Climate change and vulnerability: Responding to climate change impacts on the coastal urban corridor, Barbados.

Introduction: Barbados

The Barbados SIDS (Small Island Developing State) is the easternmost Caribbean island geographically located at 13º 4' North latitude and 59º 37' longitude (see Fig. 1). The island is predominantly flat and is bounded on its eastern coast by the Atlantic Ocean and on its western coast by the Caribbean Sea. The island's population is approximately 278,000 people. The majority of the island's total population, over 60%, is located in the three coastal parishes, St. James; St. Michael; and Christ Church, of the west and south coasts (GOB, 2001).

Figure 1 Showing a Map of Barbados

Source: http://sevenandseven.wordpress.com/2009/02/02/coastal-scenery-more-from-a-warm-climate-on-a-cold-day/

The Barbados landmass has an area of approximately 431 square kilometers bound by 92 kilometres of coastline comprising coral limestone cliffs, coral sand beaches, silica sand, sedimentary slopes and artificial man-made sea defences primarily on south and west coasts (Khan and Alleyne, 1996). The island is surrounded by two reef systems: near shore, inner/fringing reefs extending approximately 60m offshore, and the barrier/bank reefs lying about 100m offshore in deeper waters. Lying between these are several seagrass beds, providing a valuable habitat for marine life. Barbados' Exclusive Economic Zone (EEZ) is about 167, 000 square kilometres. Barbados' EEZ area versus its land area indicates, similar to most of the other Caribbean SIDS, a very small land- water ratio (United Nations Environment Programme (UNEP), 1999). Lewsey et al. (2004) notes the significance of this ratio in respect of the unique circulation pattern of the Caribbean Sea resulting in human impacts such as pollution and run off being concentrated in nearby coastal waters and having severe and cumulative negative effects on the entire coastal region. Specifically in Barbados, the marine influence is felt across the entire small island, for example, trees on Barbados' west coast show a wind trim architecture that is influenced by winds blowing off the east coast, and inland property shows the effects of airborne salt molecules, most likely blown by winds coming off the east coast, notes (Ramcharan, 2001). In respect of the foregoing Barbados could well be considered a coastal zone in its entirety.

This paper, using the Barbados Case study, firstly discusses the climate change threats to the urban coastal corridor and the urgency for reducing the vulnerability of this south- west urban region. Secondly, it reviews the existing linkages between predicted climate change impacts and the land use planning responses. Thirdly, the paper presents conclusions on state policy reforms, challenges in policy practice and general recommendations for integrating adaptation and mitigation responses into the land use planning as part of the Barbados sustainable development agenda.

Background: Climate change and sea level rise

Emissions of greenhouse gases (GHGs) have damagingly increased over the last two centuries as a result of certain economic activities and demographic growth. The increased concentration of GHGs as a result of human activities has enhanced the Earth's 'natural greenhouse effect' and has led to climatic variability and change. The Intergovernmental Panel on Climate Change (IPCC) noted the United Nations Framework Convention on Climate Change (UNFCCC) definition of climate change as a change in climate that is attributable directly or indirectly to human activity which alters atmospheric conditions (IPCC, 2001). There is still enormous uncertainty about the timing, severity and distribution of climate change impacts (Pittock et al., 2001). Climate change is expected to result in increased seasonal and inter- annual variability, as well as generating slow changes in mean conditions such as sea level, air temperature and precipitation rates; an increase in the frequency of extreme events; and possibly abrupt systems changes (Tompkins, 2005). These impacts can be devastating to SIDS which, although emitting less than 1% of global GHGs, have been recognized as particularly vulnerable to the impacts of climate change phenomena and are anticipated to suffer the greatest consequences of the effects of climate change (Mimura et al., 2007).

