

**Water, Water Everywhere: Sea Level Rise and Land Use Planning in Barbados,
Trinidad and Tobago, Guyana, and Pará**

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**Lincoln Institute of Land Policy
Working Paper**

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Lincoln Institute Product Code: WP13TB1

Abstract

The Caribbean and northern coastal Brazil face severe impacts from climate change, particularly from sea-level rise. This paper analyses current land use and development policies in three Caribbean locations and one at the mouth of the Amazon River to determine if these policies are sufficient to protect economic, natural, and population resources based on current projections of urbanization and sea-level rise. Where policies are not deemed sufficient, the authors will address the question of how land use and infrastructure policies could be adjusted to most cost-effectively mitigate the negative impacts of climate change on the economies and urban populations.

Keywords: sea-level rise, land use planning, coastal development, Barbados, Trinidad and Tobago, Guyana, Pará, Brazil

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Water, Water Everywhere: Sea Level Rise and Land Use Planning in Barbados, Trinidad and Tobago, Guyana, and Pará

Introduction

Even though the details are under dispute, the resounding fact is that climate change is a reality. As illustrated in several reports by the Intergovernmental Panel on Climate Change (1990, 1995, 2001, 2007), the overwhelming majority of scientists agree that human consumption habits and activities exacerbate the series of natural phenomena that suggest alterations to global temperatures, frequency of storm systems, and other weather events. While the causes of these changes are still intensely debated in the political sphere, the impact of one such climate change result, rising sea levels and coastal erosion around the world is beyond debate. Because sea-level rise (SLR), defined as a mean increase in global sea level measures, is a relatively newly scrutinized phenomenon, monitoring it involves complicated measurements that are difficult to discern, especially when coupled with a lack of historic data resulting in a large range in predictions for how much the sea will actually rise in the future (Miller, 2012). In addition, these other studies on SLR tend to be at the global scale and highly scientific (Nicholls & Cazenave, 2010; Merrifield, et al, 2009; Dasgupta et al, 2009; Rahmstorf, 2006; Church & White, 2006; Cabanes et al, 2001; Douglas, 1991). There is a lack of studies that take into account the policy responses that are pushed through by governments to protect human settlements and economic resources.

This paper delves into SLR and the policy frameworks and physical interventions that governments have implemented to protect the human geography and economic vitality of four locations: Barbados, Guyana, Trinidad and Tobago, and the Brazilian state of Pará, all of which are part of the Greater Caribbean. This region is primarily composed of members of the Small Island Developing States (SIDS), a network of low-income countries that are physically and economically vulnerable to global climate changes and SLR (Pelling and Uitto, 2001). Three of the four sites (Barbados, Guyana, and Trinidad and Tobago) are members of the Caribbean Community (CARICOM)¹, and the two of the four sites (Guyana and Pará, through parent country Brazil) are members of the Amazonian Cooperative Treaty Organization (ACTO). CARICOM and ACTO are deeply concerned about the potential impacts of climate change. For example, “the estimated total annual impact of potential climate change on all CARICOM countries is estimated at US\$9.9 billion in 2007 US\$ prices or about 11.3 percent of the total annual Gross Domestic Product (GDP) of all 20 CARICOM countries (Member States and Associate Member States) according to the World Bank estimates” (Liliendaal Declaration, 2009). Such an estimate clearly illustrates the high fiscal stakes for an already fragile economy like the Caribbean, with a risk over one-tenth of the CARICOM economy. ACTO, for its part,

¹ CARICOM is a super-national, political, and economic union for the Caribbean region, which seeks to prove leadership and service in partnership with the union’s institutions founded in 1973, but stems from past regional federations and free trade agreements. The current members of CARICOM are Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago. The CARICOM Secretariat is in Georgetown, Guyana.

has placed climate change at the top of its regional agenda in recent years by promoting and attending major regional workshops and conferences (ACTO 2007a, 2007b).

Figure 1: Geographical Location of Sites



Map: Thomas Bassett

Table 1: Background for Four Study Sites

	Area	Population	GDP	GDP Per Capita	Percent Urban	Local Government	Coastal Economic Activity
Barbados	430 km ²	287,783	US\$6.576B	US\$23,700	44%	Parishes (10)	Tourism
Trinidad & Tobago	5,128 km ²	1,226,383	US\$26.88B	US\$20,300	14%	Regions (9), Boroughs (3), Cities (2), Wards (1)	Hydrocarbon production
Guyana	214,969 km ²	741,908	US\$5.857B	US\$7,600	29%	Regions (10)	Agriculture
Pará	1,247,950 km ²	7,581,051	US\$21.69B	US\$3,050	N/A	Municipalities (144)	Fishing

Source: CIA World Factbook, 2012 and IBGE, 2012)

The economic profiles of the study sites are diverse. Trinidad and Tobago has extensive oil and gas industry, Barbados is focused on tourism, Guyana's coast is primarily agricultural, and Pará's coast is prime for fishing and crabbing. Land use and infrastructure policies are thus designed or should be designed to protect these major economic interests in addition to major population centers, which are coastally oriented. This study can be applied to other cities and regions with similar economic concerns and geographic conditions. Vulnerable low-lying coastal areas and small island nations are found throughout the world.

There is limited research dedicated to the specific topic of land-use policies designed for SLR; even further, comparative studies are either on a global scale or focused on two geographical sites (Pomeroy et al, 2004). Other works study SLR on a larger scale, sometimes global, other times on a regional scale, not specifically addressing the individual nations (Lewsey et al, 2004). There are many papers that look individually at one of this study's four sites, but these still are overwhelmingly slanted towards empirical scientific data, and some are not current (Szlafsztein, 2012; Szlafsztein & Sterr, 2007; Dalrymple & Pulwarty, 2006; Belle and Bramwell, 2005; Pielke, et al., 2002; Pelling, 1999; Singh, 1997; Lakhani, 1994; Daniel, 1988). This paper specifically focuses on the four sites and their adaptation measures. These sites are experiencing the greatest impacts of climate change through SLR, despite not being main contributors to climate change. Developed nations are in fact the main contributor to climate change, and the only choice for this region is to adapt to the predicted future that they themselves cannot control (Barnwell, 2012). By analyzing the policies and physical interventions pursued by the local and national governments of the study sites, the authors will highlight the balance of accomplishments and future efforts to be undertaken in a still-developing region of the world that faces institutional, governance, and organizational capacity challenges. The major finding of this research effort is that although sea-level rise is generally on the planning and land-use agenda, there is a need for more capacity and funding in this particular region of the world to support comprehensive coastal zone management planning and the necessary infrastructure to protect vulnerable coastlines. At present, consequently, existing efforts are patched together from whatever resources are available. With the exception of regional model Barbados, it is largely

donor agencies or development banks (Guyana), a distant national government (Pará), or the state-owned representative of a private sector interest (Trinidad and Tobago) that leads planning and adaptation on this vital topic.

One area of this study, which plagues most SLR research, is the issue of a common understanding and use of terminology. Risk and vulnerability are terms used to assess the situation of a place in relation to SLR, and more broadly to environmental impacts. Major institutions such as the United Nations have moved towards a vulnerability-based approach of presenting the existing condition that is susceptible to an event. The risk-based approach focuses on the event that will impact the existing condition. Both approaches are speaking to the same problem and looking for solutions, but use different mechanisms to explain the situation (Brooks, 2003). Most simply, risk is geared to highlighting those factors that are relatively out of control of humans such as weather events, while vulnerability identifies those actions that humans can take towards preparing themselves against disaster.²

Methodology

The research team approached this project through a comprehensive planning framework, focusing specifically on the degree to which policies in the site areas addressed not just a narrow physical or social concern, but sought to treat the challenge of SLR in the coastal zone in the broadest way possible. Specifically, they considered the framework of integrated coastal zone management (ICZM), the international standard for sustainable development in coastal areas and the basis for scientifically grounded, comprehensive, effective legislation in North America and Europe (European Parliament, 2002; Eremina & Stetsko, 2007; Dahl et al 2009). “ICZM is a continuous, adaptive, day-to-day process which consists of a set of tasks, typically carried out by several or many public and private entities. The tasks together produce a mix of products and services from the available coastal resources. ICZM involves continuous interaction between human systems and natural systems, among human systems, and among natural systems, as these systems ‘coevolve’ over time.” (Bower and Turner, 1996; Szlafsztein & Sterr, 2007) The team used analytical skills to judge the relative effectiveness of policies given the political, economic, natural, and social conditions they encountered through literature review, interviews, and site visits. In addition, the team sought, wherever possible, to acquire quantitative data on a number of topics, including land-use patterns, human settlements, economic activity, and SLR projections in the coastal zones of the four sites.

In addition to performing a comprehensive literature review, the research team conducted fieldwork through interviews and site visits, abetted by the American Planning Association’s extensive set of contacts in the region. The team focused on academics, policymakers, public officials, and planning professionals involved in the issue of SLR and land-use planning. They conducted six interviews in Barbados, six in Trinidad and Tobago, seven in Guyana, and three in Pará. They performed five site visits in Barbados, six in Trinidad and Tobago, three in Guyana, and three in Pará.

² Of course, human existence has had an impact on the global climate as a whole, but individual weather events are mostly viewed as outside of human control.

