on the order of 0.3° to 5.0° C are anticipated (Jaeger, 1988); however, the geographical distribution, magnitude or timing of the increases remain uncertain. The lack of resolution of climate changes on a regional scale - even for surface hydrology, precipitation, cloudiness and contemporary warming-precludes policy actions that would favor draconian measures at present.

Associated with the global temperature warming aspect of climate change are the secondary responses, altered precipitation patterns and increases in sea surface temperature - leading to changes in storminess, longshore winds, cloudiness and changes in relative sea levels (Maul, 1989). Aubrey *et al.*, (1988) have ascertained historical rates of relative sea-level in the Caribbean. Their results indicate that the rates of change over the past half century or so vary from an emergence (sea-level lowering) of 5.3 mm/yr to a submergence (sea-level rising) of 9.3 mm/yr throughout the Caribbean Basin. The recent global rate of sea-level rise, determined from tide gauge stations may exceed 2.0 mm/yr (Peltier and Tushingham, 1989), though for the past century it is generally believed to be 1 mm/yr to possibly 2 mm/yr (Wyrtki, 1990).

Other influences upon the coastal zone from climate change may be erosion, leading to shoreline retreat, tidal range alterations, leading to flooding and saltwater intrusion further inland, changes in ocean chemistry through ocean pH from atmospheric CO_2 doubling, and biological effects, leading to changes in species representation (biodiversity) and productivity in both marine and terrestrial ecobiomes (Viles, 1989).

Another omen for marine biological resources - shellfish and finfish especially - is the occurrence of ciguatera and red tides, both caused by toxic algae. These toxic organisms are known to cause illness and even death in humans. Apparent increases in red tides and toxic algal blooms may be linked to global change (Anderson, 1989). An increase in the occurrence of ciguatera or red tide as a possible secondary effect of climate change in coastal zones could have an economic impact especially through shellfish aquaculture and fisheries that are important in providing provisions for tourists (Shumway, 1989).

While increased temperatures may have ramifications for biological organisms, it is the associated effects of rising sea levels and increased storminess that are especially important to tourism activities in the Caribbean. Recently, some unusually powerful hurricanes and an increased number of tropical storms have been felt in the region (Lawrence and Gross, 1989; Case, 1990).

Impacts of Potential Climate Changes on Tourism

One of the fastest growing sectors of international trade, especially for small Caribbean countries and territories with limited alternative development opportunities, is tourism. Tourism in the Caribbean has been growing both in size (*Figures 2* and *3*) and complexity in an attempt to satisfy both the sophisticated international travellers and the mass marketing of the region (ECLAC, 1986).

More importantly, the link between environmental quality and tourism is evident, especially in the wider Caribbean, where the environment is the significant part of the product. The predominant product for tourism in this region is the attraction of beaches and the appealing climate (ECLAC, 1986; Gable and Aubrey, 1990). Moreover, while "beach tourism" has predominated in most Caribbean countries since the 1960's, the Caribbean Basin now competes worldwide for these types of tourists, with parts of the Mediterranean coast, Africa and other exotic locations such as the Maldives and Seychelles in the Indian Ocean and the islands of the South Pacific (ECLAC, 1986). Because of the global tourism market and its important contribution to the Caribbean economy, the effects of anticipated climate changes on Caribbean coastal zones should not be taken lightly.

Beach tourism has significant impacts on coastal zones. For example, construction accentuates and accelerates erosion by eliminating plant life which anchors sand dunes (ECLAC, 1986). In addition, coastal engineering works that once were envisioned as shoreline stabilizers, are now known to accelerate erosion downdrift as a result of improper planning (Walker, 1984).

Caribbean tourism, with its large dependence on sandy beach front locations, is especially susceptible to the consequences of a rising sea level - inundation, erosion, increased flooding and saltwater intrusion into aquifers (Blommestein and Singh, 1987). As beaches are the prominent attraction for tourists, the loss of sandy beaches from any cause will diminish carrying capacities and ultimately tourism earnings. Several locations throughout the Caribbean are already experiencing this problem (see Kohsiek *et al.*, 1987; Cambers, 1988).