For SIDS, while their small land masses and geographical location already renders them prone to hydrometeorological disasters, their vulnerability to climate change phenomena is enhanced by various interconnected factors (Mimura et al. 2007). Among these factors which enhance their vulnerability are: relatively large populations with high growth rates and densities; poorly developed infrastructure and limited natural, human and economic resources; reliance on a limited resource base and subjection to external forces, such as changing terms of trade, economic liberalization and migration flows; and dependence on marine resources. Indeed, the unique constraints facing SIDS were forcefully recognized in AGENDA 21, as a special case for the environment and development (Toppin- Allahar, 2001). This perspective was further developed in the Programme of Action for the Sustainable Development of Small Island States, which noted that sustainable development in SIDS are ultimately dependent on the sustainable utilization of coastal and marine resources (Toppin- Allahar, 2001). As such, climate change impacts which leave coastal resources vulnerable are a serious threat for SIDS.

Following Clark (1977) the Caribbean is, by definition, a coastal region, a region where coastal resource management is critical to sustainable human development. Lewsey et al. (2004) note that few areas of the world are more vulnerable to climatic variability than the low- lying SIDS of the Eastern Caribbean. Environmental degradation in many Caribbean SIDS has led to an increase in the risks that climate change portends (Lewsey et al. 2004). Satterthwaite (1999) stated that in order to achieve sustainable development in Caribbean SIDS, long-term environmental stewardship of resources must be promoted. Indeed, the intimate interconnectedness between economic growth and ecosystems health within these small islands means that the high levels of uncertainty connected with climate change impacts could have significant consequences for both their economy and the environment (Pelling and Uitto, 2001).

Amongst the plethora impacts of climate change, sea level rise remains one of the most important effects for Caribbean SIDS (Lewsey et al., 2004). Maul (1993) estimated relative sea level to rise on average 2.8 to 5.0 mm/ year during the 1990s and projected a rise in sea level of 10 to 50 cm by 2025. While these estimates are conservative, Nicholls et al. (1999) estimate that in the event of a 38cm sea level rise from 1990 to 2080, the number of people likely to be flooded by storm surge in a typical year will increase five- fold, with people in low lying areas being most vulnerable. Nicholls (2002) goes on to suggest that population growth in the coastal zone is expected to exacerbate this problem. This estimation is of grave significance to the populations of Caribbean SIDS, where over 50% of the population is already concentrated within 1.5 km of the shore. Additionally, climate change scenarios project an increasing frequency and intensity of hurricanes and tropical storms, for the Caribbean region (Schleupner, 2008). Nurse et al. (2001) asserts that climate change can mean increased levels of coastal erosion, loss of land and property, dislocation of people, increased risk from storm surges, reduced resilience of coastal ecosystems, saltwater intrusion into freshwater resources and high resource costs to respond to and adapt to these changes.

Most island economies have become largely dependent on the tourism industry as an important source of income and foreign exchange. The Caribbean is the most tourism dependent region in the world (Tewarie, 1997) as well as the most tourism penetrated region (McElroy, 2002). As such, the IPCC suggests that most of the Caribbean SIDS face severe economic disruption from climate change and sea level rise (IPCC, 2001). According to Lewsey et al. (2004) the need to act decisively in protecting coastal zones must recognize the demands of the immense tourism industry, which is likely to remain central to Caribbean island economies. Following Lewsey et al. (2004) a key challenge to Caribbean SIDS is how to balance the immediate economic needs that the tourism industry fills while minimizing the environmental stresses that tourism has created and its resultant vulnerability to climate change.

Land use characteristics of the South- West Urban Coastal Corridor

Since the 1960s there has been increasing pressure for coastal development in the south and west coasts of Barbados. In response, the coastal land use pattern has changed from being primarily agricultural, and has gradually become increasingly residential, commercial or recreation-oriented (Khan and Alleyne, 1996). Within the south and west coastal regions development expanded significantly in a continuous coastal perimeter ribbon development with the four major towns, Oistins, Bridgetown, Holetown and Speightstown, acting as nodes to produce the south- west coastal urban corridor extending for the entire length of the west and south coasts. With few exceptions all of the main urban settlements in Barbados, including its capital, Bridgetown, are located within this coastal urban corridor (GOB, 2001).

