THE PENNSYLVANIA STATE UNIVERSITY
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"BRAVING THE STORM":
THE SUSTAINABILITY OF FRESHWATER IN BARBADOS' TOURISM-DRIVEN ECONOMY IN AN ERA OF CLIMATE CHANGE

JOSEPHINE RAE FARINELLI
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Reviewed and approved* by the following:

Brian King
Associate Professor of Geography
Thesis Supervisor

Roger Downs
Professor of Geography
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

This thesis will analyze the concept of climate justice by examining small island developing states' anthropogenic contributions to the greenhouse effect and other forms of environmental degradation and the projections they face in an era of climate change. Specifically, the thesis focuses on Caribbean islands and their characteristic low greenhouse gas emissions and agricultural land use as well as highly tourism-dependent economies. The concept of double-exposure is also an important aspect of climate justice that will be considered with respect to not only the emissions from other countries, but the environmental impacts tourists from developed nations create within their Caribbean host countries. The thesis narrows its focus to the specific effect climate change will have on freshwater resources in the region as the vitality of freshwater provides a case study for other important resources faced with the effects of climate change. Using Barbados and its freshwater situation as a case study for this region, the thesis draws conclusions about the future of small island, tourism-dependent states like those in the Caribbean in the face of climate change.

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Chapter 1

Introduction: Climate Justice

Earth's climate system is comprised of the atmosphere, land, hydrosphere, cryosphere, and biosphere and the precipitation, temperature, atmospheric pressure and wind occurring across these five entities. The greenhouse effect occurs when gases emitted into Earth's atmosphere trap heat that would usually escape to space, producing a warming effect on the air and the surface of the planet. Combined with other factors like albedo, changes in tropospheric ozone and changes in solar irradiance, the greenhouse effect has a large influence on the processes of the climate system. According to the Intergovernmental Panel on Climate Change, the anthropogenic contributions to the greenhouse effect have increased significantly since pre-industrial values; these findings implicate human activities as the cause of the net warming effect that climate change will have on the planet, (IPCC, 2007).

Before the Intergovernmental Panel on Climate Change drafted reports for policymakers, the issue of climate change was generally brought into the light as a social problem only when public attempts were made to dispute its validity or policymakers determined how much money mitigation or adaptation efforts were necessary or economical. This is certainly not the case anymore as government agencies from the Department of Defense to the National Park Service, non-governmental organizations,

local community groups and more are major actors in the era of climate change, focusing on education, communication and community preparedness matters among other issues. Most importantly, perhaps, there is a major focus by actors from the legal community to non-governmental organizations and other interest groups on climate justice and the ethical issues inherent to both the causes and effects of climate change. The climate justice movement seeks to "address the issues and concerns that arise from the intersection of climate change with race, poverty, and preexisting environmental risks" (Burkett, 2008).

Many studies on the emergence of the climate justice movement have narrowed the root of the discrepancy in discourse to the aforementioned science-central mindset. Rather than recognizing the effects of climate change in multi-lateral terms, especially with respect to the issues of race, poverty and preexisting environmental risks as outlined in the climate justice movement, the issue is too singular in its understanding. In the "global north" and industrialized countries, climate change is viewed as an exclusively environmental issue. It is assumed that non-governmental organizations and specialized research teams are focusing on solutions stemming from science and technology such as stemming the flow of emissions and implementing carbon credit-based systems (Petit, 2004). Conversely, the interpretation of climate change issues in the "global south" and developing nations is one of solutions that are inherently inseparable from social issues like poverty, trade and globalization. In these countries, climate change is more of a sustainable development issue than economic mitigation efforts like cap and trade heavily considered by their industrialized and post-industrial counterparts (Petit, 2004). These views stem from what is more important in each place; while developed nations must

worry much more about how mitigation efforts will impact their current industrial workflow and economy, developing nations stand to lose much more in the social realm due to weaker economies, poorer citizens and characteristic preexisting environmental risks (Burkett, 2008).

The concept of climate justice questions who is responsible for the new threats these developing nations face and how these nations can influence those responsible to help them handle the vast effects with which their countries are primarily concerned. Making their voices heard is one of the biggest challenges to the climate justice movement as many of the countries, despite banning together with non-governmental organizations and interested parties in the legal community, have little global political force and influence at the multiple levels necessary to persuade responsible parties into helping.

Climate change mitigation is costly no matter where it is implemented but, for developing regions with emissions levels already much lower than the rest of the world, reducing their impact on climate change is even more costly economically and is far less effective than if their developed counterparts would take the same measures. Unfortunately, climate change adaptation is even more costly in a great deal of these developing regions. The Caribbean, for instance, stands to suffer from warmer temperatures in the dry season, potentially leading to drought and intensified cyclone activity leading to coastal erosion, inundation and salt-water intrusion (IPCC, 2007). The region contributes less than 1% of the planet's annual greenhouse gas emissions but will likely spend a great deal of money trying to keep a sense of normalcy to counter the drastic effects climate change might have on the area (World Bank, 2012).

Climate change is a rights issue. The global north and industrialized nations have historically and presently led the globe in greenhouse gas emissions and other practices influential on the anthropogenic global warming effects. While they work on their own mitigation and adaptation strategies, the lack of real, political traction behind the climate justice movement has all but absolved them of moral accountability for the environmental threats other regions face in the wake of their practices.

In addition to their disproportionately large contributions to climate change, many industrialized nations pose other environmental threats to countries already facing the effects of their emissions. For instance, the main participants in the Caribbean tourism industry hail from the United Kingdom, United States and Canada (Gossling, 2012). During their stay in the Caribbean, the tourists use resources such as water, fossil fuels and electricity in excess, promote unsustainable standards and encourage the industries in these locations to degrade the environment in order to remain cost effective and maximize profits. The region faces a threat of double-exposure to the pollution of developed nations in terms of climate change and environmental degradation stemming from tourism. Not only do Caribbean islands face enormous threat from the effects of climate change brought on in major part by the tourists' home countries unsustainable practices, but their beaches and subsequent tourism-dependent economy attract more resource use and environmental degradation from the same industrialized nations responsible for much of climate change's harsh effects.

This thesis examines the responsibility behind the intensely questionable ethics associated with current climate change mitigation and adaptation responsibility assumptions. The freshwater supply of the island nation of Barbados will serve as a case

study for how the double-exposure of climate change effects and tourism-driven environmental degradation can wreak havoc on crucial resources. Analysis will begin by tracing the island from its contributions to climate change to the projected effects global warming and its associated circumstances such as sea level rise and changes in the patterns and intensity of precipitation and cyclones. Then, an outline of Barbados' history, political system, economy, topography and typical climate will guide the discussion toward the current freshwater supply and its potential future in the face of climate change. The importance of the tourism industry to the country's economy will also be analyzed and the impacts of the tourism sector on the freshwater supply and other environmental aspects of the island will be determined.

The ethical side of climate change cannot be ignored; responsibility for the causes of climate change and subsequent responsibility for mitigation and adaptation efforts cannot be equally assigned to each member of the global community if some members contributed much more to the problem than others. It is the argument of this thesis that the combined impact of climate change and the tourism industry on Barbadian water resources acts as a mirror for the impact of climate change and other unsustainable practices on the environmental and social health of all countries at a distinct disadvantage due to low anthropogenic contributions and preexisting environmental risks in the era of climate change.

Chapter 2

Low Fault, High Punishment:
The Fate of Small Island Developing States

This chapter establishes the basis of the argument for climate justice by outlining the conflicting situation faced by many developing states, specifically small islands like those in the Caribbean. As Barbados is the case study for this thesis, the figures and comparisons in this chapter will focus on the island and the Caribbean region. These countries emit relatively small amounts of greenhouse gases and, though their characteristic economic development does not generally coincide with environmental preservation, the citizens are often expected to comply with suggested or mandatory conservation measures. Due in part to their size, amount of resources and economic dependencies, countries which contribute so little to climate change will suffer its consequences, possibly even more greatly than its developed counterparts.

Emissions: The Measure of 'Blame'

The Intergovernmental Panel on Climate Change has determined with "very high confidence" (at least a 90% chance of certainty) that "the global average net effect of human activities since 1750 has been one of warming" (IPCC, 2007, 3). The United States Environmental Protection Agency lists three human-induced variations in Earth's balance that contribute to climate change: the greenhouse effect, alterations in the sun's energy reaching the surface and changes in Earth's atmospheric and surface reflectivity or albedo (EPA, 2013). Each of these variations is caused in part by emissions.

The IPCC has found that the concentrations of greenhouse gases like carbon dioxide, methane and nitrous oxide in the atmosphere has risen since 1750 due to human

activities: “the combined radiative forcing due to increases in carbon dioxide, methane and nitrous oxide is +2.30 W/m2 and its rate of increase during the industrial era is very likely to have been unprecedented in more than 10,000 years” (IPCC, 2007). Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are the “key greenhouse gases emitted by human activities” (EPA, 2013) but water vapor, troposphere ozone (O_3) and chlorofluorocarbons (CFCs) are also important factors.

Burning fossil fuels is the primary source of human-induced carbon dioxide emissions, but land use patterns also affect the concentration in the atmosphere; while deforestation increases the amount of CO_2, reforestation has the opposite effect. Methane is emitted through agricultural practices such as raising livestock, waste management and energy use. Similarly, nitrous oxide is emitted through agricultural activities, primarily fertilizer use. (EPA, 2013). Since these emissions contribute to the EPA’s three human-induced variations in the planet’s balance, analyzing the quantity of these emissions is a common way of measuring a country’s contributions to climate change.