Finally, the research team conducted extensive follow-up correspondence to corroborate site visits with expert opinions and to retrieve further items in the academic and public literature on these topics. They read academic journals, local newspaper articles, development bank reports, and international fact books to gather relevant information for this paper.³

Barbados

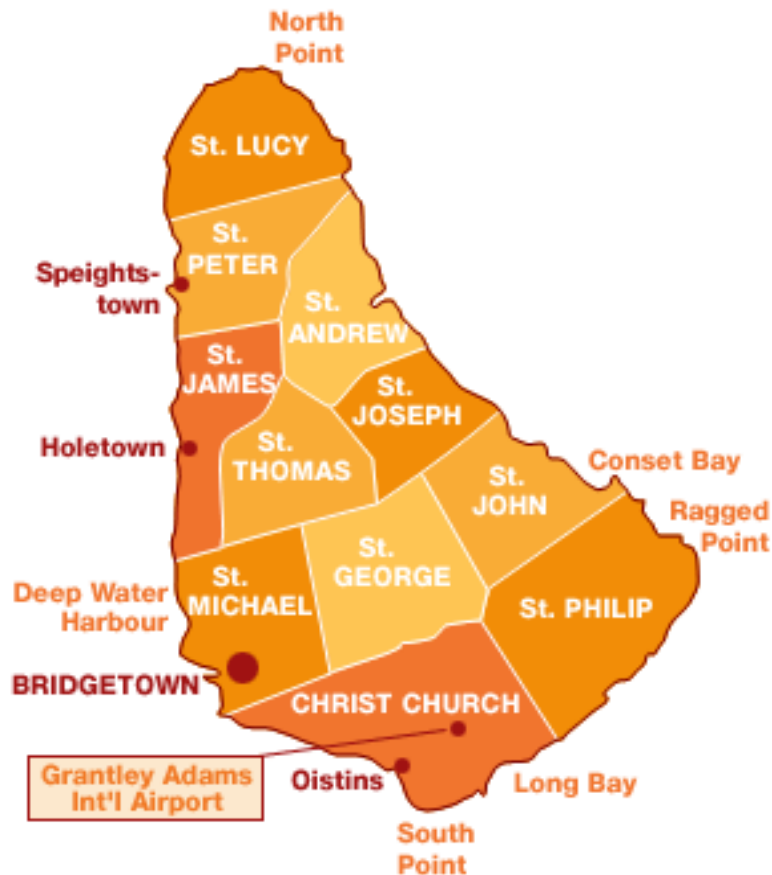
Historical Background

Barbados is an island nation in the eastern Caribbean. Part of the Lesser Antilles, this small island country lies just east of the main grouping and arc of the other Caribbean islands. This geographic position is to Barbados' advantage, as it lies outside the band where the majority of hurricanes pass in the region, known as the Atlantic hurricane belt. While certainly susceptible to major storms, Barbados experiences hurricanes with much less frequency than its neighbors to the northwest. With only 430 square miles of area divided into 10 parishes, and nearly 300,000 people living on the island, Barbados has 44 percent of the population living in urbanized areas, centered in the capital, Bridgetown. Known for beautiful beaches and calm waters, Barbados is heavily reliant on the tourism and service industries, composing over 80 percent of the US\$4.4 billion GDP. With a per capita GDP of US\$23,600, Barbados is the wealthiest of the independent Caribbean nations.

Originally inhabited by a native Amerindian population, Barbados was first settled by the English in 1627. Barbados' colonial history is particular for the region, as it did not leave British rule until independence, unlike many other Caribbean islands, which saw multiple changes of colonial powers. The colonial economy was a classic model of trade to enrich the metropolis. The English imported African slaves to work on the sugarcane plantations that produced sugar, rum, and molasses. Complete independence from Britain came to Barbados in 1966, although the colonial economic relationship remained in place. The population also reflects colonial structures, with more than 90 percent of Barbadians claiming African descent. Due to global economic shifts and island political reforms, Barbados has moved towards an economy based more on service industries. The 1990s solidified the island as a major resort destination for international travelers, so much so that during the winter holiday season, Barbados' Grantley Adams International Airport received regularly scheduled British Airways flights from London on one of the few Concorde supersonic jets.

³ This paper intended to include an analysis component using Geographic Information Systems (GIS). The idea was to overlay SLR projections with topographic spatial data for four areas of the four sites. With this analysis, the area affected by rising sea levels would be clear, thus showing the most vulnerable areas of each site. Unfortunately, as the researchers conducted their fieldwork, the essential shapefiles to do any sort of analysis in GIS were not available. Either the data simply do not exist, or the researchers attempted to obtain the files to no avail. Formal requests were made but went unanswered. However, some GIS analysis has shown results in the existing literature, which the authors refer to as appropriate.

Figure 2: Map of Barbados with Parishes Indicated



Source: http://www.accessbarbados.com/images/photos/1_3_1.gif

The Planning Process: A Procedural and Governance Overview

Barbados's British colonial history has allowed the island to have a long history of town and country planning. The modern government's jurisdiction over development stems from the 1972 Town and Country Planning Development Order. Presently, the Town and Country Development Planning Office (TCDPO) oversees all development on the island, but the parliamentary government structure of Barbados grants the ability to each new administration to change the composition of ministries and their functions. The Physical Development Plan from 1988 guides development on the island. Since the document's amendment in 2003, there has been a turn towards sustainable development, not just as a catch phrase, but as an inherent value for the government's vision for the island. Under the current government configuration, the Prime Minister oversees the TCDPO, and has posited the reasoning behind the amended Physical Development Plan. In a conference speech in 2008, the previous Prime Minister, David Thompson, outlined a few core ideas of the plan: protect natural, agricultural, and cultural resources; promote mixed-use centers and corridors to encourage a diversified economy; maintain central Bridgetown as the financial and commercial hub; and stimulate tourism by the modernization of older beachfront properties and development of new opportunities. (Thompson, 2008). Today, the current Prime Minister, Freundel Stuart, continues this push for sustainability,

as shown by his participation in high-level panels at the recent Global Climate Talks, Rio+20, held in Rio de Janeiro, Brazil in June 2012.

For the past forty years, the focus of the economy on Barbados has been shifting from agriculture to tourism, which has resulted in a change in land-use policies and regulations around development. During the agriculturally focused colonial period from the 17th to the 19th centuries, development mainly consisted of plantations, exporting, importing, and fishing facilities centered on the port in Bridgetown and scant coastal towns. Therefore, the majority of development was focused inland, where the land was more suitable for sugarcane cultivation. Beginning in the 1970s, the island's economy began to shift and as most of the tourism activities occurred along the coast, development began to creep towards the water.

With the shifting development patterns to accommodate tourism in the late 1970s, the concern of coastal erosion became paramount. In addition to SLR, other natural and manmade disasters, such as tsunamis from earthquakes or volcanic activity, oil spills, and hazardous waste from ships all would have a great effect on Barbados' coastal zone (Inter-American Development Bank, 2010). Given that the mainstay of the tourism industry is sun, sea, and sand (which is all coastal based), Barbados needed to protect the coast in order to keep drawing tourists from mainly North America and Europe (Dharmaratne & Brathwaite, 1998). Barbados needed to protect this asset of pristine beaches, as well as create more development along the coast. Coastal zone management was thought to act as a conservation tactic to ensure the growth of the tourism industry.

In 1981, with funding from the Inter-American Development Bank (IDB), the Barbados government embarked on a diagnostic and pre-feasibility study under the first phase of the IDB's Coastal Conservation Program (IDB, 1981). The study focused on the west and south coasts, as these areas of the island had the largest amount of and potential growth for tourism infrastructure. At that time, the government set up the temporary Coastal Conservation Project Unit (CCPU), which oversaw the pre-feasibility study and came to a series of conclusions on the causes of coastal erosion and damage to beachfronts. For example, since Barbados had poor water quality, the runoff polluted the sea, damaging the coral reefs. Natural phenomena, such as storm swells and the occasional erratic hurricane, also caused erosion. In turn, the sea defense structures in place were poorly designed (Proctor and Redfern, 1984). The IDB study mandated the CCPU to continue monitoring the coastlines, to provide advice to the public on coastal matters, and to serve as an advisor to the TCDPO on coastal development.

As the CCPU continued its mandate for a decade, the Government of Barbados, along with additional funding from the IDB, embarked on another study, which recommended the permanent establishment of a unit to oversee the coastal zone. This Coastal Zone Management Unit (CZMU) was created in 1996 to regulate, make recommendations, and educate the Barbadian population about the management of the coast, one of the most important aspects of the island. Still receiving a large amount of its funding from the IDB, the CZMU is currently housed in the Ministry of Environment, Water Resources, and Drainage. As its title suggests, the CZMU manages the coastal zone, defined as "The transition zone where the land meets water; the region that is directly influenced by marine hydrodynamic processes. Extends offshore to the continental shelf break and onshore to the first major change in topography above the reach of

major storm waves” (CZMU, 2010). Therefore, the unit oversees the coral reefs around Barbados and all coastal engineering projects, in addition to serving as an advisor to the TCDPO on coastal development.

Moreover, the CZMU has a major outreach campaign to educate the island’s population. The unit distributes a newsletter, has a strong social media presence, and produces an educational TV show that explains the geological history of the island, as well as techniques to raise awareness about SLR and the importance of coastal management. The CZMU also hosts many activities like International Coastal Clean-Up Day, Sundown Beach Walks, Summer Seminar Series, and a summer internship program for secondary- and tertiary-level students, and provides lectures to schools and educational institutions, NGOs, private organizations, and the general public (CZMU, 2012).

The most important aspect of the CZMU to this study is its coastal engineering projects and its role in conjunction with TCDPO to review all coastal developments. Major capital and infrastructure developments for the management of the coast are under the purview of the CZMU. The unit implements many strategies to achieve the goal of protecting the coastline and stopping beach erosion. The most natural conservation technique is to restore sand dunes, which can protect the coast (see Figure 3). Planting vegetation in the coastal areas allows the dunes to form naturally and hold back inundations from storm surges. Beach nourishment, which is the adding of sand to an erosion-prone beach, is another strategy to keep the beach from eroding. This process is more costly and less effective, as currents and storms can easily erode the nourished beach.