As a result of population growth, high urbanization and a movement towards the coast urban sprawl has occurred along the coastal corridor. Cambers (2001) noted that in the 1950s and 1960s, the low south- west coastal area between the west coast highway and the sea was a swampy low-lying area with many ponds and mangroves. At that time the area was undesirable for settlement as persons avoided living in this area because of mosquitoes and the threat of flooding by the sea. As tourism rapidly from the 1960s to present-day this low lying area has become completely developed with houses, hotels, roads and other infrastructure. The corridor contains Barbados' most urbanized, highly desired and priced land which in 2004 was as much as US$263 per square metre in these prime coastal locations (Mycoo, 2006). The increasing unavailability of land leads to the exclusion of the poor from formal land markets and development of squatter settlements on the outskirts of the city characterised by the poor settling on marginal lands or vulnerable sites such as flood plains and coastal water courses. Around the capital of Bridgetown there exists much low income, 'slum' housing, which sits on low gradient coastal land, which forms part of the Constitution River catchment (GOB, 2001). Furthermore, there are now only a few vestiges of the original mangrove swamps remaining along the coastal corridor, notes Cambers (2001).

Major infrastructure and utilities development mirrors that of the population and is strung out along the south- west corridor. The two coastal highways that run out of Bridgetown, northward along the west coast, and towards the southeast, are the connective vein within the coastal urban corridor. These highways are between 100m and 1 km from the coastline (Cambers, 2001) and both are just above sea level, running essentially along the back beach routings. Even Barbados' only airport, the Sir Grantley Adams International Airport, is barely above sea level. There are also several water supply wells and mains along the south and west coasts and the Barbados Light & Power Company Limited, the sole electric utility on the island, has two of its main facilities on two sites, both of which are located near to the shoreline, on either side of Bridgetown.

The World Bank (1986) reported that the tourism industry was the largest employer and prime generator of foreign exchange for Barbados in the 1980s. In 1999, over 70% of Barbados' foreign exchange was earned by the tourism sector (Mycoo, 2006). To date the dynamic tourism industry remains Barbados' largest provider of jobs (GOB, 2001). The marine and coastal environment forms the backbone of Barbados' tourism industry (Khan and Alleyne, 1996). Beaches have considerable economic and environmental importance in Barbados. Use of Barbados' beaches has been valued at $24 million annually (Dharmaratne and Braithwaite, 1998). Beach based tourism is crucial to the economy of the island and accounts for more than half (56%) of export earnings, with annual visitor numbers exceeding the resident population by approximately two to one (McElroy, 2002). Mycoo (2006) notes that unsustainable tourism development has had negative impacts on Barbados' natural resources. These impacts include the removal of stabilizing coastal vegetation, the elimination of mangroves, coral reef destruction, unauthorized and poorly designed protection structures such as groynes and revetments, and the loss of habitat for endangered species. Coral reef decline is a major concern as reefs play an important role in the creation of beaches and are a major diving and snorkeling attraction. Destruction of coastal vegetation, mangroves and coral reefs triggered erosion on the west coast beaches, which were receding at 1.5 metres per decade notes Mycoo (2006). Furthermore, in Barbados, it is the individual landowner's responsibility to protect his or her property from the sea (Khan and Alleyne, 1996). According to Khan and Alleyne (1996) many people have unilaterally erected several man-made barriers, such as groynes or gabions (see Fig 2). In some instances these works have created an imbalance in the supply of sand on either side of the structure causing increased build-up and widening of the beach on one side, counteracted by the loss or retreat of the beach on the other. This, combined with waste water pollution has led to acute damage to the network of reefs, nearshore fisheries and the coastline (Khan and Alleyne, 1996). Growth in the tourist industry has left its impact on the environmental resource base, leading to increasing awareness of tourism as an environmentally-dependent industry and the maintenance of a healthy environment being a *sine qua non* for the sustainability of the industry in Barbados, asserts Khan and Alleyne (1996).