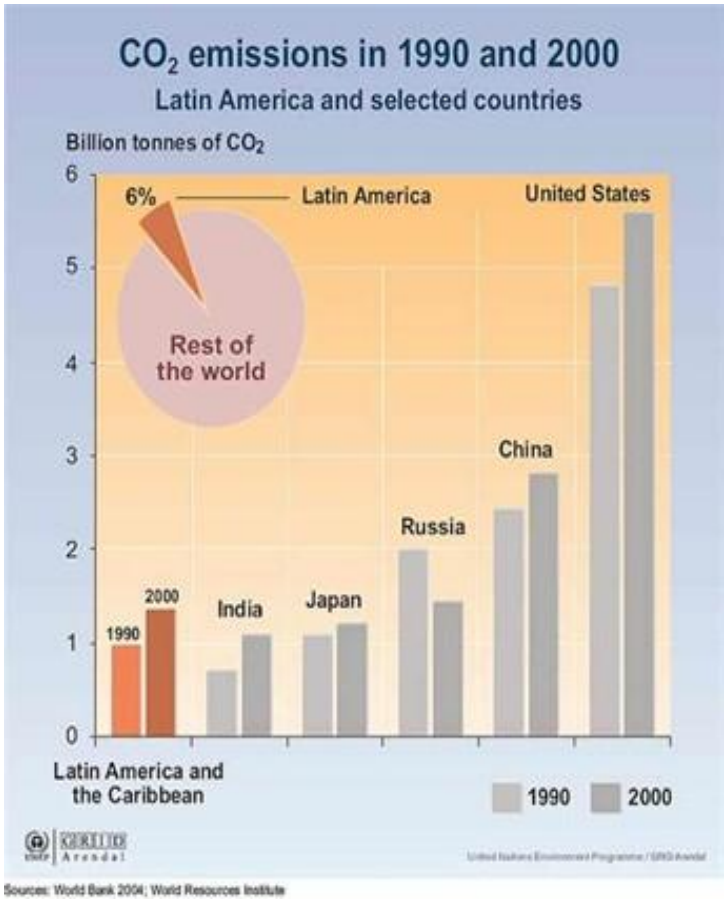

Figure 2-1: Carbon dioxide emissions in 1990 and 2000 (World Bank, 2004).

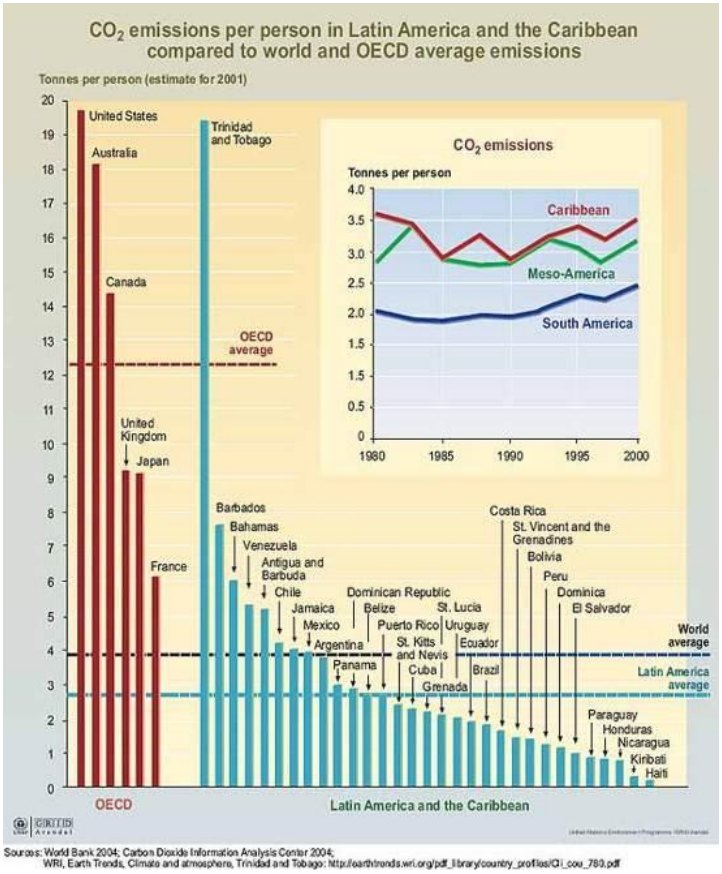

Figure 2-2: Carbon dioxide emissions per capita in Latin America and the Caribbean compared to world and OECD average emissions (World Bank, 2004).

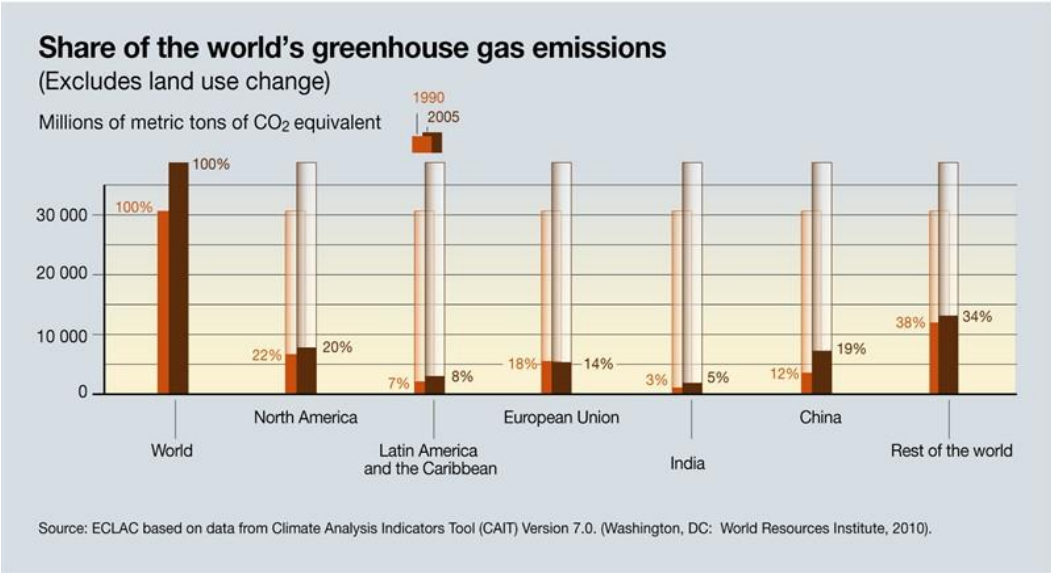

Figure 2-3: Share of the World's Greenhouse Gas Emissions (World Resources Institute, 2010).

Caribbean Contributions to Climate Change

The Caribbean is often grouped with Central, South or 'Latin' America for the purpose of emissions and climate change analysis. This regional definition is actually indicative of the fact that the Caribbean emits so few greenhouse gases; though the region is commonly referred to on its own, in the case of emissions, its percentage is not even enough to warrant its own title or section in comparison with other world regions. Figures 2-1, 2-2 and 2-3 demonstrate this grouping in a number of measurements and comparisons in regards to carbon dioxide emissions.

The Caribbean's 13 island and island groupings include Antigua & Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & the Grenadines and Trinidad & Tobago. Together, these 13 locations account for much less greenhouse gas (CO_2, N_2O and CH_4) emissions than their Latin American counterparts, let alone many OECD nations and the world average.

Carbon dioxide emissions are commonly considered indicators of contributions to climate change because of its ignition of the greenhouse effect and subsequent shift in the Earth's natural balance (EPA, 2013). As shown in table 2-1, Latin America and the Caribbean combine to have emissions of 1.59 billion metric tons total (World Bank, 2009). The CO_2 emissions from the Caribbean, however, totals 117,642,795 metric tons (calculated in Table 2-1), only approximately 7.4% of the entire 'Latin America and the Caribbean category (World Bank, 2009). Moreover, the 'Latin America and the Caribbean' category accounts for only 4.85% of the world's total CO_2 emissions, but the

true Caribbean carbon dioxide emissions only account for .359% of the world's total (World Bank, 2009).

Caribbean CO_2 Emissions			
Country	**CO_2 per Capita (metric tons)** (World Bank, 2009)	**Population** (World Bank, 2009)	**Total CO_2 Emissions (metric tons)**
Antigua & Barbuda	5.3	89,610	474,933
Bahamas	7.6	347,200	2,843,920
Barbados	5.8	273,900	1,588,620
Cuba	2.8	11,250,000	31,500,000
Dominica	1.9	67,680	128,592
Dominican Republic	2.1	10,060,000	21,126,000
Grenada	2.4	104,900	251,760
Haiti	0.2	10,120,000	2,024,000
Jamaica	3.2	2,709,000	8,668,800
Saint Kitts & Nevis	5.0	53,050	265,250
Saint Lucia	2.2	176,000	387,200
Saint Vincent & the Grenadines	1.8	109,400	196,920
Trinidad & Tobago	35.8	1,346,000	48,186,800
Caribbean Region	**3.2**	**36,706,740**	**117,642,795**
Latin American & Caribbean	**2.7**	**589,000,000**	**1,590,000,000**
World	**4.7**	**6,974,000,000**	**32,777,800,000**

Table 2-1: Total CO_2 emissions and CO_2 emissions per capita for Caribbean countries compared with Latin American and World averages (World Bank, 2009).