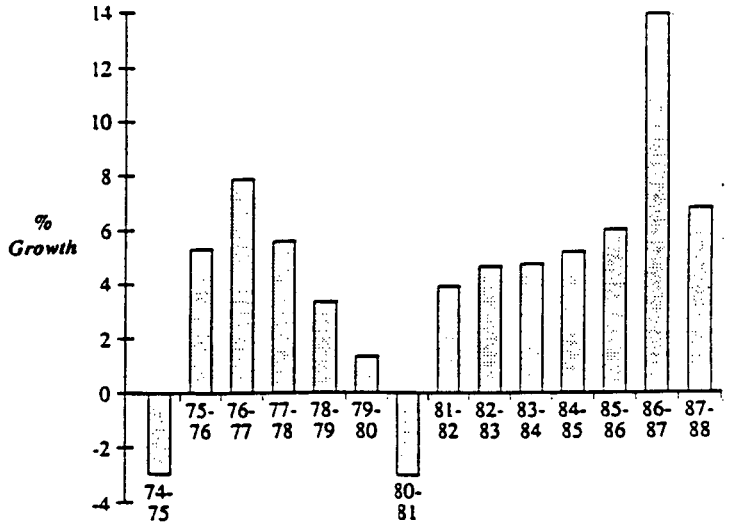


Figure 3: International tourist arrivals in the Caribbean 1974-1988, annual percentage change. The negative growth depicted is a result in part, of high interest rates on North American currencies and low exchange rates. (Caribbean Tourism Organization, 1989).

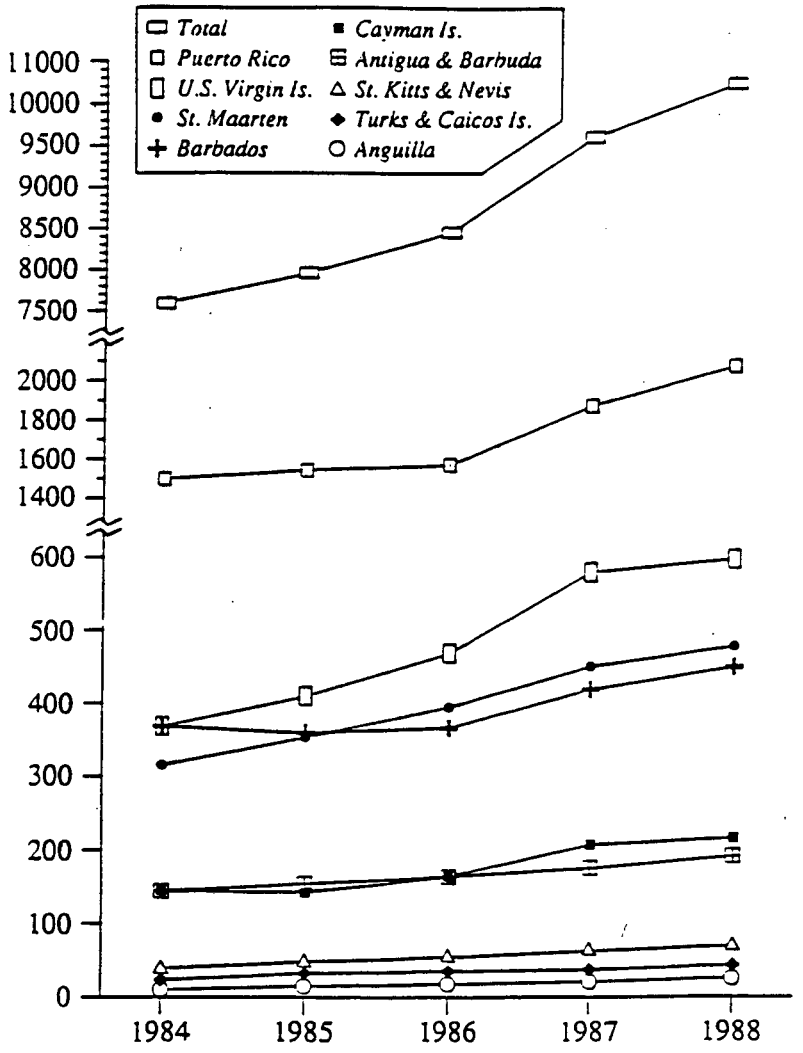
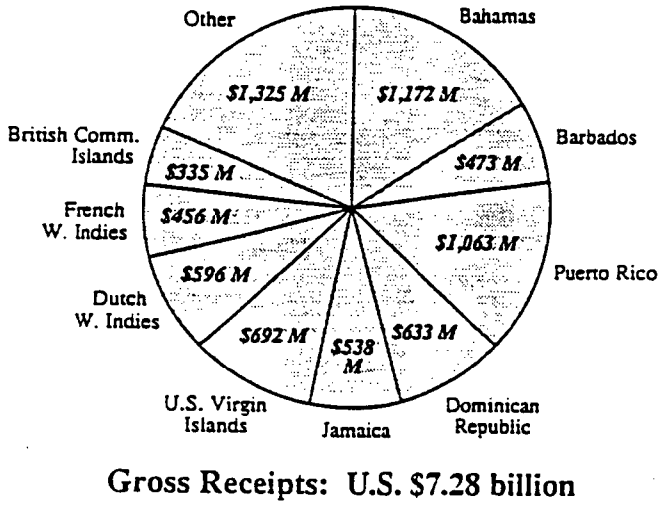