Figure 2 Showing coastal engineering to protects a restaurant and bar on the beachfront in Barbados

Source: Mycoo (2006)

Climate change and Vulnerability

Parry et al. (2007) indicated that vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change. Alternatively, according to Susman et al. (1983) vulnerability refers to the degree to which different classes within the society are differentially at risk, in terms of the probability of occurrence of an extreme physical event and the degree to which the community absorbs the effects of extreme physical events and helps different classes to recover from them. Following Tompkins (2005) vulnerability is generated by the combined effects of a society's exposure to hazards and the society's capacity to withstand those hazards and recover from any impacts. Schleupner (2007) indicates that a study by the World Bank criticizes the lack of adequate data to conduct vulnerability assessment in the Caribbean. In this light there is a necessity to develop alternative assessment methodologies and results in a lack of vulnerability studies where accurate data are missing (Klein and Nicholls, 1999). However, Schleupner (2007) asserts that accelerated sea level rise already affects the Caribbean coasts and there is a need to formulate risk and vulnerability assessment methodologies compatible with data available.
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The threat of sea level rise, and the other impacts it induces such as coastal erosion, inundation and saline intrusion, as well as the threat of the intensification of hydrometeorological hazards, have highlighted the vulnerability of the coastal corridor. Lewsey et al. (2004) noted that for each centimeter of sea level rise a shoreline retreat up to several metres horizontally could occur for Eastern Caribbean islands. Assessment of sea level rise scenarios in Barbados under the CPACC Project showed that a 1-metre rise could result in beach losses between 5 and 30 metres (GOB, 2001). Barbados is exposed to few natural hazards. Due to its location in the southern portion of the Caribbean, hurricanes are not a great threat. However, Barbados is brushed by a tropical depression, tropical storm or hurricane every 3.07 years. Hurricane Lily was the most recent; in September 2002 it passed to the south of the island blowing the roofs off some 135 houses. During the last century, Barbados has been hit by five systems, the most devastating being Hurricane Janet in 1955, which killed 35 people, destroyed 8,100 homes and left 20,000 homeless. Since then the country has counted 58 events of heavy rains, flooding, and wind. Two tropical systems, Hurricane Allen (1980) and a tropical wave (1995), cost the country over BDS $11 million.

Flooding from these events was also a major problem. Climate change projections which suggest an increase in rainfall intensity could have serious consequences for the island's economy (GOB, 2001). Flood hazard mapping by the Barbados Coastal Zone Management Unit (CZMU, 2009) indicates with the use of 1:100 year storm modeling that flood hazard damages could include some 6,000 residents along the west and south coasts and 70% of the west coasts hotels being flooded, amongst other damages. Due to its low elevation and low lying coastal plain, Barbados is classified as vulnerable to sea- level rise (Fish et al., 2008).

Figure 3Showing Flood Hazard Map for the Wider Bridgetown Area

Source: CZMU, 2009

Barbados Land Use Planning Policy

Barbados, like other English- speaking Caribbean nations, has legislation that deals with land use planning, based on British Town and Country Planning legislation. These enactments provide for the preparation of development plans, the implementation of such plans and their revision to ensure that they do not become obsolete. In addition, they provide for development control, via the grant or refusal of permission for development projects, in accordance with the prescriptions of land use plans (Toppin- Allahar, 2001). The Town and Country Planning (TCP) Act, forms the core legislation for physical planning in Barbados (Khan and Alleyne, 1996).

The development planning process in Barbados seeks to order, control and pattern land uses to ensure adequate site planning, environmental protection, overall economic efficiency in land use, aesthetic control, and conservation of the built heritage and safety in land use arrangements (Nurse and Blackett, 1990). This Act makes provision for an orderly and progressive development of land in both urban and rural areas, and preserves and improves the amenities. According to Khan and Alleyne (1996) the fundamental principle underlying physical planning in Barbados is to ensure that no development takes place without prior approval.

Coastal Zone Planning and Management

As a small island state, coastal zone management is crucial to Barbados surviving climate change impacts. Coastal zone management forms one aspect of development planning in Barbados, focusing on strategic development planning within the coastal environment (Khan and Alleyne, 1996). In 1983 the Government of Barbados established the coastal conservation project unit, as a problem solving activity in coastal conservation – the problem being beach erosion and within a wider context a rapidly developing coastal fringe (CZMU, 2009). The coastal conservation project unit later evolved into the CZMU. The CZMU, which was established in 1996, is the lead organization for coastal zone management in Barbados.