Unlike the World Bank's measurements for carbon dioxide emissions, there are few reputable sources with standardized measurements of nitrous oxide and methane across a global scale. However, the World Bank does reveal that agricultural land use is the leading global contributor for both of these gases. Nitrous oxide (NO_2) is emitted through fertilizers, both synthetic and animal manure, animal waste management and the burning of savannahs and agricultural waste. Like NO_2, methane (CH_4) is also emitted by burning as well as animals, animal waste and rice production. Globally, 53.3% of global nitrous oxide emissions and 43.2% of global methane emissions come from an agricultural source (The World Bank Group, 2012). Therefore, it stands to reason that

measuring the amount of land devoted to agriculture per region offers a glimpse at how much potential nitrous oxide and methane are emitted in these regions.

The unfairness of grouping Caribbean with Latin America in this category cannot be overstated. Whereas Latin America (Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Ecuador, El Salvador, Guatemala, Guyana, Honduras, Nicaragua, Panama, Paraguay, Peru, Suriname, Uruguay and Venezuela) and the Caribbean account for 36.1% (World Bank, 2012) of combined agricultural land in of the surveyed regions of China, India, North America, the EU and Latin America and the Caribbean. However, the Caribbean only accounts for 0.6% of the 36.1%, making its impact nearly sixty times smaller than that of Latin America. In fact, as shown in Table 2-2, Latin America has the most agricultural land of these regions at 6,231,477 km^2, followed by China which has 29.6% of agricultural land, the European Union with 12.3%, North America with 11.8%, India with 10.2% and the Caribbean has the least amount of agricultural land of those surveyed with 0.6% or 113, 390 km^2 (World Bank, 2012).

Agricultural Land Percentage by Region			
Country/Region	**Total Land (km^2)** (FAO, 2011)	**Agricultural Land (km^2)** (FAO, 2011)	**Percentage of Combined Agricultural Land**
China	9,327,490	5,191,482	29.6%
India	2,973,190	1,797,990	10.2%
North America	20,184,880	2,068,893	11.8%
European Union	4,181,721	2,156,456	12.3%
Latin America	17,961,282	6,231,477	35.5%
Caribbean	211,510	**113,930**	**0.6%**
TOTAL	--	**17,560,228**	--

Table 2-2: Agricultural land percentage by region (FAO, 2011).

Caribbean Climate Change Projections

Despite its low emissions and subsequent negligible influence on global climate change, the Caribbean region stands to suffer major losses in the face of these changes. According to the IPCC, sea levels will continue to rise around Caribbean islands at unpredictable rates with rise varying geographically (IPCC, 2007). Though the average warming in the region will not be much warmer than the global average, precipitation will be a determining factor in the health of the Caribbean in the era of climate change as summer rainfall in the Caribbean is likely to decrease (IPCC, 2007) leaving the islands susceptible to drought.

Coastal zones will be in a great deal of trouble due to climate change because of processes stemming from sea level rise like inundation, erosion and salt water intrusion

(IPCC, 2007). The Caribbean, in particular, is home to miles of coral reefs that line the coast. These reefs, already under threat from pollution, are some of the Caribbean coastlines' only lines of defense against the increased risk of extreme storms and hurricanes. As climate change influences the path and intensity of cyclones in the region, these reefs and their coastlines will be under extreme pressure; weather conditions such as these can erode the coast line, allowing sea level rise to inundate the land and sea water to seep into the freshwater supplies. Low-lying, coastal areas in the Caribbean are typically lined with houses, hotels, roads and other infrastructure – the threats imposed by climate change to these important and developed sections of these countries would be devastating to the human and economic resources at risk (Belle, 2005).

Chapter 3

Low Resources, Risky Economic Strategies and Environmental Vulnerability: Meet Barbados, a Caribbean Case Study

This chapter serves to establish a preliminary understanding of the history, government, economy, topography and climate of Barbados. This thesis examines Barbados as a case study for most small island developing states. This background information plays an important role in analyzing Barbados' current freshwater shortage and, specifically, the measures the government is taking to prevent disaster in the face of climate change. It also solidifies the critical function tourism has in the economy; this relationship, however, breeds conflict because of its impact on the looming freshwater crisis.

A Brief History of Barbados

The first inhabitants of Barbados established themselves around 1600 B.C. when they paddled to the island from Venezuela. These indigenous Barbadians formed several tribes and, over the years, the Caribs emerged as the tallest and the strongest, making them the dominant force on the island around 1200 (Barbados Tourism Encyclopedia, 1995). The Portuguese were the first Europeans to find the island and named it "Los Barbados" which translates to "bearded ones," a description of the numerous fig trees growing there. While the Portuguese quickly moved on in search of other Caribbean prospects, the Spanish landed in 1492 and were the first to attempt to colonize Barbados. The Spanish enslaved the Caribs and infected many of them with smallpox which contributed to the decimation of the tribe. As the Portuguese had before them, the Spanish left Barbados to compete for more profitable Caribbean land.

In 1627 the British landed with 80 settlers and 10 slaves to colonize the land. Eleven years later they established a House of Assembly, mostly for the purpose of

allocating land for those traveling from England with money and social influence. Under British rule, the 1630s and 1640s saw the land stripped for tobacco, cotton and sugar cane plantations (Barbados Tourism Encyclopedia, 1995).

The British needed help with planting and harvesting on their new land so they began a system of indentured servitude where those wishing to travel to Barbados for pay signed up for five to seven years of work on the island in exchange for passage from England; unfortunately, a great number of these servants were victims of kidnapping or criminals shipped to the island as slaves. From the 1640s to 1700, many African slaves were introduced to the island from Sierra Leone, Guineas, Ghana, The Ivory Coast, Nigeria and Cameroon. However, after a series of natural disasters including locust plague, fire, hurricanes, drought and excessive rain the Barbadian dominance in the Caribbean sugar industry was depleted and there was little need for slavery. As such, the practice was abolished in 1834.

Post-agricultural Barbados may not have been ideal for plantation owners and indentured servants but, after 1834, it became appealing for the some of the same reasons many tourists enjoy the island to this day. The slow pace of life and climate spurred a notion that the island was a cure for tuberculosis and, because of the British influence, the education system in Barbados was an influential factor to draw in settlement and promote infrastructure. In 1966, Barbados gained full independence from Britain and, to this day, maintains ties as a member of the Commonwealth (CIA, 2013).

Government

Barbados functions under a Constitutional Monarchy and Parliamentary Democracy. This means that as the country is a Commonwealth, the Queen of England is the Head of State but she grants all regulatory power to a mixture of appointed and elected officials. The country has a two-party system (Democratic Labour Party and the Barbados Labour Party) and, as shown in Figure 3-1, three branches of government (judicial, legislative and executive). The judicial branch includes three courts: the Magistrates' Court, High Court, and Court of Appeal. The country also maintains membership in the Caribbean Court of Justice and allows some appeals to the International Court of Human Rights (a branch of the human rights protection system of the Organization of American States). The legislative branch is more complicated. The Queen chooses a Governor-General to serve as her representative (Sir Elliot Belgrave is the current Governor-General) and this official oversees much of Parliament's appointments and functions. There is a 21 member Senate, 12 are appointed by the Prime Minister of Barbados (currently Freundel Stuart) and two are appointed by a leader of the Prime Minister's opposing party while the final seven members are appointed by the Governor-General. There is also a 30 member House of Assembly where each member is chosen by public election. The executive branch is made up of the Cabinet and the Prime Minister.

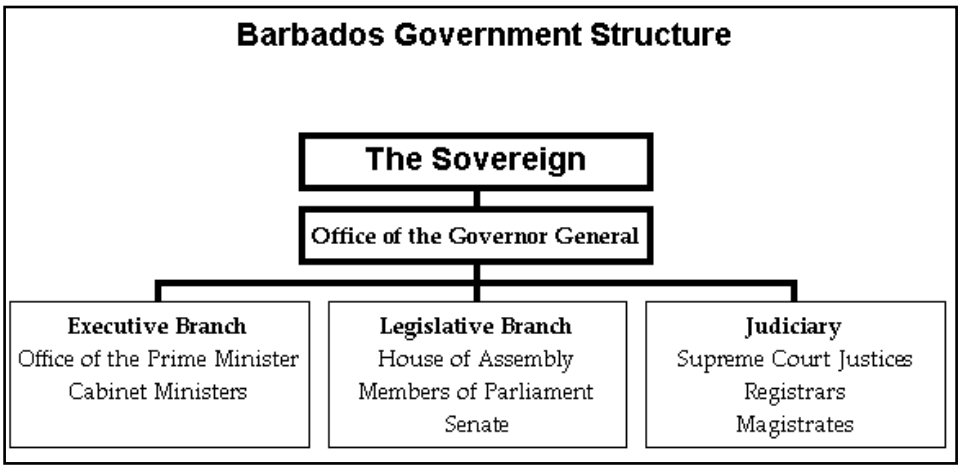

Figure 3-1: The government structure of Barbados (CaribData, 2011).