Figure 4: Stayover tourist arrivals in the Caribbean 1984-1988, selected countries. (Caribbean Tourism Organization, 1989)



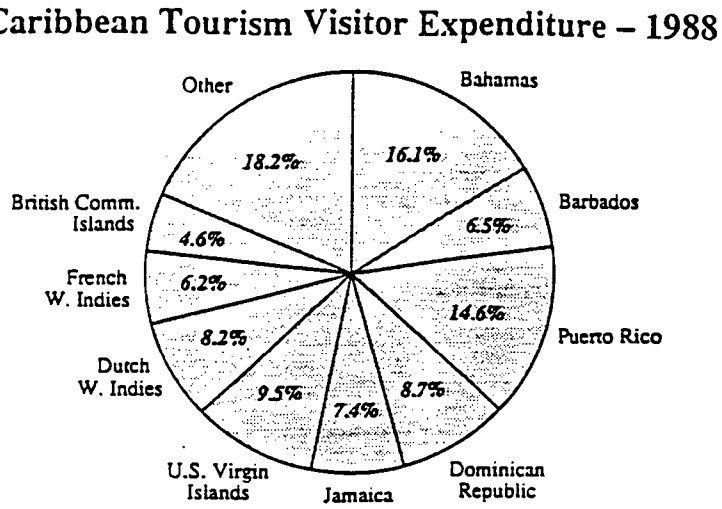


Figure 1: A snapshot of Caribbean tourism visitor expenditure for 1988 selected countries, percent of gross receipts and revenue. About 58% of the tourists in 1988 arrived from the U.S., Europe supplied just under 13%, while residents of Canada constituted 6.5% of arrivals. Intra Caribbean tourists made up a little over 9% of arrivals. Venezuela has been an important market for the southern Netherlands Antilles islands. (Caribbean Tourism Organization, 1989).

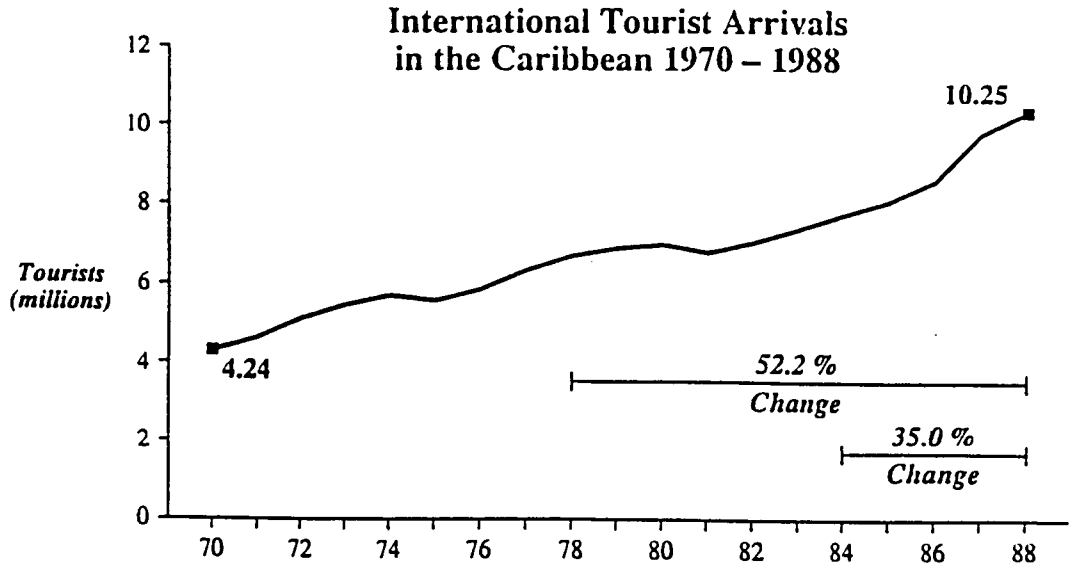


Figure 2: International tourist arrivals in the Caribbean 1970-1988. (Caribbean Tourism Organization, 1989).