Integrated Coastal Zone Management in Barbados is supported by two key pieces of legislation: the Coastal Zone Management Act and the Marine Pollution Control Act. The Town and Country Planning Act supports these two acts. The Marine Pollution Control Act establishes the framework for pollution control in the marine environment and applies to most sources of marine-based and land-based pollution. The Coastal Zone Management Act of 1998 establishes the legal framework for coastal zone management in Barbados. The Coastal Zone Management Act requires the development of a Coastal Zone Management Plan (CZMP). Coastal development, requiring planning permission, is legally defined as the carrying out of any building, engineering, mining or other operations in, on, over and under any land, the making of any material change in the use of any building or other land or the subdivision of land. In the decision making process the Minister responsible for planning and the Chief Town Planner (CTP) are solely responsible for the granting or refusal of permission to develop lands in Barbados. The Minister makes decisions on all beachfront properties, whereas the Chief Town Planner makes decisions on all cliff top properties. The boundary for the CZM area, along the south and west coast, has been identified to be wide enough to influence the main activities and uses, which affect the coastal environment. On its landward extent the boundary is defined as the first coastal road or the limit of the predicted 100-year storm surge modeling or whichever is further inland (See Fig.3). Notably, the coastal road has been traditionally used as the boundary when considering coastal development applications by the Town and Country Planning Office. The seaward boundary is considered to be the 100m isobath or 200m seaward of the outer edge of the bank reef or whichever is further seaward (CZMU, 2009). However, while in principle policymakers agree that sustainable tourism has economic and environmental costs, Barbados has no legislative framework for requiring environmental impact assessments (EIAs) so these are done on an ad hoc basis at the discretionary request of the CTP (Mycoo, 2006).

Coastal setback distances have been used for decades as a regulatory measure for coastal development in Barbados. The CZMU setback criteria for coastal developments currently provide the most important policy regarding regulatory control of coastal infrastructure, within the context of the “precautionary approach” towards planning for coastal hazards. Coastal setback distance, defined as a prescribed distance to a coastal feature within which all or certain types of development are prohibited, is used to buffer zones between the ocean and coastal infrastructure, within which the beach zone may expand or contract naturally therefore eliminating the need for seawalls and other engineering structures that are sometimes used to reduce beach erosion. Setback distances from the coast also reduce threats to human safety and damage to beachfront property during high wave events such as hurricanes notes Mycoo (2006). Barbados’ Integrated Coastal Management Plan generally recommends a variable setback distance of 10 m from the toe of cliff undercut for cliff top developments and a setback of 30 m from the high water mark (HWM) for beachfront developments. Mycoo (2006) notes that the coastal setback distance of 30m from the HWM is relatively low given that tropical storms and hurricanes may cause waves to inundate coastal properties. From the perspective of developers' coastal setback stipulations utilizes a large amount of highly priced land. At the same time the government runs the risk of losing investments if prime beachfront property is not zoned for development. This scenario creates difficulty to operationalise environmentally sustainable coastal development and management, argues Mycoo (2006). However, Mycoo (2006) highlights that properties along the south and west coasts have complied with government regulations, despite developers' objections, because the CZMU has been strict in enforcing coastal setback distances required for new development, thereby safeguarding public health and safety.

Coastal zone management functions as a key dimension of environmental management. This is especially important for adapting to climate change where this concept refers to the management of human use of the environment in such a way that the greatest sustainable benefit can be derived (Khan and Alleyne, 1996). Caribbean SIDS have typically perceived development within the narrow context of economic growth, with the tendency to deal with major sectors in isolation, failing to recognize intersectoral linkages. In this vein, little progress has been made over time in explicitly integrating climate change issues and environmental dimension into the activities of sectoral ministries and private sector organizations.

Tourism Policy and Planning

Wilkinson (2002) found that while Barbados does not have a tourism plan or policy per se, the government has addressed tourism through national development plans and physical development plans. The 1988 National Development Plan paid particular attention to the problems of the tourism sector and gave priority to the prevention of beach erosion (Wilkinson, 1997). Mycoo (2006) identified that since the 1980s several policies have been developed to tackle the environmental problems relevant to tourism development and climate change. Presently, Barbados' general policy is that erosion- prone lands are not approved for built development. In instances where development is permitted, the Town and Country Planning Department uses the tree Preservation Act to limit soil erosion. Additionally, for building and engineering operations a sediment control and management plan must be submitted.