Rather than the electoral college system favored by the United States, Barbados decides its election with a simple majority, meaning that the political party which gets over 50% of the nation's votes will control the executive branch in elections held every five years. The Prime Minister controls a Cabinet with nineteen ministries which oversee the various functions of the Barbadian government including the Ministry of Agriculture, Food, Fisheries and Water Resource Management, Ministry of Environment and Drainage, Ministry of Housing and Lands, Ministry of International Transport and International Business, Constituency Empowerment and Community Development, and the Ministry of Tourism (CIA, 2012).

Development and Economy

According to the World Bank's World Development Indicators, Barbados's gross domestic product (GDP) is $3.685 million annually, its population is 273,900 and its gross national income (GNI) per capita is $12,660 (approximately $10,000 less than the

global average). In the category of 'improved rural water source,' Barbados is highly developed with 100% of its rural population having access to fresh water.

According to the CIA "Barbados is the wealthiest and most developed country in the Eastern Caribbean and enjoys some of the highest per capita incomes in Latin America" (CIA, 2013). The economy is historically dependent on sugarcane, cotton, tobacco, molasses and rum but now over 80% of its exports stem from the service industry, meaning that tourism is their primary source of national income; to be exact, the country's comes from agriculture (3.1%), industry (13.6%) and services (83.3%). In this same fashion, the 145,000 person labor forces is divided accordingly among the three sectors with 10% working in agriculture, 15% in industry and 75% in services (CIA, 2013).

Topography and Climate

Barbados (featured in Figure 3-2) is an isolated island located at the easternmost part of the Caribbean. The island is not mountainous but is elevated above sea level. It is approximately 430 km^2 which is about 2.5 times the size of Washington, D.C., of that land 50 km^2 is irrigated, 37.21% of the country is arable land, only 2.33% is used for growing crops and, of the other 60.46%, 18.6% is forest (CIA, 2013). The island's 97 km of coastline is surrounded by coral reefs, an important and endangered habitat that also works to protect Barbados' seashore. Mangrove swamps used to border the entire island but were cut back as their locations were idyllic for hotel construction; the two remaining wetlands are extremely important to preserve because they both protect the coasts and provide habitats for migrating fish and birds.

Figure 3-2: A map of Barbados (CIA, 2013).

Figure 3-3: A map of Barbados with major roads, water ways and political boundaries (CaribbeanIslands.us, 2005).

There are only three rivers on the island – this low number (evident in the map in Figure 3-3) can be attributed to the presence of several deep gullies that channel rainwater to the coast. These gullies ensure that water does not stay on the surface very long but instead becomes trapped between coral limestone and the sedimentary bedrock underneath. This process is fortunate because the island is made of 85% coral limestone; the limestone rock acts as a natural filter for the underground water and contributes to the water quality and potability in Barbados.

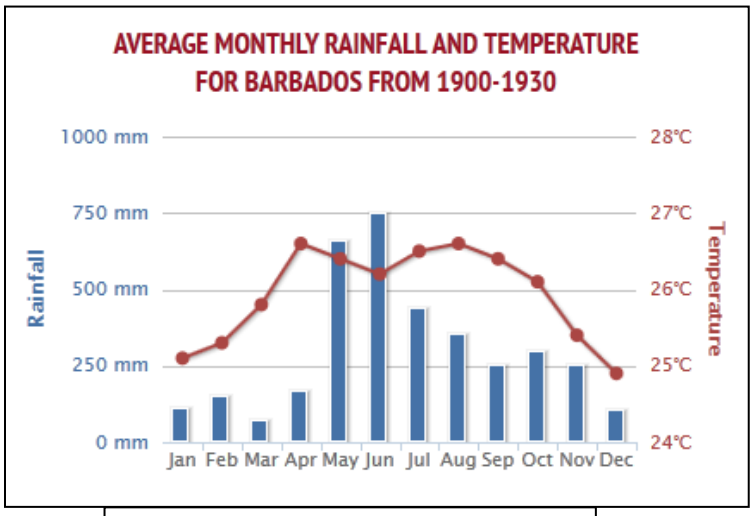

Figure 3-4 (World Bank, 2013)

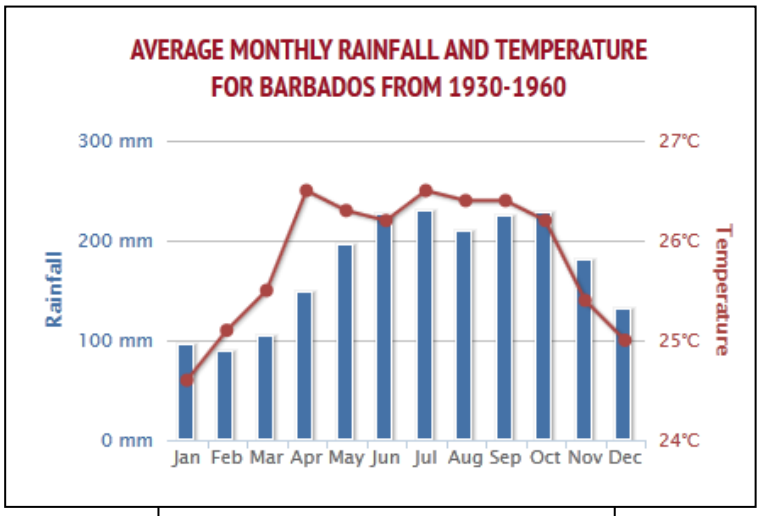

Figure 3-5 (World Bank, 2013)

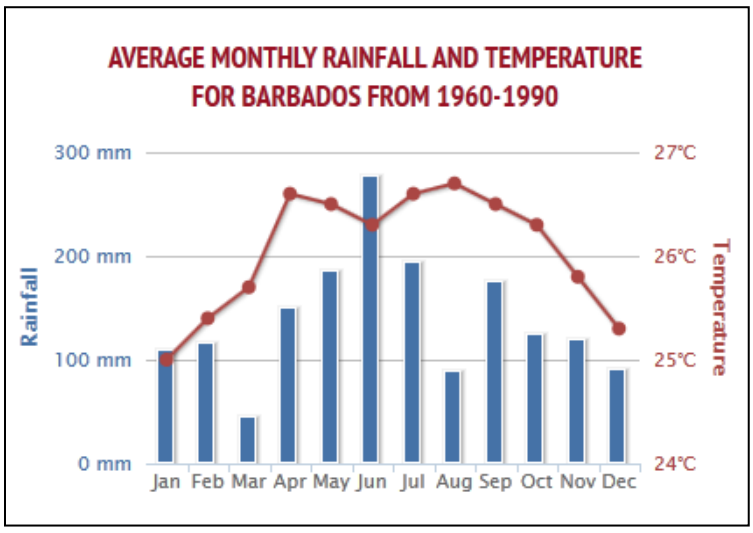

Figure 3-6 (World Bank, 2013)

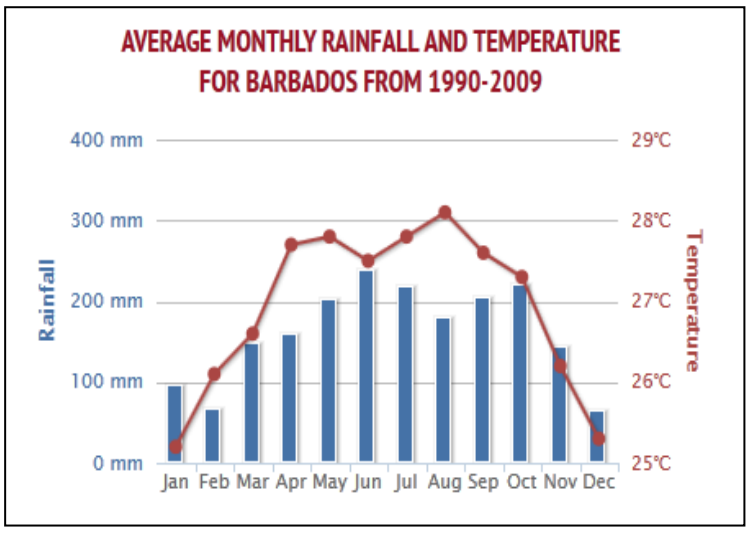

Figure 3-7 (World Bank, 2013)

The Barbadian climate is tropical which is typical of a Caribbean island. Barbados has both a wet and a dry season. The dry season occurs from December to May and the weather is mostly mild with cool winds and brief rain showers. The rainy season lasts from June to November with the most rain occurring between August and October. The World Bank has accurate recordings of the island's rain levels dating back to 1900. These measurements are average amounts of rainfall by month for 30 years (Figures 4-7).

From 1900-1930, the average annual rainfall was 300.45 mm, from 1930-1960, it was 174.37 mm and from 1960-1990 it was 135.71 mm. The most recent average only covers nine years from 1990 to 2009; this total is 161.7 mm. Using these numbers, the average annual rainfall from 1900-2009 is approximately 193.06 mm (World Bank Group, 2013). The average temperatures were recorded in the same fashion (Figures 3-4 through 3-7). From 1900-1930 the average temperature was approximately 26^{o}C, from 1930-1960 the average is 25.9^{o}C and from 1960-1990 the average is 26.1^{o}C. The most recent average only covers nine years from 1990-2009 and the temperature is 26.7^{o}C. This makes 26.2^{o}C the average temperature for the last 109 years in Barbados (World Bank Group, 2013).

The importance of a sound comprehension of Barbados' history, government, economy, topography and climate cannot be understated in the interest of understanding the implications of climate change on the island. Climate change will not only affect the natural landscape and ecology of the country, it will be pervasive throughout each level of social, environmental, economic and governmental systems. Tracing the impacts of change from their sources to the environments and people who will have to mitigate and adapt to these changes is only possible with an understanding of the historical and current basic systems in Barbados.