The CZMU also undertakes various physical interventions to safeguard the coast. Among these are breakwaters, groynes, and seawalls. The CZMU employs a range of interventions depending on the specific site and does not implement the same technology everywhere. Breakwaters (Figure 4) in Barbados are concrete structures sunken close to the beach, which interrupt the natural breaking of waves. By forcing them to break further from the coast, these devices alleviate their direct pummeling of the beach, securing the sand. Groynes (Figure 5) are rock structures that jut out into the ocean to disrupt the movement of sediment. The largest type of intervention that the CZMU undertakes is the construction of seawalls. These projects are larger in scale and tend to be in more populated areas. These construction projects can be riprap along the coast as seen in Figure 6, or larger projects that create public space attractive to both tourists and residents as is the case with the Richard Haynes Boardwalk (Figure 7). These techniques are up for debate because of their effectiveness, which sometimes exacerbates erosion (Phillips & Jones, 2006). Even with their questionable outcomes, in the short term, these interventions protect the coastline and the tourism industry. However, their continued long-term effectiveness is less apparent; most of the infrastructure will need substantial physical improvements as it ages and at this point, it is unknown if or when these improvements will take place due to the recent completion of interventions.

Figure 3: Restored Coastal Vegetation, South Coast



Photo: Gregory Scruggs

Figure 4: Breakwater off the South Coast



Photo: Gregory Scruggs

Figure 5: Groyne on South Coast



Photo: Gregory Scruggs

Figure 6: Holetown Seawall, West Coast



Photo: Gregory Scruggs

Figure 7: The Richard Haynes Boardwalk, South Coast



Photo: Gregory Scruggs

The island varies in tourism uses from coast to coast. The west and south coasts are mostly developed, with the urban core of Bridgetown in the middle (southwest corner). The east and north are much less developed and have conservation plans in place to remain that way in order to protect their biodiversity and unique landscape of bluffs and cliffs. Therefore, projects such as the Haynes Boardwalk are on the south coast, where most tourists stay and where the island has concentrated most of the larger hotels and other tourism amenities. The east and north coasts have rougher seas and are visited less by tourists, thus resulting in smaller amounts of investment. As such, strategies like beach nourishment and vegetation restoration are preferred in those areas.

The other aspect of the CZMU important to this study is the review of applications for development in the coastal zone on land, which is “onshore to the first major change in topography above the reach of major storm waves.” (CZMU, 2010) Since the tourism industry is based in these areas of the island, many of Barbados’ development applications go through the CZMU for review. The unit reviews the application to make sure the correct setback is in place, which is 30 meters from the high water mark for developments along the beach and 10 meters for developments along cliffs, measured from the landward point of undercut. In addition to looking for setbacks, the CZMU looks at drainage requirements, buffer zones, fencing restrictions, and myriad other regulations. The CZMU then makes recommendations to the TCDPO for the application. These recommendations are purely advisory and have no binding power for the TCDPO to enforce. This process is the closest Barbados approaches to a

formalized environmental impact assessment (EIA). With a lack of laws, this procedure is merely a small gesture to curb any negative effects from a development.

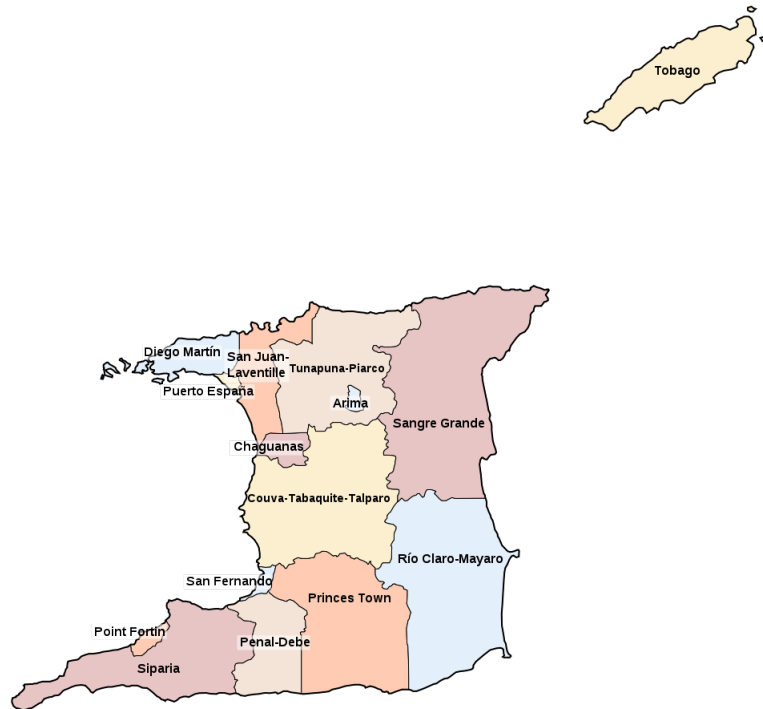
Trinidad and Tobago

Historical Background

Trinidad and Tobago is a twin-island nation with a population of approximately 1.2 million and a land area of 5,128 square kilometers (CIA World Factbook, 2012c). It has 362 kilometers of coastline along the Atlantic Ocean (east), Caribbean Sea (north), Gulf of Paria (west), and Columbus Channel (south). The country is located outside the Atlantic hurricane belt, but has suffered several serious storms over its history, as well as a major earthquake in 1766 (IDB, 2010). The islands were colonized by a succession of European powers—Spain, the Netherlands, France, and Great Britain. The latter acquired Trinidad and Tobago in 1803, abolished slavery in 1833, and joined Tobago and Trinidad as a single crown colony in 1888. The two islands subsequently obtained independence in 1962 as a single nation, with a British political and legal legacy. The nation observes English common law tradition and is governed by a democratically elected, bicameral parliament, led by a prime minister whose cabinet of ministers is drawn from among the members of parliament. At the local level, the country is divided into nine regions, three boroughs, two cities, and one ward with some measure of decision-making autonomy. The two legally designated cities are Port of Spain, the capital, located on the northern half of the island of Trinidad, and San Fernando, the second-largest city and the dominant urban area in the southern half of the island. The country is considered only 13.7 percent urban, but is expected to grow at a rate of 2.2 percent over the next decade (UN-Habitat Urban Info, 2008). Tobago, a short plane or ferry ride from Trinidad, is considered a ward for administrative purposes.

In its 50 years of independence, the republic of Trinidad and Tobago has largely observed a multi-party system divided along ethnic lines between Afro- and Indo-descendants population. Given the short history of African slavery under the British (30 years, from 1803 to 1833), a large south Asian population was brought to Trinidad as indentured servants during the remainder of the 19th century in order to make up major labor shortages in the agricultural sector. The most recent national elections were in 2010, when the People's Partnership coalition (PP) displaced the People's National Movement (PNM), which had been in power for nearly 40 years. Those most recent legislative elections were considered free and fair (Freedom House, 2011). Kamla Persad-Bissessar became the country's first female prime minister, and also called for the first local elections since 2003, which had been repeatedly postponed by the PNM. Trinidad has had previous ethnically, religiously Hindu leadership besides Persad-Bissessar, as well as the first Muslim head of state in the Western Hemisphere, President Noor Hassanali (1987–1997). During his tenure, the Muslim organization Jamaat al Muslimeen led a failed coup attempt in 1990, during which members of the government, including the prime minister, were held hostage and the national television station was occupied. The crisis was ultimately defused with an amnesty agreement. This fractious political history has laid the groundwork for ineffective governance, as agencies are shuttled between ministries, which in turn change names and priorities based on the prevailing winds of Trinidad and Tobago politics.

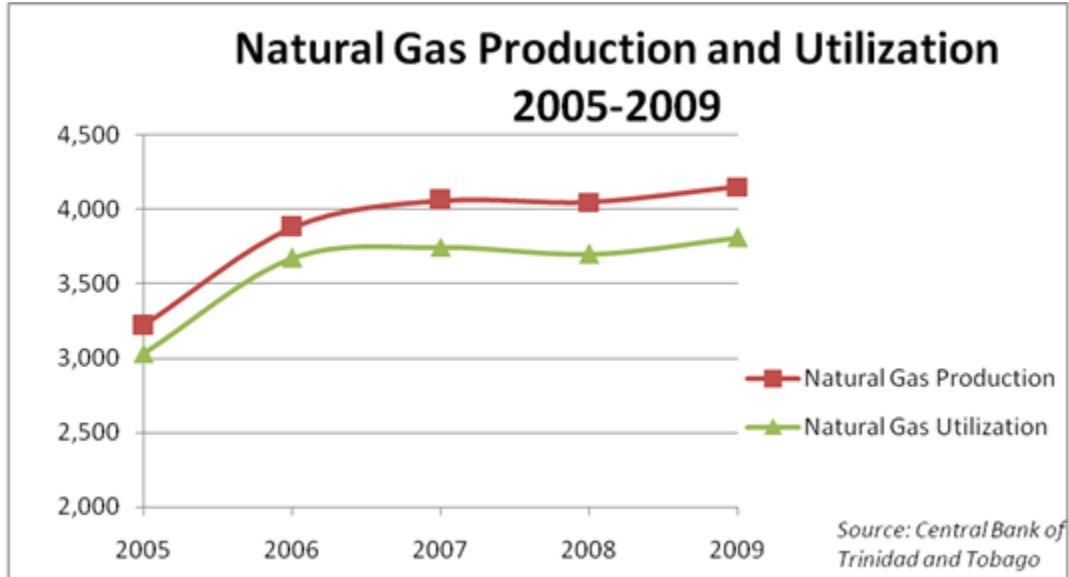
Figure 8: Map of Trinidad Divided into Regions, Boroughs, Cities, and Wards



Source: <http://www.worldofmaps.net/uploads/pics/karte-verwaltungsbezirke-trinidad-tobago.png>