Factors such as habitat destruction, coastal pollution and shoreline alteration when coupled with relative sea-level rise reinforce beach loss (Blommestein and Singh, 1987). Besides the aforementioned problems with beach loss, tourism may be impaired by climatic changes through impacts on hotels and similar facilities, marinas and infrastructure for cruiseship dockings, sewage outfalls and waste disposal sites, and the alteration or loss of natural ecosystem attractions such as coral reefs (Blommestein and Singh, 1987).

Socioeconomic impacts at both the local level (micro-economic) and the national level (macro-economic) will result from man-induced climate change (Maul, 1989). With one of the major economic activities in the wider Caribbean being tourism (*Figure 4*), negative impacts upon this sector will have detrimental reverberations for the prospect of sustainable development and economic growth, and perhaps for political stability. Already this sector provides over two million jobs basin wide and accounts for over half of Gross National Product (GNP) for some of the smaller nations (Beekhuis, 1981).

The tourism sector accounts for about 33% of GNP (*Figure 5*) and directly or indirectly for half of employment in the Bahamas (UNIDO, 1987). In the Netherlands Antilles, tourism is the second largest sector for employment and foreign exchange earner. For Antigua and Barbuda, tourism is directly or indirectly responsible for over 40% of GNP - the highest in the region - and employs greater than 50% of the labor force. This has resulted in the expansion of the construction industry for hotels and other tourism associated conveniences and industries. Tourism in Barbados has contributed to GNP by about the same amount that the manufacturing sector has, *i.e.,* roughly 10% over the past decade or so (UNIDO, 1987; Figure 6).

In the British Virgin Islands, the tourist sector depends primarily on the charter and maintenance of yachts, contributing more than 50% of GNP while providing employment for roughly 30% of the populace. The yachting activity has an associated focus of snorkeling around coral reefs - a habitat already adversely impacted from environmental stress. Similarly, other Caribbean micro-states rely heavily on tourism and its associated infrastructure developments (water desalination, roads, electricity, airport improvement, waste treatment), as for example the Cayman Islands. Here, hotel capacity has recently increased by 30% (UNIDO, 1987). In Montserrat, the economy is primarily dominated by tourism and related activities in real estate and construction.

Policy Responses

While further study (particularly through case examples) is necessary for analysis of climate changes and their direct and indirect effects on Caribbean coastal and marine tourism, governments do have some management and policy options to consider. Blommestein and Singh (1987) offer these policy options:

* promotion of alternative styles of tourism, thus reducing the primary dependence of Caribbean tourism on the beaches;

* restoration of beaches (sand replenishment);

* protection and provision of shoreline space for diverse ecobiomes such as mangroves, lagoons, coral reefs, seagrass beds, shrub vegetation;

* promote changes in insurance legislation whereby requiring building setback lines to be promulgated and properly placed depending on terrain and marine conditions;

* include conceptualized climate change scenarios (*e.g.,* sea-level rise) in the design of structures and engineering drawings;

* leave high risk areas fallow;

* *do nothing.*

Other ways to address the human and scientific aspects of global environmental change when coupled with present environmental stress can be considered. The adoption of comprehensive coastal zone management/planning schemes is one noteworthy example. A few of these planning texts have been implemented in the wider Caribbean (Gable, 1987; Sorensen and Brandani, 1987); however, they were promulgated because of crises that existed. Planning texts that foresee problems for a given locale and then provide mechanisms for mitigation specifically for those distressed areas would be a better approach. Because of the ramifications of potential climate change, environmental impact assessments should be performed when site analysis for tourism facilities are being planned, modified or modernized.