Chapter 4

Barbados' Freshwater and Plan for Sustained Potability

This chapter focuses on the availability and management of freshwater in Barbados as well as its distribution throughout the country. It aims to trace the water from its source to its disposal to consider the implications of climate change in future use. The chapter will also discuss measures Barbados is taking to prevent the projected negative consequences of climate change and adaptation efforts to meet upcoming challenges.

The Barbadian Water Cycle:

In 1861 Barbados began its first freshwater management system when the first islanders used stand pipes to collect water (pictured in figure 4-1). Rain water would collect in the standpipes and, in turn, islanders would collect water from the pipes and bring buckets back to their homes for basic usage. These humble beginnings were not indicative of the intricate and sophisticated water management scheme in place today in Barbados where 99% of homes on the island are connected to a system put in place by the Barbados Water Authority (BWA). The BWA is charged with supplying the island of Barbados with potable water and the provision of wastewater treatment and disposal services. The statutory body was established by legislation on October 8, 1980, thereby replacing the Waterworks Department of Government, and beginning its operations on April 4, 1981. The Barbados Water Authority's official designation is the responsibility of "monitoring, assessment, control and protection of the water resources in the public's interest" (BWA, 2012). The BWA defines potable water as a "product free of any

harmful substances or organisms and safe for all domestic purposes including drinking…achieved by using chemical and physical processes to remove or neutralize harmful substances or organisms" (BWA, 2012).

Figure 4-1: A traditional stand pipe where Barbadians used to gather with buckets to supply their homes with water (BWA, 2012).

Barbados has three major sources of freshwater: freshwater springs, wells, and water extracted by desalination processes. Each of these sources is monitored by the BWA, Environmental Protection Department (EPD) and Ministry of Housing, Lands and the Environment on a monthly basis. In particular, the springs in Barbados are heavily scrutinized by the Barbados Water Authority. While there are many springs across the island, only those at Codrington College Spring and Benn Spring provide potable water at present. Since the other natural springs on the island are major attractions for recreation, the BWA expends a lot of effort warning the public about the dangers of these waters. The agency is currently advising that anyone interested in doing more than swimming in

the springs boil all water as a means of decontamination before drinking or washing with it.

Wells are the largest font of water for the island with 22 well sources and seven boreholes. The geology of Barbados plays a large role in its well water accumulation. The island is made of 85% coral limestone; the karst topography acts as a filter for surface water runoff trapped between the coral limestone and sedimentary rock underneath, purifying it until the underground water can be pumped to the surface for human use.

Much of the purified well water is mixed with water pumped into the system using desalination plants. Desalination of seawater, brackish groundwater or river water for public use is being utilized more often as traditional sources of potable water become increasingly less available. While its primary goal is to provide potable water, the process also opens countries to the potential of desalinating wastewater to be used for mining and industrial purposes which not only recycles old water but takes pressure off of the potable supply. Drier and warmer climates are prime candidates for desalination plants due to their increased need for freshwater supplements and the method is already used extensively in the United States, Singapore, China, Europe, the Middle East, North Africa and Australia. Over the last five years, over 800 desalination plants have been constructed annually with the Middle East acting as the current dominant market for the facilities (BWA, 2012). At present, Barbados is using a desalination method called 'Brackish Water Reverse Osmosis' (BWRO) which is a membrane separation process (depicted in figure 4-2) in which water from a pressurized saline solution is separated from the dissolved material by flowing through a membrane (BWA, 2012).

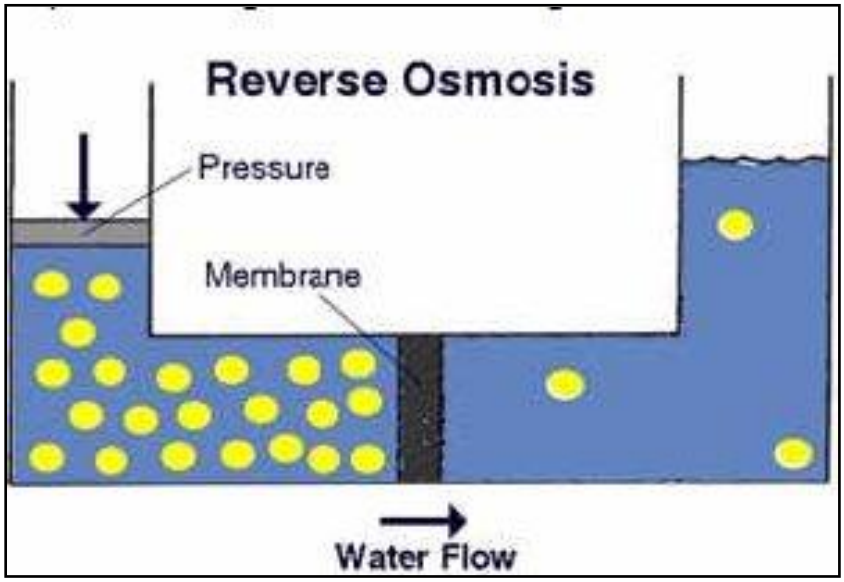

Figure 4-2: A diagram explaining the basics of reverse osmosis (BWA, 2012).

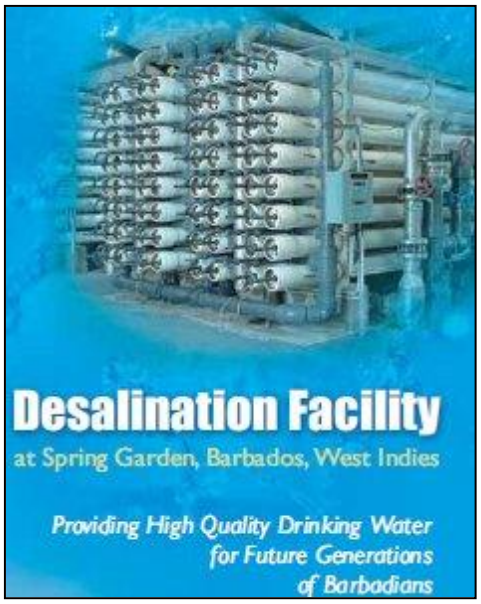

Figure 4-3: A picture of the Desalination Facility from its brochure (Ionics Freshwater Ltd, 2008).

The Barbados Water Authority supports the Desalination Facility at Spring Garden, Barbados, a facility created by a private company named Ionics Freshwater Ltd (pictured in figure 4-3). This plant began operations on February 15, 2000 and is the largest brackish water desalination facility in the Caribbean. The plant provides Barbados with 30,000 cubic meters of potable water per day and passes the same biological tests as the rest of Barbados's water supply; water from the plant could potentially supply drinking water for 20% of the island's population (Ionics Freshwater Ltd, 2008). The brackish water initially pumped into the plant comes from ten different wells each 80 feet beneath the surface; however, before the desalination process begins, pretreatment is required. Pretreatment entails the removal of suspended solids in the liquid and the introduction of antiscalant to prevent any mineral build-up. Once the water is ready, the reverse osmosis desalination process begins. The system used at the BWA's

Spring Garden facility manages to reduce the overall energy requirement of the process by using a combination of membranes functioning at low pressure. The water is then treated with lime dosing for mineral content and taste and transferred to a storage tank at the facility before being tested and sent to BWA reservoirs to mix with well and spring water.

The Barbados Water Authority has 27 reservoirs attached to 22 pumping stations and 14 re-pumping stations which connect to over 2,000 miles of transmission and distribution mains (BWA, 2012). The water provided by the government agency goes to every home and business connected to the mains and works either as the singular source of potable water or, in the case of homes with private water tanks, as a supplementary stock. Homeowners in Barbados are encouraged to own and operate their own water tank. It is mandatory for new homes built with a floor area of 1,500-1,999 square feet to have a water tank of at least 3,000 gallons (BWA, 2012). New homes built with over 2,000 square feet of floor area are required to have a tank of 6,000 gallons (BWA, 2012). These tanks are very popular, especially in island nations where rainwater (and groundwater collected due to surface run off after rains) is the premier source of potable water. The tanks (shown in figure 4-4) work by collecting rainwater in the gutters and pumping it through a sediment filter powered by gravity's force on the water. The water flows from the filter to the tank where it waits to be used as needed by the household.