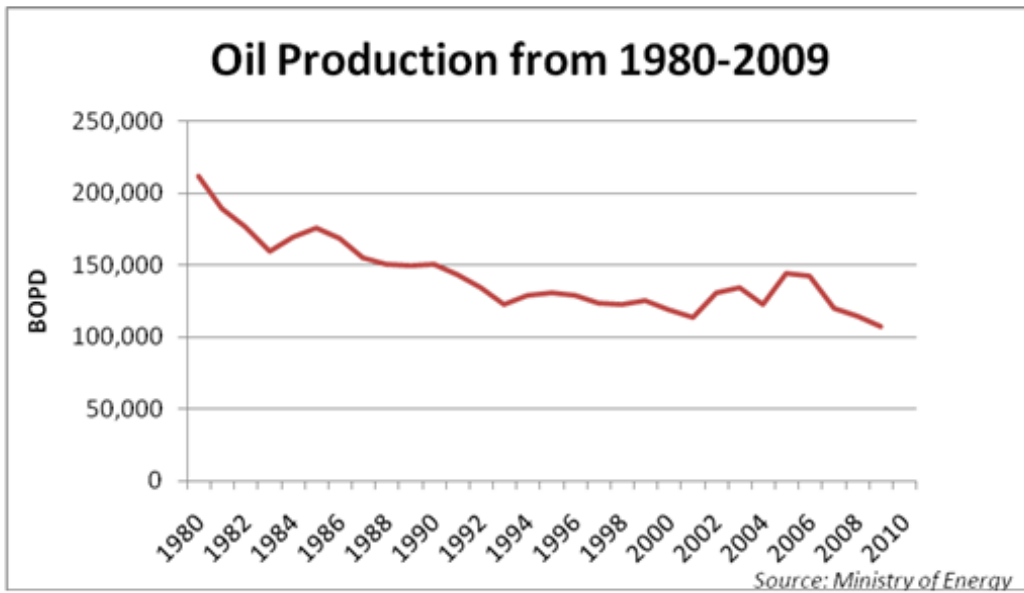
Trinidad’s agricultural wealth during the colonial era focused on sugar and cocoa. In the post-independence era, coconuts assumed a larger role in agricultural production, but the industry is under threat from an invasive pest (Ministry of Food Production, Land and Marine Affairs, 2012). Consequently, Trinidad’s national economic focus is largely on heavy industry, oil, and natural gas. Indeed, Trinidad has one of the world’s oldest oil industries, dating to the early 20th century (Higgins, 1996). However, the past three decades have seen steep declines in the nation oil production, from a 1980 annual average of 212,057 barrels of oil per day (bopd) to nearly half that amount, 107,169 bopd, by 2009” (The Energy Chamber, 2012). By contrast, as a 2004 news story reported, “The importance of natural gas in Trinidad's economy eclipsed that of oil in recent years, with gas output now worth about \$4.8 billion a year compared with \$1.4 billion for oil, according to the Inter-American Development Bank” (Romero, 2004). Collectively, “Oil and gas account for about 40 percent of GDP and 80 percent of exports” (CIA World Factbook, 2012c). Total GDP is US\$22.1 billion and per capita GDP is US\$20,300. Oilfields are found both onshore and offshore, while gas fields are almost entirely offshore. Oil and gas pipelines, however, crisscross the island, concentrating at major ports clustered in the coastal zone. Figures 9, 10, and 11 illustrate the statistical change and geographic distribution of oil and gas production in Trinidad and Tobago.

Figure 9: Natural Gas Production and Utilization



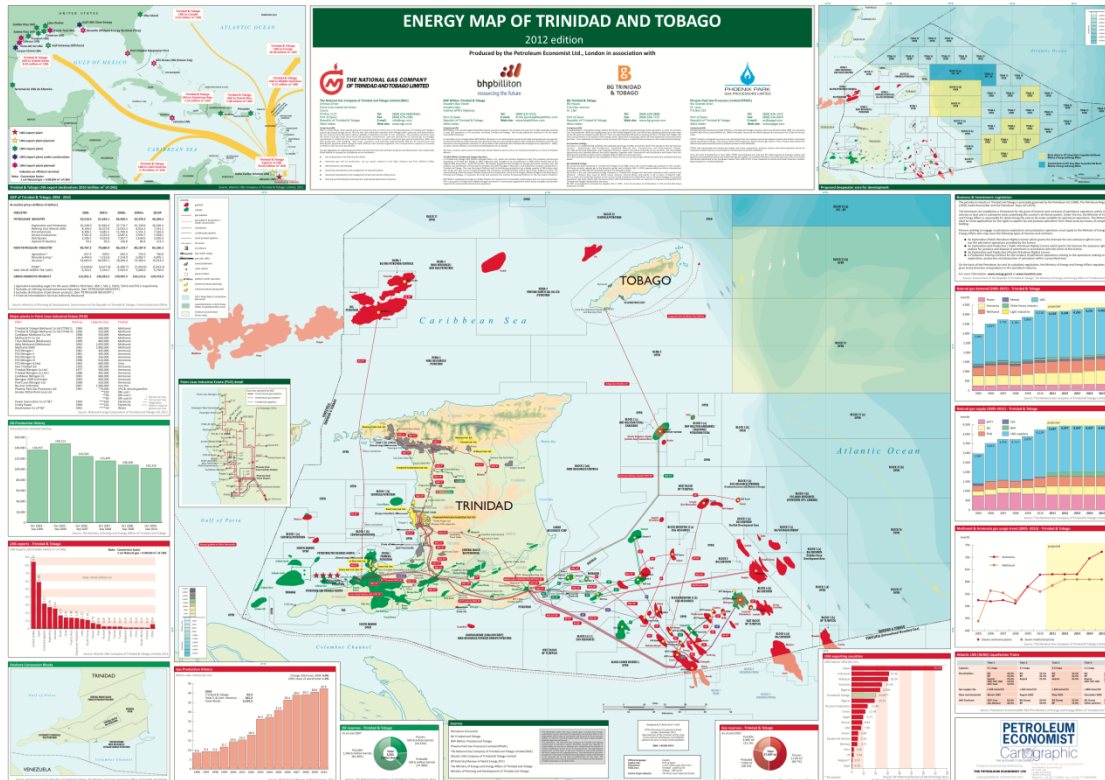
Source: Central Bank of Trinidad and Tobago

Figure 10: Oil Production in Trinidad and Tobago



Source: Ministry of Energy, Trinidad and Tobago

Figure 11: Energy Map of Trinidad and Tobago



Source: Petroleum Economist Cartographic

Moreover, the energy industry in Trinidad has diversified considerably from upstream to midstream (gas-to-liquid) and downstream production. The latter includes ammonia, methanol, urea, ammonium nitrate, nitric acid, and melamine. As such, “Trinidad's gas resources have fueled a web of chemical factories, including nine ammonia plants, an iron and steel complex, and two of the largest methanol plants in the world” (Romero, 2004). Much of this activity is clustered in the coastal Point Lisas Industrial Estate, where over US\$2 billion of investment covers 860 hectares at a location on the Gulf of Paria about 32 km south of Port of Spain. The adjacent Port Point Lisas is the second major port in the country, covering 19.51 hectares (PLIPDECO, 2012). The country’s only oil refinery is located in the coastal town of Pointe-à-Pierre and is maintained by the state-owned Petroleum Company of Trinidad and Tobago, better known as Petrotrin. It includes a recently completed, US\$500 million gas-to-liquid plant and total assets valued at US\$2 billion, according to Calyon Credit Agricole CIB (Leonard, 2010).

Meanwhile, the Atlantic LNG (liquid natural gas) terminal in Point Fortin, on the southwest coast of Trinidad and also along the Gulf of Paria, represents a total investment of US\$3.6 billion for an industry that exported US\$4 billion worth of gas from Trinidad in 2006 (Davis, 2006). Of the major petrochemical and industrial infrastructure along the Gulf of Paria, Point Fortin is the furthest from Port of Spain, but is also the destination of a new highway under construction, an investment valued at 7.2 billion TT dollars, or US\$1.13 billion (Sookraj, 2012). This highway will in turn only further cement the economic importance of the Gulf of Paria coast, with its multibillion-dollar cluster of petrochemical and heavy industry facilities.

The Planning Process: A Procedural and Governance Overview

Although Trinidad has a National Physical Development Plan, it has not been updated since 1984 and needed a parliamentary act to provide for such a revision (Kopstein, 2000). Such an outdated plan during a boom period in Trinidad's growth has required significant land-use planning changes. For example, following landslides in 2011 that damaged several homes, a proposal was made to ban hillside development; the bill also made provisions for 585 local plans (Pickford-Gordon 2012). The Town and Country Planning Division (TCPD) is the agency responsible for this plan, as well as for the government body that reviews all development proposals. This body is currently under the aegis of the Ministry of Planning and Sustainable Development, but with the parliamentary system can shift to be placed under whichever ministry the current government chooses. This flexibility and shuffling of governance structures allows for new, progressive forms of government to become reality more quickly, but the negative side is that continuity can be lost, priorities can be diluted, and the different divisions can lose power. In February 2012, the TCPD released a tender (request for proposals) for outside consultants to update the National Physical Development Plan and candidates will be vetted for experience with climate change issues (Hinds and Maharaj, 2012; Ministry of Planning and Sustainable Development, 2012). This long delay, despite massive changes in the country's economy in the interim, is indicative of the lack of quality planning in Trinidad. As Dr. David F. Brown, an expert on planning in Trinidad, points out:

“In 1962 Trinidad and Tobago inherited a planning system from the British that had been designed for colonial times. While this system offered rigorous control over formal development applications and in good times served the country well, the centralized, top down approach that it embraced was simply not resilient enough to handle the range of challenges that were encountered over the years. [...] While formal plans for Port-of-Spain and other sections of the country were prepared over the 1980s the development proposals and requirements were well beyond the capacity of most residents and government resources with the result that building approvals declined dramatically and it is estimated that 78 percent of projects were developed without any form of approval” (Brown, 2007).

This weak planning framework in Trinidad is subsequently reflected in its approach to the coastal zone. Despite being an island nation, the government does not address the coastal zone as a discrete unit for planning purposes, as there is no separate coastal zone planning or management agency. While this may soon change, it is a bureaucratic misstep caught up in the complicated machinations of parliamentary politics.