Infrastructure standards are also promoted to reduce coastal pollution and minimize energy consumption. The Town and Country Planning Department's pollution regulation states that no outfall should be built that allows wastewater to enter coastal waters directly, without at least primary level treatment. Prompted by evidence of coral decline related to coastal water pollution from sewage Barbados policymakers constructed a central sewerage system on the south coast which is to be later replicated on the west coast. Bridgetown has also been centrally sewered (Mycoo, 2006). Moreover, Barbados has adopted an incentive approach, using market instruments to achieve sustainable tourism practices. The Tourism Development Act 2002, provides that an operator who incurs expenditure in improving the wastewater disposal system be allowed a tax credit of 20% of the capital cost of fittings, pipes and pumps used in the improvement of the wastewater system. Additionally, the Town and Country Planning department offers an advisory role on the use of renewable energy resources. Today there are over 35, 000 solar water heaters (SWHs) installed in Barbados. This figure corresponds to about one in every three households (Langniss and Ince, 2004). SWHs are also widely used in the hotel industry. According to (Langniss and Ince, 2004) each unit save about 4, 000kWh per year which is a cumulative energy saving of 140 million kWH. This in turn is the heating equivalent of about 227, 000 barrels of oil. The use of SWHs reduces a substantial quantity of GHG emissions. While it is not mandatory under existing planning regulations to build structures or use fittings that promote energy savings (Mycoo, 2006), the SWH industry has benefited from the Fiscal Incentive Act of 1974, which provides import preferences and tax holidays. In addition, a 30% consumption tax on electric water heaters helped to make SWH competitive in Barbados (Ince, 1999).

Conclusion

The west and south coasts of Barbados typifies the conditions which enhance vulnerability to climate change in Caribbean SIDS. Cambers (2001) argued that population growth, high urbanization and migration towards the urban coastal corridor have increased the vulnerability of these coasts. Lewsey et al. (2004) indicate that to reduce vulnerability and the potential impacts of the interconnected forces of: climate change; increasing human coastal settlements; damaging coastal activities; deficient urban planning (top- down decision making process); and destruction of coastal resources, a land use planning approach must be adopted.

In response to this vulnerability ICZM has emerged the preferred option for adaptation in Barbados (GOB, 2001). The extent to which the south west coastline will be affected by sea level rise is strongly determined by local physical, biological and socio economic conditions. The scope for beaches to adjust to sea level rise will depend on the land use behind the beach (Fish et al., 2008). Fish et al. (2008) insisted that setback regulations provide a pre emptive retreat strategy and within a survey of 33 Caribbean islands the most common setback distance was 30 m, the same as for Barbados. Wason and Nurse (1994) suggest the use of variations in setbacks based on the slope of the land and determination of the highest contour normally reached by high seas.

McElroy (2002) notes that there has been a history of environmental neglect within Caribbean SIDS. Since the 1980s several policies have been developed to tackle environmental problems and vulnerabilities in Barbados but there remains a need for policies to be more anticipatory instead of simply reactionary (Khan and Alleyne, 1996), especially in relation to climate change and sea level rise. Furthermore, Barbados requires that a specific legislative mandate and managerial initiative be directed towards the use of EIAs as an analytical tool.

Any attempt to predict the response of Barbados' coasts to climate change and sea level rise is subject to uncertainty (Fish et al., 2008). Following Tompkins (2005), that does not mean that no anticipatory adaptation can be undertaken towards planning for climate change in Caribbean SIDS. In those SIDS which are already operating at the limits of sustainability there is clear justification to begin taking adaptive responses to climate change (Changnon et al., 2000). Thus, Barbados's approach to coastal zone management signals a useful precedent for consideration by other Caribbean SIDS for addressing the myriad issues at play in adaptation to climate change. If supporting legislation and regulations are in place and the organizational arrangements are resolved, broader networks can emerge to support more integrated institutional arrangements for climate change land use planning responses (Tompkins, 2005).

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