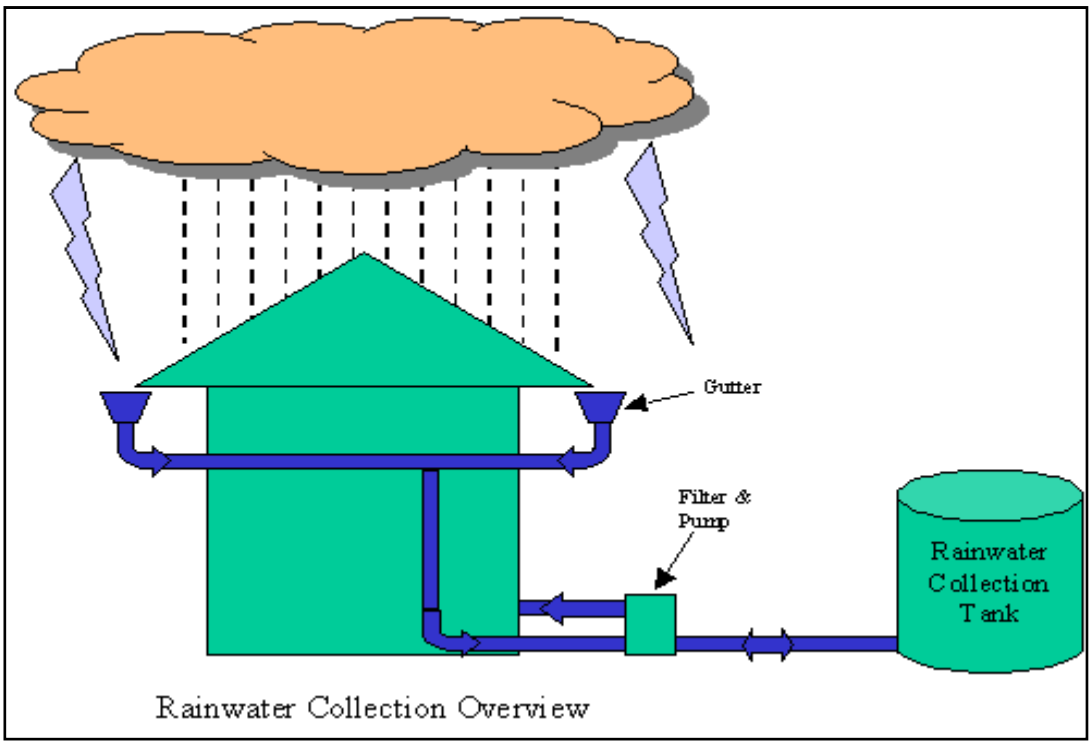

Figure 4-4: A diagram explaining the basics of home-based rainwater collection tanks (BWA, 2012).

The final step in the Barbadian water cycle is wastewater management. There are two sewage treatment plants in Bridgetown and the South Coast. In order to have a connection to these treatment facilities, owners and occupants of each household pay a lump sum for the initial connection then an additional fee in their monthly water bills for the collection, treatment and disposal of the wastewater. In Bridgetown, the water receives primary and secondary treatment meaning that both suspended and dissolved solids are removed but in the South Coast facility, only primary treatment is performed. The discharge from the two plants face one of two fates: effluent water is disposed of in the sea and the remaining sludge is sent to the island's landfill.

Barbadian Water Projections in the Face of Climate Change:

Barbados has been declared a water scarce country by the United Nations (BWA, 2012). The parameters by which a country is judged by the Food and Agricultural Organization (FAO) are per capita water resource availability. If the country has less than 1,000 cubic meters of water per capita per year, it is deemed water scarce (one cubic meter of water is equal to approximately 220 gallons). As of 2012, Barbados only has 390 cubic meters of water per person per year. The country's supply is threatened by increasing population, a rising standard of living and, most conspicuously, climate change.

The Barbados Water Authority states that "climate change is likely to impact significantly on our island and there must be decisive action to deal with the financial, social and health impacts if we are to brave the storm," (BWA, 2012). The primary concerns for the country include extreme weather conditions resulting in a surplus of rainwater, flooding, rising sea levels, ocean acidity, drought, and disease. According to recent reports (BWA, 2012) the BWA is concerned that an increase in hurricanes will cause flooding, rising sea levels, destruction of the coral reefs and more acidic oceans. Rising sea levels will, in turn, overwhelm low-lying lands, erode beaches and intensify flooding. Flooding from the ocean will increase the salinity of groundwater tables; this is a truly tragic consequence as the majority of Barbados's potable water comes from wells containing the surface runoff turned limestone-purified groundwater (BWA, 2012).

Agriculture is also heavily dependent on freshwater and, as such, will be highly impacted by climate change. Weather extremes including droughts, heat waves, and severe storms and flooding will decrease crop yields. In addition to this predicted lack of

water and food, the burden of disease will rise when disaster occurs. Drought both triggers and exacerbates malnutrition and famine by denying people access to adequate water supplies. It also leads to an increase in migration and homelessness (BWA, 2012). However, most of the disasters predicted for Barbados will result from flooding which impacts the water supply through poorly structured sanitation systems and contamination from industrial waste and refuse dumps. Sickness and disease will spread easily, especially without clean water and adequate nutrition to strengthen the population.

Mitigation and Adaptation

The Barbados Water Authority recognizes the danger of climate change and has reacted accordingly with their designation as a United Nations water scarce country. The Spring Garden Desalination Facility is a major preventative measure. It was built in 2000 to prevent a dry spell or drought catastrophe and supplement the current Barbadian potable water supply. This plant currently focuses on deep groundwater but it has the potential to desalinate seawater or wastewater that has been previously treated. At present, the water from this desalination plant is tested and mixed with well water, but there is a possibility that wastewater will, in the future, be cleaned enough to use in mining and industrial settings.

The BWA also has a groundwater zone protection policy (mapped in figure 4-5) which it introduced in 1963. Zone one affords the highest level of protection. These areas designated as having zone one status are within 300 days travel time of existing potable water sources when the source is being pumped at its design rate. No further development other than improvements to what already exists is allowed in zone one areas

and existing residencies must be fitted with septic tanks. Zones two through four have similar, yet less precise restrictions and mostly focus on protecting water sources from organic compounds that are not water soluble or are hard to degrade. The entire island of Barbados is broken into these zones and the BWA is heavy-handed in its restrictions; the limited water supply the country faces cannot afford the agency to behave any differently. However, zone five has no developmental controls. It should come as no surprise that this zone, which spans the entire coast, is prime real estate for the tourism industry. This is especially true of the thick section of zone five on the southwest coast where higher priced, luxury resorts are concentrated (Belle, 2005).

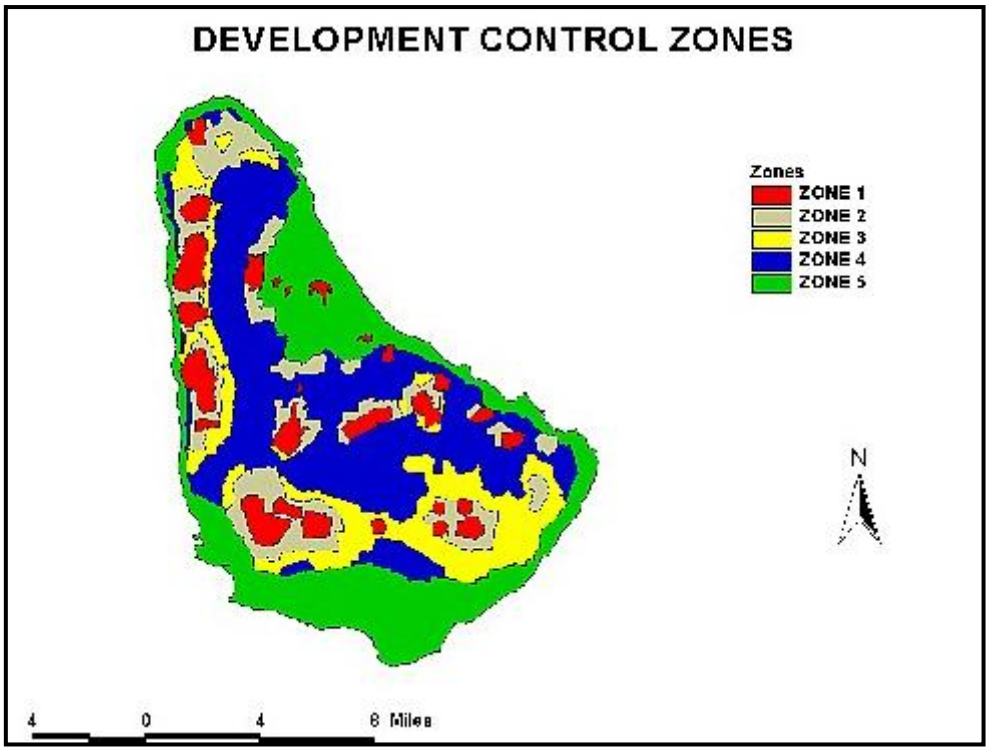

Figure 4-5: A map of development control zones by the BWA – it is important to note that zone five, where development has no restrictions, is prime real estate for the tourism industry (BWA, 2012).

On a public level, the BWA Drought Management Plan has been put into place with three stages: voluntary, mandatory and extreme. Once the stages are enacted, unless potable water levels increase dramatically, lifestyle in terms of water usage undergoes a dramatic change; there is no return to a time before the management plan's restrictions. Barbados is currently in the voluntary stage of the plan.

The voluntary stage of the plan means that the BWA's task force is mobilized and water table levels, reservoir levels and salinities are measured constantly. As the Water Authority works, the public is asked to follow conservation suggestions. These suggestions include not watering ornamental plants and lawns and not washing vehicles. If the public wants to do any of these things, they are encouraged to save the cold water that first comes from the shower in a bucket while they wait for warm water in which to bathe. The agency's website also suggests a whole list of ways to make homes and offices more efficient. These include recommendations such as: detecting and fixing leaks around the home, purchasing faucet aerators and low-flow showerheads which create a strong spray while reducing the water use by half, only flushing water-soluble materials down the toilet, installing high efficiency washing machines and dishwashers and purchasing water tanks to complement the BWA's supply.