There is a government-appointed body known as the National Planning Task Force, a group of experts who advise the government on land use policy and planning. They have revised the 2001 Planning and Development of Land Bill, which would have authorized an update to the National Physical Development Plan had it not become a political football at the time. The new legislation is known as the Planning and Facilitation of Development Bill and has already been approved by cabinet for presentation to parliament. However, it must wait for parallel legislation, such as a new Registration of Planners Bill, as registered professional planners must oversee the work that the new law will facilitate. While these are important, positive steps for planning capacity in

Trinidad and Tobago, they occur at a frustratingly slow pace. For example, the task force attempted to prepare a comprehensive plan for the Gulf of Paria region over a decade ago, but such a plan became politically untenable and the effort was shelved by a new administration before the work was completed. (Mohammed, 2012b).

Consequently, investments made to protect the coastline are sporadic and disjointed. Royal Hanskonig, a project management, engineering, and consultancy provider that organized a recent workshop on coastal zone management in Trinidad, explained, “Significant investment is being made in the development of Trinidad’s infrastructure, however, as is seen in many other countries where coastal projects are delivered on an isolated basis, there is a lack of coherence between objectives and what infrastructure is trying to achieve” (Carpenter et al, 2011). These efforts are further hampered by the fact that all land inland from the high water mark is privately owned, with most private landowners taking it upon themselves to mitigate SLR with the construction of sea walls to protect their land. The TCPD and the Drainage Division of the Ministry of the Environment and Water Resources must approve any sort of improvement, like a seawall (Hinds, 2012). However, the majority of the improvements are illegal (Mohammed, 2012a).

Ultimately, the process that does exist for reviewing coastal development consists of an informal consultative process pursued by the TCPD. Typically, TCPD reaches out to the Institute of Marine Affairs (IMA), a public research institute, which in turn provides recommendations on the proposed development. These recommendations are not binding. They also consult with the Reclamation Committee and the Ministry of Energy if the application in question involves reclaiming land or the energy industry, respectively. Applicants need to acquire a certificate of environmental clearance and may have to go through an environmental impact assessment (EIA). Incidentally, the IMA conducts EIAs for private firms, which is a clear conflict of interest. These institutions, along with a wider constellation of ministries and agencies, such as the Ministry of Works and Transport; Ministry of Housing and the Environment, Ministry of Agriculture; Ministry of Food Production, Land and Marine Affairs; Ministry of Local Government; Ministry of Tourism; and Water and Sewage Authority were identified by the aforementioned workshop organizers as potential members of a future Coastal Management Unit, whose overall goal “should be to design and implement an island wide ICZM Plan, along with taking responsibility for coastal monitoring, data collection research and coastal planning” (Carpenter et al, 2011). However, there are no indications that the country’s parliament is prepared to take such a step in the immediate future.

Instead, the most comprehensive assessments of risk from sea-level rise have come from the energy industry, which has played a significant role in the politics of Trinidad and Tobago for nearly a century. In particular, Petrotrin, which has a foot in both the private and public sectors, has prepared a “Vulnerability Assessment to Climate Change Driven Sea Level Rise—a Case Study for Trinidad” (Dyal, 2010). It uses two Ocean General Circulation Models, namely the Canadian (CGCM1) and British (HadCM3) models, to predict potential impacts on major Petrotrin installations, including oil fields, refineries, and ports that as previously mentioned are valued in the billions of dollars.⁴ The assessment authors indicate best- and worst-case scenarios

⁴ Predictions of sea-level rise are highly controversial and highly variable. In the absence of an alternative reference for this paper, and in recognition of the work that has already been completed, the authors make reference to both

of land inundation for 2031, 2051, and 2071, factoring in both predicted erosion and potential storm surge. Results of the study through 2071 range from as little as just under 9 hectares of inundation (HadCM3 model with no storm surge) to 380 hectares (CGCM2 model with minimum storm surge) to 616 hectares (CGCM2 model with maximum storm surge). The land use affected is a relatively even mix of agricultural, residential, and industrial uses in the best-case scenarios given the small amount of area involved. Under the worst-case scenarios, the amount of industrial land affected assumes the largest percentage of land-use types (see Figure 12), with residential the second most common, but a variety of natural environments, including mangroves and grasslands, also would suffer significant inundation. (Singh et al, 2010).

Figure 12: Petrotrin’s Point Fortin Facility

Petrotrin’s Point Fortin facility includes port facilities and is located on a low-lying coastal area.

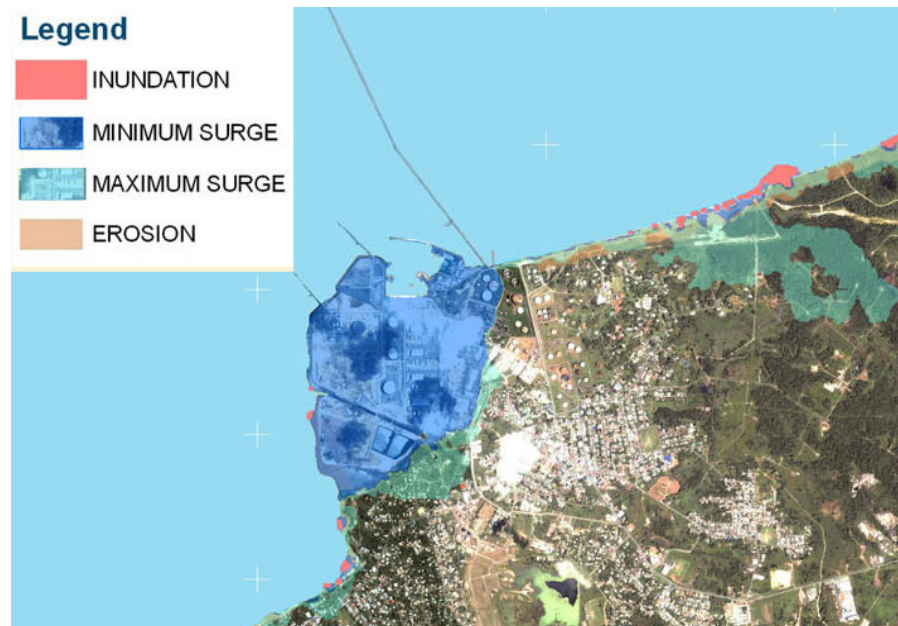


Photo: Gregory Scruggs

the CGCM1 and HadCM3 models, the most widely cited in the literature, while recognizing that there is little certainty in this field.

Figure 13: The Point Fortin Facility

The Point Fortin facility at the upper left corner would be inundated under minimum storm surge conditions.



Source: Shyam Dyal

In a descriptive analysis of the assessment’s results for 2051, the authors explain, “However, when the maximum storm surge (5m) is superimposed on sea level rise the effects are catastrophic for the town of Point Fortin where Trinmar operations are located and for the Guapo area where several field installations of Petrotrin, including access roads, pump jacks, pipelines, storage tanks and oil capture ponds are located” (Ibid). Thus, SLR is a major risk for the energy industry, and subsequently the national economy (see Figure 13). The authors conclude, “Based on the results of the preceding sections then, it is evident that future sea level rises, according to the CGCM2 and the HadCM3 scenarios, and extreme weather events, considering a category 2 hurricane and a minimum (2m) storm surge and a category 5 hurricane and a maximum (5m) storm surge, would cause moderate to severe land loss in the Vessigny to Cap-de-Ville quadrant along the Gulf of Paria in the west coast of Trinidad” (Ibid). These dire projections prompted recommendations for both physical infrastructure and restructured governance. For the former, “Installations at risk such as protective ripraps, landing platforms, jetties, access roads and on-land infrastructure facilities, should be retro-fitted or designed so as to accommodate, at minimum a one and a half metre rise in sea level and where required as for offshore platforms and low-lying coasts, storm surges of up to 5 metres” (Dyal, 2010). For the latter, “Develop a coastal zone management plan, integrating the various land uses of the area along the Gulf of Paria and how these might be affected by climate change and sea level rise and storm surges” (Ibid). These recommendations are encouraging, and perhaps Petrotrin’s role as a powerbroker in Trinbagonian politics could have a positive bearing on the adoption of such suggestions. Unfortunately, the other major petrochemical companies operating in Trinidad with headquarters in other countries have less incentive to conduct vulnerability studies and make recommendations for their own vulnerable installations, as they are not local stakeholders.

Guyana

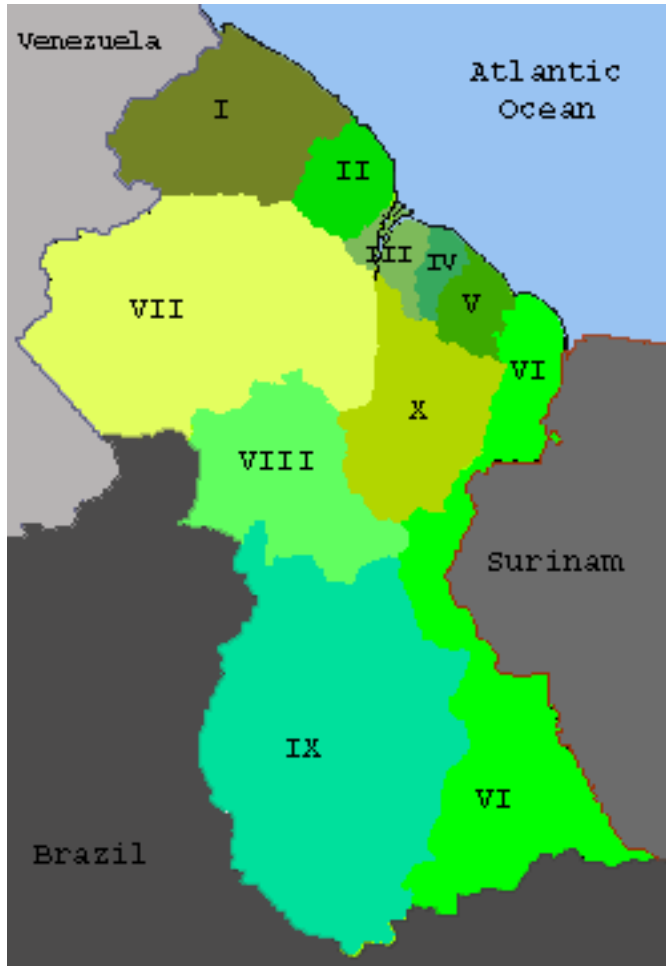
Historical Background

Guyana is an independent nation in northern South America with a cultural and linguistic affinity to the Anglophone Caribbean. It is a founding member of and headquarters to CARICOM. Guyana is a former Dutch and later British colony. The British ruled for 200 years before granting independence in 1966. Guyana became a republic in 1970. The country is divided into 10 administrative regions, six of which are coastal. At nearly 215,000 square kilometers, it is the third-smallest country in South America but the largest within CARICOM by landmass. The population of nearly 750,000 is only 28.4 percent urban; however, 90 percent of the total population is clustered along the coast in both urban agglomerations, such as the capital Georgetown, and rural settlements. The coast extends for 459 kilometers, the vast majority of which is fertile land formed of Amazonian sediment deposits. Lying at or below sea level, and often flooded at high tide, the coast does not have a defined shoreline, but rather varying degrees of mudflats, swamps, mangroves, and marsh. Since colonial times, much of the coastal strip has been reclaimed through sea defenses, as it is productive agricultural land. Guyana is located outside the Atlantic hurricane belt, but it is subject to heavy rains that can cause flooding given the low-lying terrain.