Based on knowledge of local response to the direct and indirect changes in climate along with the best available scientific findings on the magnitude and timing of human-altered climatic conditions, appropriate decisions can be arrived at concerning policy implementation. Though the uncertainties concerning the human-altered global climate change do not

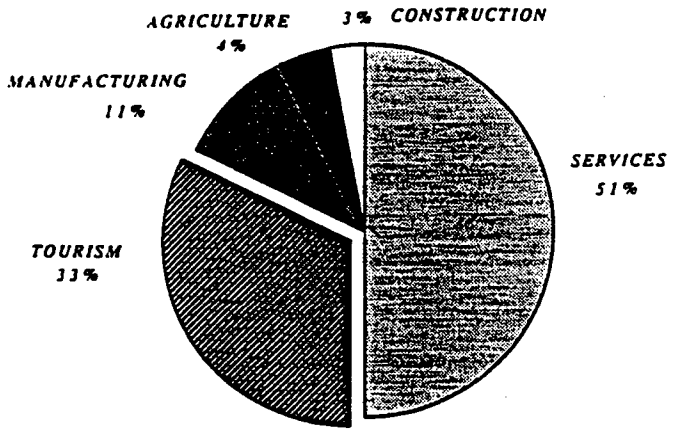


Figure 5: Bahamas gross domestic product by sector (1985), by percentage. (UNIDO, 1987)

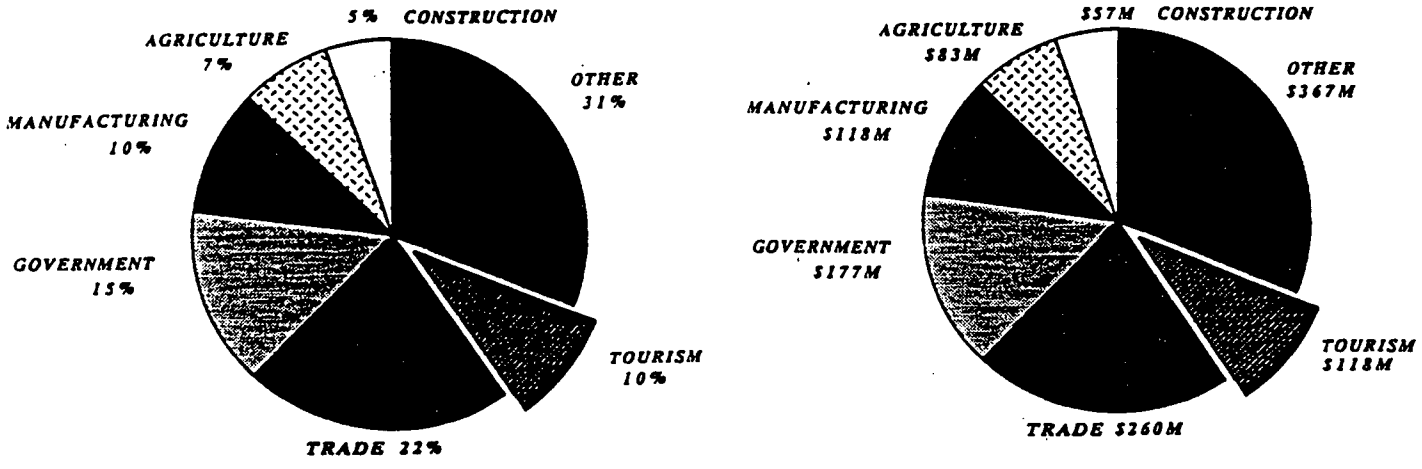


Figure 6: Barbados gross domestic product (GDP) by sector (1985), by percentage and by revenue. Total GDP, US $1,183.8 million (est.). (UNIDO,1987)

warrant draconian developmental and environmental regulations, global climate change demands increased consideration as part of the matrix of both environmental and economic issues (Gable and Aubrey, 1990).

The application of this thesis also poses similar consequences to other regions of the world, for example, Pacific archipelagoes. The managing of resources for economic development (tourism) in light of looming global climate change needs to be addressed and ascertained so proper policy responses can be formulated. It should also be noted that a generic response to climate change is not likely to succeed in foreseeing local environmental stress that is presently exhibited and the likely effects of climate change for those same areas. Further case work at specific sites concerning the linkages between environmental resources used for tourism (beaches; underwater parks) and how they may be affected by likely climatic changes (increased storminess; turbidity) needs to be conducted. Awareness of the interdependencies among nations and territories of the region in ecological, economic, social and technological terms, particularly with the likely advent of man-induced climate alterations, is vitally important. The indirect socioeconomic effects on tourism from pollution, coral reef mortality, loss of fisheries and storm damage already are considered important problems for Caribbean officials to deal with; man-induced climate change will likely become another.

Acknowledgments

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