If the BWA has its choice, rain harvesting will be the future of potable water in Barbados. The agency is encouraging people to gather and filter their own rainwater for personal usage rather than using the water authority's supply. This practice is already commonplace and highly successful in similar countries like Bermuda. Homeowners are obliged to have their own water tanks and almost ever new home is equipped with a tank; houses being built at present have a mandatory requirement of a 3,000 gallon tank. This

requirement rises to 6,000 gallons if the floor space of the home exceeds 2,000 square feet. In addition to its countless tips on water conservation, the BWA's website has several ads for water tanks and home filtration systems.

Water tanks are not the only plea the Barbadian government is making to its people. In fact, all of the BWA's suggestions to conserve water are deeply rooted in public compliance: "Caring for our water is not just the business of the government, it is everybody's business" (BWA, 2012). In a single statement, the BWA places the blame on civilians for wasting water and goes so far as to imply that citizen participation might solve the vast challenges the country faces, stating that "You will be surprised at how much water you waste in your home, but that can be controlled by examining your faucets, toilet bowls, shower heads, washing machines, dish washers, hoses and your personal habits. Conserving water is going to mean that you make a personal decision to change your habits and your attitude towards water" (BWA, 2012). However, decreasing domestic use of the island's freshwater supply will have a miniscule effect on overall consumption; the people of Barbados are not causing the problem with their use at home, nor are their attempts to conserve a viable solution.

Even if every citizen participates, taking shorter showers, making sure laundry loads are full and purchasing rainwater tanks will mean nothing in a country where 10% of national freshwater use comes from international tourism (Gossling, 2012). The average country devotes less than 1% of its freshwater to international tourism, 70% to agriculture, 20% to industry and 10% to domestic and public service purposes. In Barbados, less than 15% of the national water is devoted to domestic purposes and, of that 15%, 10% is used for international tourism (Gossling, 2012). Though the Barbadian

tourism sector's use currently exceeds its renewable resources by a factor of 15 (Gossling, 2012) the relatively low-impact domestic sector is the focus of instructions to reduce consumption. The country may not have reached the point of imposing mandatory water conservation yet, it is expected to be chronically short of water by 2050 (Gossling, 2012). With its citizens already only using 5% of the national supply to support their lives, the government will have a hard time justifying mandatory cuts to personal usage while allowing international tourism and its complete lack of BWA developmental controls along the coastal zone five to continue at its current rate despite the imminent decimation of the island's freshwater supply.

Chapter 5

The Complicated Nature of Barbadian Tourism

This chapter analyzes the international tourism industry in Barbados, outlining its influence on the economy and employment as well as the government and development of the country. It considers the pressures tourism places upon the freshwater supply and how its level of usage compares to other sectors within the Barbadian economy. It also discusses the possibility of maintaining the industry without sacrificing freshwater supply through sustainable tourism.

Barbadian Economic Reliance upon Tourism Sector

With beaches and coral reefs as its primary draw, tourism in Barbados is naturally concentrated along the shoreline in the Barbados Water Authority's fifth developmental zone (figure 4.5). Development is unlimited by law and is centered largely along the west and south coast; the west coast has grown into a haven for luxury tourism while the south is a more budget friendly-location. The Barbadian Minister of Tourism describes the industry as "the mainstay of the Barbadian economy and a major foreign exchange earner for the country" (Sealy, 2011, 1).

Large scale tourism development began in Barbados in the late 1950s and grew rapidly; a mere decade later in 1966 the number of overnight guests was 79,104 (Belle, 2005). By 2001 the number rose to a total of 507,078 overnight international tourists and 527,597 cruise ship passengers, accounting for 52.6% of Barbados' foreign exchange earnings and 10.6% of its employed workforce (Belle, 2005). The Ministry of Tourism's

most recent statistics show that the number of overnight international tourists has risen to 567,724 and the number of cruise ship passengers to 619,054 (Barbados Ministry of Tourism, 2011).

The total expenditure of stay-over visitors in Barbados was $915,020 in 2011 with the United Kingdom as the primary country of residence for 40% of the money spent in Barbados, closely followed by the United States at 22% (Barbados Ministry of Tourism, 2011). While this directly tourism-based income may only be a small part of the country's $3.685 billion GDP (World Bank, 2013) the loss of this income would greatly harm the economy through the loss of jobs it currently represents.

Barbados has a population of 273,900 (World Bank, 2013) with approximately 128,375 people employed in 2011 (Barbados Ministry of Tourism, 2011). The tourism sector in Barbados currently employs over 13,000 citizens across eight sub-divisions: accommodation, food and beverage, adventure tourism, transportation, attractions, travel trade, events and conferences, and tourism services (Government of Barbados, 2011). This number means that in 2011, over 10% of the employed population worked for the tourism industry directly under the realm of 'Accommodation and Food Services' (Table 5-1). In fact, only two other markets (Construction, Mining & Quarrying and Wholesale & Retail Trade) employed more people and other sectors indirectly related to the tourism industry (Finance & Insurance, Transportation & Storage, Elec. Gas, Steam, Water & Air Conditioning Supply, and Agriculture, Forestry & Fishing) employed an additional 21,050 people or 16.4% of the workforce (Barbados Ministry of Tourism, 2011). Therefore, despite being only the third highest employer of 17 categories, the indirect employment that stems from the tourism sector combines to account for almost 27% of

the employment market, making the industry the most important economic asset to the citizens of Barbados vested in the job market.

Employment by Industry and Sex

Industry	2011											
	Thousand Persons											
	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter		
	SEX		Both	SEX		Both	SEX		Both	SEX		Both
	Male	Female	Sexes	Male	Female	Sexes	Male	Female	Sexes	Male	Female	Sexes
Agriculture, Forestry & Fishing	3.7	2.0	**5.7**	2.8	1.5	**4.3**	2.6	1.1	**3.7**	2.3	0.9	**3.1**
Construction, Mining & Quarrying	13.0	1.5	**14.5**	12.4	1.0	**13.4**	13.4	1.4	**14.9**	14.0	1.7	**15.8**
Manufacturing	4.6	4.0	**8.6**	5.5	2.6	**8.1**	4.5	3.4	**8.0**	5.1	4.5	**9.6**
Elec. Gas, Steam, Water & Air Conditioning Supply	1.8	1.2	**2.9**	1.9	1.0	**2.9**	1.9	0.7	**2.6**	2.3	0.9	**3.2**
Wholesale & Retail Trade	8.6	10.6	**19.2**	8.4	11.8	**20.2**	9.5	11.8	**21.4**	8.8	11.5	**20.3**
Transportation & Storage	7.4	1.9	**9.3**	6.8	2.1	**8.9**	6.4	2.0	**8.4**	5.4	1.9	**7.4**
Accommodation & Food Services	4.3	8.0	**12.3**	5.0	8.6	**13.6**	5.3	7.7	**13.0**	4.6	9.1	**13.7**
Finance & Insurance	2.3	3.4	**5.7**	2.1	4.0	**6.1**	2.2	3.9	**6.2**	1.8	3.0	**4.8**
Professional, Scientific & Technical Services	2.1	1.8	**3.9**	2.2	1.9	**4.1**	2.3	1.8	**4.1**	1.8	2.4	**4.2**
Administrative & Support Service	5.0	4.0	**9.0**	4.8	3.7	**8.5**	3.9	3.0	**6.9**	5.0	2.6	**7.6**
Public Administration & Defence	4.5	4.5	**9.0**	4.9	4.5	**9.4**	5.1	4.3	**9.4**	5.1	3.5	**8.6**
Education	1.5	4.0	**5.5**	2.1	4.5	**6.6**	2.2	5.5	**7.7**	2.3	4.8	**7.0**
Human Health & Social Work	1.6	5.2	**6.7**	1.7	5.1	**6.8**	1.2	4.6	**5.8**	1.2	5.3	**6.5**
Other Services	2.6	2.5	**5.1**	1.1	2.7	**3.8**	1.1	2.2	**3.3**	2.1	2.5	**4.5**
Activities of Households as Employers	1.2	4.9	**6.1**	0.8	3.9	**4.7**	1.0	4.3	**5.3**	1.0	3.8	**4.7**
Other Groups *	3.4	3.9	**7.3**	2.8	3.2	**6.0**	3.3	3.2	**6.5**	3.3	3.3	**6.6**
Not stated	0.1	0.0	**0.1**	0.4	0.1	**0.5**	0.0	0.0	**0.0**	0.0	0.0	**0.0**
Total	**67.4**	**63.4**	**130.9**	**65.7**	**62.2**	**127.9**	**66.1**	**60.8**	**126.9**	**66.0**	**61.7**	**127.8**

Table 5-1: Barbadian Employment by Industry and Sex for 2011 (Barbados Ministry of Tourism, 2011).

Reciprocal Negative Influences of Tourism and Climate Change

It is evident that the influence of climate change on Barbados will not be positive. The tourism-based infrastructure along the coast was hastily constructed in the 1950s and 1960s and, in many instances, this poor planning of the tourism industry combined with overuse exacerbates the challenges the island must meet in the face of climate change. However, the tourism industry will also suffer the negative consequences of climate change alongside its host country (Belle, 2005). Regardless of its negative impact, the tourism industry accounts for a great deal of capital and employment and, therefore, any

blows taken by the sector will be nearly as devastating to the country as most of the effects of climate change intensified by tourism.