The colonial economy of Guyana was based largely on sugar production, which occurred near the coastline on land irrigated and protected by an extensive series of earthworks, seawalls, and canals. After the abolition of slavery, large numbers of South Asian workers were brought over as indentured servants. This migration pattern created demographics similar to Trinidad and Tobago, whereby the population is roughly split in half between those of African and Indian descent, a division that often plays out in party politics. In the post-independence era, sugar has continued to play a vital role in the Guyanese economy through preferential pricing from the EU Sugar Protocol, though recent reforms have threatened that economic relationship (McDonald 2004). However, gold, located in the country's interior, recently overtook sugar as the largest contributor to the Guyanese economy (AP, 2012). The 2011 GDP was \$2.215 billion USD, with per capita GDP of \$7,500 USD (CIA World Factbook, 2012b). Foreign aid and loans from the EU, the IDB, the World Bank, the Caribbean Development Bank, and the Government of Venezuela continue to bulwark Guyana's economy and development programs (Yearwood, 2006).

Figure 14: Guyana's 11 Administrative Regions

Barima-Waini (I), Pomeroon-Supernaam (II), Essequibo Islands-West Demerara (III), Demerara-Mahaica (IV), Mahaica-Berbice (V), East Berbice-Corentyne (VI), Cuyuni-Mazaruni (VII), Potaro-Siparuni (VIII), Upper Takutu-Upper Essequibo (IX), Upper Demerara-Berbice (X). Regions I–VI are all or partially in the coastal zone.



Source: http://upload.wikimedia.org/wikipedia/commons/0/0f/Guyana_regions_numbered_%28GINA

The Planning Process: a procedural and governance overview

Like Trinidad and Tobago and Barbados, Guyana's planning tradition is based on British law, specifically the Town and Country Planning Act of 1947. The Central Planning and Housing Authority is responsible for planning, as well as the site selection and construction of public housing projects. It also oversees the National Land Use Planning Project under the guidelines of the Lands and Surveys Department. There is no specific coastal zone planning process, but some interagency dialogue occurs. Agencies involved include the Environmental Protection Agency, Lands and Surveys Department, the Ministry of Public Works, and the National Drainage and Irrigation Authority. That said, given that the coastal plain runs anywhere from 26 to 77 kilometers inland—the extent of land which is upwards of 6–8 feet below sea level, including

Georgetown, at an average of two meters below sea level—nearly all development proposals are by default in the coastal zone (UNEP/ROLAC, 2010).

Due to this geographic fact, climate change and SLR are major concerns in Guyana. A 2002 national assessment of SLR vulnerability considered scenarios of 0.2 meters rise by 2020, 0.5 meters rise by 2050, and 0.9 meters rise by 2100. The assessment concluded that a combination of inundation, salinization, and erosion would have a major impact on agriculture, human settlements, tourism, and water resources (EPA, 2002). A 2007 World Bank comparative analysis on the impact of SLR in developing countries determined that Guyana would be the most affected by urban extent, the second most affected by population, and the third most affected by percentage of GDP in all of Latin America and the Caribbean (Dasgupta, et al., 2007). Consequently, in 2009, the government launched Guyana's Low-Carbon Development Strategy (LDS) in the hopes of using Guyana's extensive forested hinterland as a carbon sink and thus mitigating the effects of global climate change (Office of Climate Change, 2009). In 2012, the LDS received an injection of capital from the Inter-American Development Bank and later from the Government of Norway during the Rio +20 summit, creating conditions for up to \$250 million USD in investment in Guyana's REDD+ (Reducing Emissions from Deforestation and Forest Degradation) Investment Fund by 2015 (Caribbean Journal, 2012a, 2012b).

In general, the Guyanese land-use pattern consists of a thin (about one-mile wide) strip of development along the coast with agricultural activity behind it. In Georgetown, at the mouth of the Demerara River into the Atlantic Ocean, the urbanized area extends about two miles back from the coastline (and continues in another waterfront strip along the river for 41 kilometers to the Cheddi Jaggan International Airport). There is thus a growing push toward inland development as the number of households is expanding, because extended families are moving out into new households. Although not a set policy, there is also an intuitive notion that living inland is safer given sea-level rise concerns. Adaptation strategies exist, such as building up (most houses are built on the second floor on stilts), but such methods are advisory, as there is not a form-based code and building codes are advisory, not enforceable.

For several centuries, manmade infrastructure, such as seawalls, groynes, and kokers (sluices), has protected Guyana's coastal population and economic assets. The Dutch, who have historic experience with land reclamation and protection in low-lying areas, began this process, which was abetted by French plantation owners and later British colonial administrators. Specifically, there are 270 kilometers of sea defenses, some of which date back to the first comprehensive seawall built by the British in the 1880s in Georgetown. In an urban setting, the seawall also serves an urban design role as a public space for social gatherings and recreation (Figure 15).

Figure 15: The Georgetown Seawall

The Georgetown Seawall serves as a recreational and commercial hub in addition to protecting the capital city.



Photo: Gregory Scruggs

Figure 16: Guyanese Koker

Every Guyanese coastal village has a hand-operated koker, or sluice, to help move water out of the low-lying coastal zone and back to the sea.



Photo: Gregory Scruggs

Figure 17: Koker Pumping Water Over Seawall

The koker pumps water back over the seawall and into the ocean, with questionable environmental impacts.



Photo: Gregory Scruggs

Most of the existing infrastructure dates from the 1950s and had deteriorated significantly by the 1980s and 1990s. “These defenses were subject to continuous erosion and given the country’s financial difficulties the maintenance of the defenses suffered. The situation had become so bad that in one year in the late 1980s 50 breaches were recorded” (IDB, 2002). A 1994 report funded by the Inter-American Development Bank determined that, while the seawall should be rebuilt, such a loan would not be bankable. Instead, the report recommended relocation of coastal populations (SSPA Project Team, 1994). However, the Guyanese government believes that such measures are impractical. “It is pellucid from responses that given the social and cultural attachments to their properties, respondents feel strongly about moving. Any programme the authorities may therefore have to lobby seriously with these individuals, all the time, trying to convince them that remain close to the sea is both futile and uneconomical. However, until adequate baseline data are collected and analysed, it will be virtually impossible to present sensible alternatives” (EPA, 2002).

Over the past 25 years, the European Union (EU), through its Development Funds program (EDF), has granted over €80 million (US\$98 million) for sea defense through project support, technical assistance, and supplies (Strand, 2012). In particular, the EU has brought the know how to build a riprap design, which consists of a slope of boulders that absorbs some of oncoming waves’ energy, rather than acting as an impervious wall like concrete design. The cost of riprap is US\$2,000 per meter, versus US\$5,000 per meter for a concrete wall (Braithwaite, 2012). The Sea and River Defense Unit of the Ministry of Public Works maintains this infrastructure and

with EU funding is currently conducting a monitoring project to look at the most vulnerable points. All of this data is being put into a GIS management system, which is neither complete nor publicly available at this time. The survey is annual and is moving to more real-time data so that the public can report on the quality of the sea defenses. Reduction in the number of overtopping and breach incidents, which can cause inundation of as much as five liters per second per meter, is the gauge of success. Current management challenges include the disproportionately high amount of investment that goes into the fluvial islands at the mouth of rivers compared to the relatively small number of people who live there and their economic activity. The Sea and River Defense Unit's annual budget for the division is US\$6 million (from local sources) and US\$8 million (from the EU).

Separate from the built defenses, the EU also has spent €4.1 million in a climate change grant to support a natural defense mechanism: mangroves. Mangroves are a type of forest that can grow along seacoasts despite the high salinity. They are naturally occurring in Guyana, though many have been cut down over the history of the country's development from the colonial era to the present. Mangroves complement physical sea defenses by dispersing wave energy before they affect built structures (Landell Mills, 2011). In addition to their direct role in sea defense, they provide a number of ecosystem services, such as trapping sediments, building up land, and serving as habitats for aquatic and avian wildlife. These services in turn provide economic and social benefits through tourism, recreation, and food supplies. When harvested sustainably, mangroves can provide building material, medicinal honey, and tannins for leather craft (MAP, 2010; Williams and Adrian, 2002). Their ecological significance is such that they "have been classified as keystone ecosystems, as they are important for other ecosystems and generate a wide range of natural resources and ecosystem services" (Moberg and Rönnbäck, 2003). Birds, for example, have made Guyana an important destination along the Eastern Flyway, one of the major north-south migratory routes for billions of birds annually that extends as far north as Boreal Canada and as far south as Argentina (Boreal Songbird Fact Sheet, n.d.). Birding and ecotourism, in turn, has become a growing sustainable business in Guyana (Deosaran, 2012). Guyana has much potential, as the comparatively small country is home to more bird species than all of the contiguous 48 U.S. states. Unfortunately, pristine natural environments are often pitted in a zero-sum game against resources extraction. (Butcher, n.d.).

The EU funding resulted in the creation of the Mangrove Restoration Project, overseen by the Mangrove Action Committee, which has promoted mangrove restoration activities and extensive public service campaigns to discourage nearby residents from deforesting newly planted mangroves. The mangroves face a variety of threats from human occupation, including harvesting for wood, animal grazing, trampling by boats that are dragged to and from the ocean, and garbage dumping. A 2001 Guyana Forestry Commission survey observed 80,000 hectares (800 square kilometers) of mangrove cover in the coastal zone. Since then, over 200 square kilometers have been planted, of which 100 square kilometers have died; however, this is a reasonable yield for mangrove planting. However, its operational future is in doubt after the current EU funds dry up. As a monitoring report explained, "The programme is highly relevant and has great potential but lacks an overall operational plan; instead plans are done annually and it is difficult to measure overall progress. Institutional sustainability remains a major challenge at this point" (EU 2011). Ultimately, the current EDF grant cycle will provide €30 million over three years, but is currently caught in political negotiations over whether it will arrive as general

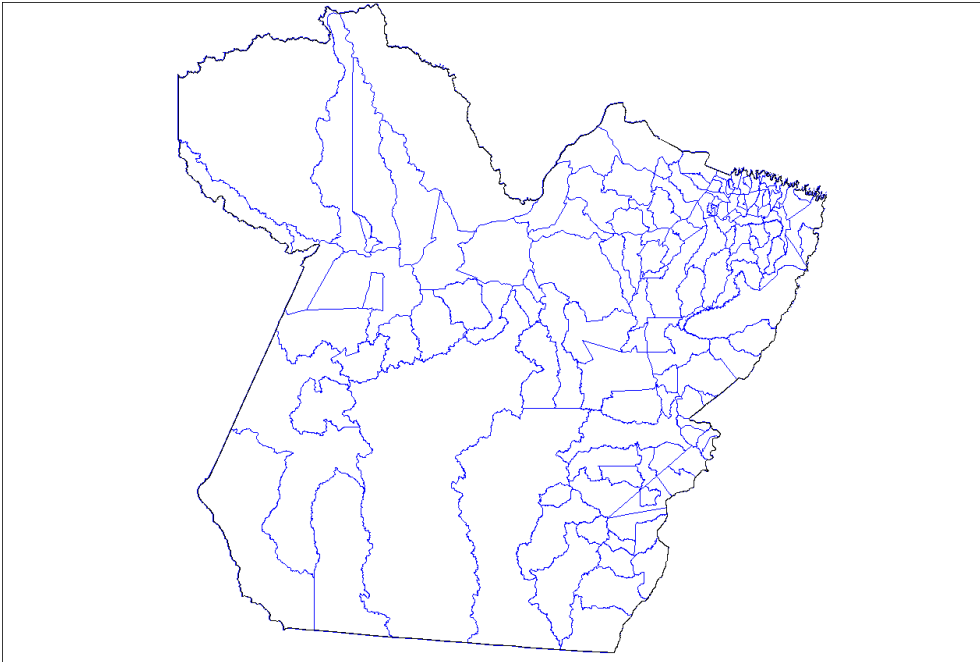
funds or grants to a specific sector. There is an ongoing tension between donor-dictated funding and trusting the Guyanese government to use the money most wisely.

Pará

Historical Background

Pará is the second-largest state by landmass in the nation of Brazil, with just under 1.25 million square kilometers. It is located in the equatorial region and home to a significant portion of Amazon rainforest. The state population is about 7.5 million inhabitants, with a per capita income of R\$7,000 (\$3,500 USD), making it one of the poorest states in Brazil at 23rd of 26 in income. The Portuguese maintained a permanent presence in Pará from the early 17th century onwards, and the state has been an uncontested territory of Brazil since independence in the early 19th century. Pará went through two boom-bust cycles with the rubber industry, which brought internal and foreign migrants to the region, and also led to the growth of its capital, Belém, the principle port at the mouth of the Amazon, located on the Guajará Bay with easy access to the Atlantic Ocean and overland routes to other Brazilian capitals. After a period of decline, the state of Pará has grown recently with mineral extraction and wood harvesting, both legal and illegal, occupying an increasing share of the state's economy activity.

Figure 18: A Map of Pará Divided into Its 144 Constituent Municipalities



Source: http://upload.wikimedia.org/wikipedia/commons/5/51/Para_Municipalities.png

Figure 19: Map of the Brazilian State Pará



Source: <http://www.v-brazil.com/tourism/para/map-para.html>

With 82,596 square kilometers of coastal zone, or about 3.5 percent of the state's total area, Pará has a significant presence on the Atlantic coastline, where fishing and tourism are the principle economic drivers. In 2010, the state of Pará was responsible for the second-largest tonnage of commercial fishing—143.078 tons (Ministério da Pesca e Aquicultura, 2012)—in Brazil, behind the state of Santa Catarina. Its Atlantic beaches are also a popular destination for residents of metropolitan Belém, which, with just under 1.5 million inhabitants, is the largest urban agglomeration in the region. However, these two economic activities are considerably less lucrative than the mining and forestry activities in the interior of the state, which coupled with the dearth of population centers on the coast contributes to poor coastal zone management (Szlafsztein 2012).

The Planning Process: A Procedural and Governance Overview

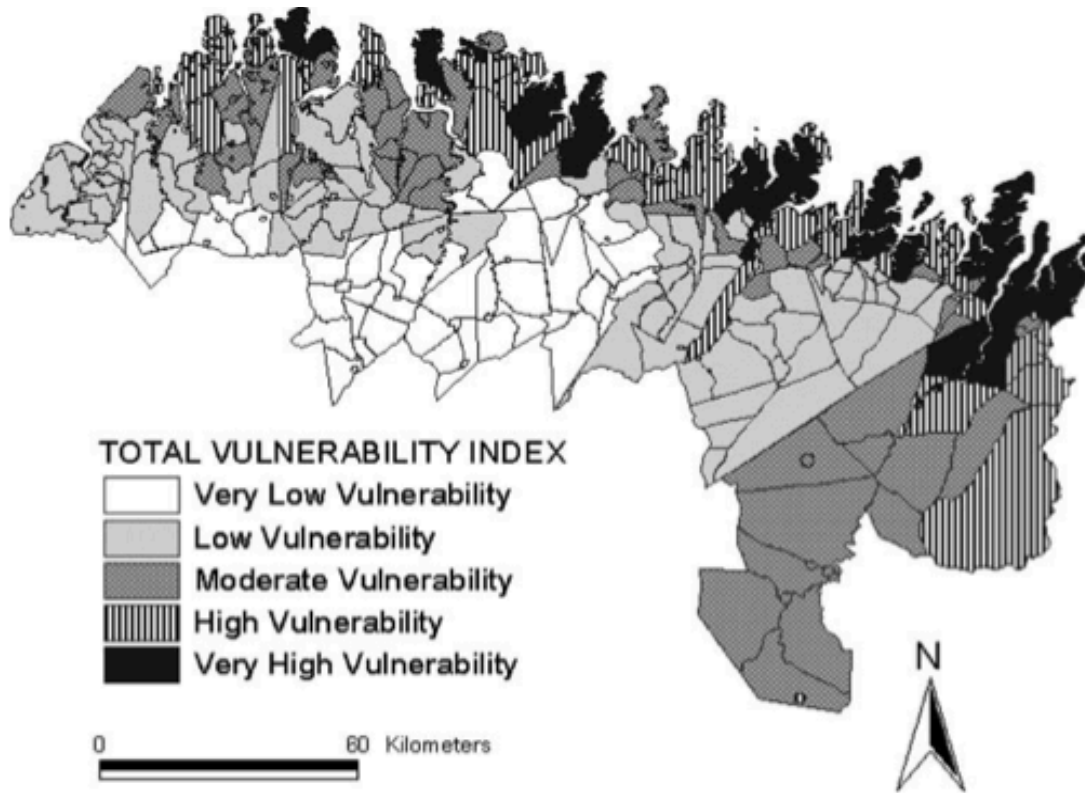
Urban planning in Brazil operates under a federative structure and is governed by the federal Cities Statute and the municipal Organic Law, which functions as a kind of municipal constitution. These legislative frameworks mandate master plans for all municipalities over 20,000 inhabitants. In practice, however, only the best-resourced municipalities are capable of undergoing this exercise. Pará, for example, has 144 municipalities, and only three are not financially dependent on the state government (Parauaperas, Belém, and Barcarena—all of

which have heavy industry). Twenty-five percent (25 percent) of the state tax, the ICMS (commercialization of merchandise), is redistributed to municipalities proportionally. As for local tax collecting, small municipalities do not have accurate property rolls to collect property taxes, known in Brazil as IPTU. Moreover, municipalities set an income limit, usually 1–2 minimum wages⁵, below which residents do not pay property taxes. In Bragança, for example, one of the larger municipalities in the Brazilian coastal zone, the 2000 census showed that well over half of residents earned less than two minimum wages (Rosas 2006). This social phenomenon leaves Bragança and similar municipalities institutionally and financially weak even as they face serious beach erosion problems, a threat to their livelihood (Szlafsztein and Sterr, 2007). With limited budgets, municipalities do not expend local funds on prevention and instead hope for the best. Moreover, few residents own insurance for economic or cultural reasons, and the economic value of the people and property in Pará's coastal risk areas is very low. Preventive policies are implemented only when there is a track record of disasters or funds available to finance such measures.

As land-use planning pertains to the coastal zone, the federative structure in Brazil again plays an important role. Firstly, all land within 33 meters of the average high tide line of the ocean or major rivers is federally owned, with legal users paying an occupation fee, though plenty of users are illegal (Szlafsztein 2006). Second, urban master plans, when present, can establish non-buildable areas along waterfronts, as Belém's does (Ibid). Finally, individual municipalities can use their Organic Law to establish setbacks that correspond to the number of stories permissible within a certain range of the high tide (Ibid). While this balance of power seems adequate on paper, in practice there is a severe lack of coordination. "The Brazilian Federal Constitution of 1988 (specifically, articles 20 and 26) clearly establishes the heritage of the union, states and municipalities as well as their rights and responsibilities for the its [sic] use, preservation and conservation. However, in practice, in the Amazon coastal zone, total or partial overlay and lack of actions are the main consequences of this type of planning and management approach, thereby hindering the policies and strategies performance and leaving the private occupants to make legal or illegal decisions" (Szlafsztein 2012). The appropriate response would be an integrated coastal zone management (ICZM) strategy given the combined high to very high natural and socio-economic vulnerability of the 22 Atlantic coastal municipalities (Szlafsztein and Sterr 2007).

⁵ In Brazil, all salaries are a multiple of the federal monthly minimum wage. In 2012, the monthly minimum wage in Brazil is R\$622,73 or about US\$348.08.

Figure 20: Northeastern Coastal Zone of the State of Pará: Spatial Distribution of the Total Vulnerability Index



Source: Szlafsztein and Sterr, 2007

However, at present, the status quo remains. “In the region, the coastal zone management organizations (e.g., State Secretary of Environment) justify this situation based on the weak societal and local community support for program activities, the absence of a strong institutional coordination, and the scarcity of resources (e.g., data, skilled professionals, and money)” (Szlafsztein 2012). The steps taken thus far largely consist of diagnostic tools, such as the federal government’s Projeto Orla (Coastline Project) and the National Center for Natural Disaster Alerts and Monitoring, known by the acronym Cemaden. The federal Ministries of Planning and the Environment administer Projeto Orla, whose goal is to provide a manual for the management of Brazil’s coastlines through the creation of individual plans for given coastal areas. The three levels of government (municipal, state, and federal) are supposed to work together in creating these plans. Unfortunately, the larger cities are the ones with the capacity to create the plans, and the smaller towns are unable to produce the plans. For example, Belém has already completed this program, but many of the other cities in the region are not done with this process, nor do they have the capacity to finish the job (Rocha 2012). Cemaden was created by the federal government in 2011 under President Dilma, but has had trouble hiring qualified geologists to conduct its proposed 400 risk mappings, even resorting to employing foreigners (Silveira 2012). In the end, only 275 will be conducted, and a mere three will be in Pará.

Conclusion

As stated before, all four sites are susceptible to the risk of sea-level rise. Guyana could be considered the most at risk, even though the coastal zone is a comparatively small percentage of total landmass out of any of the four sites. This is because the vast majority of its population and economic activity is clustered in the coastal zone, which has been below sea level since the first Europeans settled the area. The original Dutch colonists constructed a dyke system, which similar to the situation Holland, allowing the land to be below sea level. In turn, Pará, which similarly has a relatively low percentage of coastal zone relative to its total landmass, is naturally quite vulnerable, but as a portion of the state’s economic activity and human settlements, it is at a much lower risk. This reality, in turn, has driven Guyana’s historically strong attention to this issue and Pará’s historically weak attention. As island nations, both Barbados and Trinidad and Tobago are logically at risk, with Barbados’ economy driven by the fine-tuned quality of its beaches, making it very susceptible to even slight erosion. The same would hold for tourism-driven Tobago; however, as a whole, the national economy is driven by the energy industry, for which multibillion-dollar investments are clustered along the Gulf of Paria. All four sites also have major urban areas along the coast or in the coastal zone. Georgetown is most at risk, given that it is already below sea level. Belém is in a tidal bay and has already experienced issues with waterfront flooding. Bridgetown, Port of Spain, and San Fernando are vulnerable to storm surge, but do not as of yet experience day-to-day issues with sea-level rise.

Below, a table summarizes the four sites in terms of response to SLR.

Table 2: Policy and Physical Response for Four Sites to SLR

	Policy Response	Physical Response
Barbados	CZMU	Breakwaters, groynes, beach nourishment, mangroves
Trinidad & Tobago	Ad hoc from private sector	none
Guyana	Int’l donor dictation	Concrete and riprap seawall, mangroves
Pará	Federal Laws, Planning Studies	none

Regulatory Systems

Of the regulatory systems in place in these four sites, the CZMU from Barbados should be regarded as the most advanced in the region and the closest to the ideal of ICZM, while similar bodies have been proposed for Trinidad and Tobago and Pará, there are no immediate signs they will be implemented for a variety of reasons. In Trinidad, the dominance of the energy industry is a major impediment to government action, unless, as in the case of Petrotrin, the industry can become a partner with the public sector. In Pará’s case, the culprit is the devolution of responsibility to local municipalities that are institutionally and financially weak. Guyana, like Barbados, is well funded by international donors, but is mired in the back-and-forth of donor-driven politics; its programs in turn suffer from poor management and planning that raise concerns with the donors. By contrast, Barbados’ strong institutional framework stems from

various well-executed studies funded substantially by an international donor. Even today, the funding is not entirely domestic. Ultimately, this issue of institutional capacity and financial sustainability in these small nations (and state, in the case of Pará) is a major impediment to creating these frameworks.

Although the CZMU is a model for the region, the authors are unsure if the unit actually has the ability to enforce its rules and recommendations. While the unit's physical interventions, such as breakwaters, seawalls, and vegetation restoration have a beneficial outcome for the island in the short term, the long-term viability of these costly interventions is unknown, especially considering that other global examples of coastline protection similar to those in Barbados must be constantly upgraded because of wear and tear and sea-level rise (Phillips & Jones, 2006). When it comes to regulating new development, their power is severely limited. The regulations stipulate certain conditions for development, such as setbacks. From interviews, the authors have come to ascertain that this lack of enforcement is a large issue for the unit. Since the TCDPO makes the final decision on all development on Barbados, the CZMU's recommendations do not necessarily have any sway. An example gleaned from interviews would be as follows: a developer submits plans for a new hotel in the coastal zone, which goes to the CZMU for review. The unit discovers the development does not comply with the setback requirements, among other violations, and therefore does not recommend to the TCDPO to proceed with approving the development. The developer can then appeal this decision, highlighting the economic benefit of the project. Not only would construction jobs be created, but also long-term jobs at the hotel in the service sector. The government is still in the position to encourage any job growth, and therefore would let the project move forward, even though the CZMU would have denied the project for its environmental insensitivity. A more common event is the construction of an accessory building or additions to an existing building in the setback zone. Even though the CZMU will state its disapproval for the development, most likely the project will go through.

The most telling aspect of the situation is the fact that much of the coastal zone in Barbados was built out before the enactment of the CZMU. The existing development is grandfathered in and does not have to comply with any regulations set forth by the CZMU. Thus, much of the existing development is in danger of inundation and may be at risk from erosion. If there were legal backing to the CZMU, new development would certainly abide by its recommendations. The reality is that there may not be enough new development occurring in the coastal zone in the first place, and even when it does occur, the CZMU is unable to enforce its views. In the end, the CZMU is a regulatory hero without any power. Guyana has a similarly built-up coastline; thus, any future regulations would encounter the same problem. Trinidad and Tobago are less oriented toward the coast, especially given the amount of industrial infrastructure in the coastal zone, and the current revision of the National Physical Development Plan as well as the promulgation of local community plans is an opportunity to guide coastal development in the country. Pará's coastal municipalities have a patchwork of regulations and are not highly built up, so there is an opportunity to adopt some of the CZMU's ideas.

Physical Infrastructure

As for physical infrastructure, Guyana is clearly the leader with such a long history of coastal interventions. The transition from a concrete wall to riprap design has clearly been used

elsewhere, such as in Barbados, and with such a long stretch of sea defenses, Guyana is ripe to serve as a laboratory for successful efforts. The mangrove restoration process is a very innovative complement to physical sea defenses, as they provide extensive ecosystem services and align with the country's sustainable development ideals, such as the Low-Carbon Development Strategy. Restoring the natural environment and successfully protecting the coastline at the same time is a win-win. Pará, which has a similarly long coastline and climate, should conserve or, if already deforested, then restore, its mangroves. Trinidad and Tobago has extensive mangroves that should be conserved (World Wildlife Fund, 2010), while Barbados is in danger of losing its last mangrove wetland (Graeme Hall Nature Sanctuary, 2010). Unfortunately, given the economic importance of beach access, mangrove restoration is an unlikely strategy in Barbados.

However, Guyana's dependence on foreign donors should be a watchword for developing nations. The current political wrangling over the next cycle of European Development Funds and the impending termination of the EDF grant to the Mangrove Restoration Project are reminders that national governments must create sustainable institutions and build capacity in order to satisfy donor expectations and ultimately maintain programs, policies, and projects if and when donors depart. Barbados, with the highest per capita GDP of an independent nation in the region, appears to have been most successful. Guyana, with one of the lowest, appears to be struggling the most. Trinidad and Tobago, currently undergoing an economic boom, should be careful to invest more of its revenues into good governance and management. Finally, Pará and its local municipalities are in a similar situation, as Brazil as a whole is doing very well economically and investing in the underdeveloped north. They should take advantage of federal land, in the case of municipalities, state funds to strengthen their evaluation, oversight, and implementation for regulations.

Ultimately, small islands and low-lying coastal developing states face an unfair burden of responding to a problem—climate change—that they did not create. Yet their capacity to mitigate, even in the case of carbon sinks like Guyana and Pará, is relatively small. Recent underwhelming environmental summits like Rio +20 are not encouraging, and thus the adaptation route should be a priority for these governments. With an abundance of models for successful, efficient, comprehensive, and effective coastal zone management and intervention, it is incumbent upon Barbados, Trinidad and Tobago, Guyana, and Pará to pursue the best practices in planning for an uncertain but likely perilous coastal future.

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