Perhaps due to its focus on rapid development and relative immediacy in maximizing income, the Barbadian tourism industry developed with an absence of strong tourism planning framework. According to the Ministry of Tourism, this deficiency in the early stages of planning has contributed to a wealth of social and environmental problems: "In the past, tourism projects of all types, particularly hotel development along the coast, occurred with little consideration to the negative environmental impacts that they could have on these coastal areas" (Barbados Ministry of Tourism, 2001, 1). Though attractions and accommodations abound nearly 50 years after the tourism industry's initial expansion, the island's climate and coastal landscapes remain Barbados' two key pull-factors for international tourists. Poor planning and subsequent environmental degradation has left these natural draws unprepared to weather the conditions the island faces from climate change.

It stands to reason that, with the majority of its international tourism stemming from markets in the northern hemisphere, Barbadian tourist destinations are popular during the north's winter months. The months of December until May are the Barbadian dry season which is typified by cool winds and brief rain showers. Barbados' freshwater primarily comes from well sources or, in the case of self-sufficient (or, at least, partly self-sufficient) buildings, rain-collection tanks. The consequence is that unless Barbadians find a way to make the contaminated spring water or gray water from their single desalination plant potable, they are dependent upon rain water for drinking, cooking, washing and all other clean freshwater purposes. The dry season offers little

rain to supply these stocks so, even without the pressure of climate change, water is scarce from December until May (Gossling, 2012). The Barbados Water Authority estimates that drought will be a major problem during future dry seasons writing that climate change could lead to disasters including drought which would "trigger and exacerbate malnutrition and famine by denying access to adequate water supplies" (BWA, 2012).

With the impending drought conditions climate change threatens the island with, it might be time for Barbados to reevaluate how much of their undeniably precious water supply is sapped by tourism. These months already see tourism-heavy regions face a heavy threat to their water quality and availability due to increased use but, while citizens of Barbados are subject to government-encouraged water conservation, the tourism industry consumes water with no regard for the scarcity its host country faces. It has been estimated that the average tourist, staying in a hotel in a tropical environment consumes over 900 liters of water each day directly from their accommodations (Gossling, 2001). Gardening and irrigation account for 465 L per tourist per day, direct usage such as showers, flushing the toilet and tap water account for 186 L per tourist per day, swimming pools account for 140 L per tourist per day, subsequent laundry from the swimming pools account for 47 L per person per day, cleaning accounts for 47 L per person per day and restaurants account for 47 L per person per day (Gossling, 2001).

More water is consumed by tourists indirectly through infrastructure, activities, fuel usage and food. Its use in the construction of buildings accounts for 17% of global water usage; in fact, the only material more consumed than water is concrete. Tourism's contribution to this 17% global water use is likely substantial considering 49% of the

world's concrete goes into residential, industrial and commercial buildings (Gossling, 2012). Activities like swimming pools, golf course maintenance and spas also consume a lot of water in tropical tourism locations, not to mention the fuel costs of transporting tourists to these activities. It takes 18 L of water to produce 1 L of gasoline and the average international tourist trip uses 5,600 L of water in fuel (Gossling, 2012). Finally, food production requires a great deal of water; every kilocalorie of food is equal to one liter of water, therefore, human diets need approximately 2000-5000 L of water per person per day to meet their caloric requirements. It takes 400-2,000 L of water to produce a kilogram of wheat and 1,000-10,000 L of water to produce a kilogram of meat. Since tourists tend to consume protein-rich foods with greater water footprints and often require fuel to import their food, the amount of water used to sustain their diets on vacation is likely much higher than that of their diets at home (Eurostat, 2009).

According to the Food and Agricultural Organization (FAO), a country is deemed water scarce if it has less than 1000 m^3 per capita per year – Barbados has 390 m^3 per capita per year (BWA, 2012). Since one liter is equal to one thousandth of a cubic meter, this means that Barbados has 3.9 million liters of freshwater per person per year and a population of 273,900. This deficiency does not even begin to factor in the tourism industry. In 2011, 567,724 people visited Barbados (Barbados Ministry of Tourism, 2011). Assuming that each tourist stays for an average of two weeks, on any given day there would be 21,835 tourists in Barbados. Their addition to the population means that 295,735 people are meant to share the 3.9 million liters per person per year with 7% of those people (tourists) directly using over 5 times the amount of water than the Barbadian

people and indirectly (infrastructure, activities, fuel and food) using an immeasurable sum of water.

Despite all of the pressure the tourism sector places upon resources during the dry season, it also stands to lose business in regards to the upcoming extremes of climate change. Barbadian businesses need to be concerned with climate change's impact around the globe as well as their own country as the tourism industry there has such an international appeal. The majority of tourists in Barbados primarily come from the United Kingdom, United States and Canada. In time, much of the land in these source countries is expected to experience milder winter temperatures, meaning that a winter vacations might become unnecessary or replaced by a cheaper trip to a warmer part of their own countries. This will result in less business for tropical islands like Barbados where tourists frequently visit to escape cold weather in their own countries. Many are worried that less tourism means less air traffic to Barbados which, combined with levies raised to compensate for greenhouse gas emissions, could result in heightened airfare for Barbadians.

The wet season (June-November) is also exacerbated by climate change at great risk to the health of the environment and, with it, the tourism industry According to the Barbados Water Authority "there is some thought that an increase in hurricanes, flooding, drought, rising sea levels, destruction of the coral reefs and more acidic oceans is possible" (BWA, 2012, 1). While the flooding has obvious repercussions for the health of the country's water by inundating its sanitation systems and possibly contaminating the freshwater supply, these more extreme natural disasters could be trouble for the tourism industry by destroying the island's beaches.

The coast of Barbados is protected by 4.9 km^2 of bank coral reefs and 1.4km^2 of fringing reefs (Belle, 2005). These reefs are important for sand creation, beach stabilization and the prevention of erosion because they take the brunt of most tidal impact and dissipate wave energy before it can damage the shoreline. Tourists are also drawn to the reefs for snorkeling and scuba diving, creating another source of income as an attraction for the Barbadian tourism sector to promote. The reefs, however, are fragile and do not fare well with changes to their environment. Increased seawater temperature, inadequately treated sewage and contamination from fertilizers and pesticides all contribute to coral bleaching and subsequent decay (Belle, 2005). Without coral to protect the shores, the increased risk of extreme storms and hurricanes becomes more likely as these weather conditions can erode the shoreline and contribute to sea level rise and salt water intrusion.

Climate change will lead to inevitable problems for coastal infrastructure: "As tourism has developed since the 1960s and up to the present day, this low-lying area has become completely developed with houses, hotels, roads and other infrastructure…The vulnerability of this coastal area now is very high, and besides coastal ecosystems, there are now many human and economic resources at risk" (Belle, 2005). Over 90% of the hotels on the island are on the beach with 70% of all hotels located mere meters from the high water mark. According to estimates of future erosion this means that "the islands hotels [are] sitting almost exclusively within the inundation zones" (Belle, 2005) which places them at great risk for structural damage. Salt water intrusion will also inundate the island's hotels by wreaking havoc on the freshwater sources. All of Barbados' potable well water sources fall within coastal zones (Belle, 2005) and all of these aquifers are

connected to the sea and unconfined, leaving them very capable of collecting rain and ground water but also highly vulnerable to being flooded with salt water.

Possibility of Sustainable Tourism

The World Trade Organization defines sustainable tourism as "leading to management of all resources in such a way that economic, social and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity, and life support systems," (Mycoo, 2006,491). The Caribbean is arguably the most tourism-based and dependent region in the world. It is also the most tourism-penetrated, meaning the industry has left an irrevocable impact on the landscape. Barbados, like the rest of the Caribbean, has a long history of policy failure when it comes to sustainable tourism. Mass tourism has left the island to deal with coastal degradation and water pollution. Three major policy weaknesses are holding Barbados back from maintaining sustainable tourism standards: too basic of sewage treatment, a lack of required environmental assessments and low levels of community participation.

Barbados' sewage treatment is still too basic and, when the effluence is discharged into the sea, the nutrients attack vulnerable coral reefs and sea grass beds (Mycoo, 2006). The destruction of these coral reefs would lead to beach erosion and the demise of the Barbadian tourism industry but, rather than helping to find a solution, the industry often aggravates the problem by concentrating development and achieving "green" standards. Development concentration is obvious; the industry has a tendency to have spatially concentrated resorts near a natural attraction (in this case, the reefs) and

this high density development constrains resource planning. Basically, the rapid market-driven growth of the area has no regard for the severe alterations its presence will make on the ecosystems it seeks to promote. While these development concerns have existed since the industry's birth in Barbados, the dilemma of green standardization is relatively new.

In recent years, green certification has gone from a measure of excellence to a measure of normality, meaning that many hotels will do the absolute minimum they must to meet the standards and receive their label (Mycoo, 2006). The contention surrounding certification is that, while meeting the absolute minimum standards help business, they do not always help the community or environment. In Barbados, the problem is that many hotels treat and dispose of their own waste water to meet green certification but, without constant supervision and a great lack of training, their water is often untreated and disposed of in the ocean where it pollutes the marine environment (Mycoo, 2006). If Barbados is expected to achieve sustainable tourism practices, this problem will definitely have to be solved.

One such method to stem the flow of hotels that cannot maintain green certification would be the implementation of environmental impact assessments for projects that might damage the environment. Currently, Barbados does not require these assessments by law. This has been called a "serious policy failure" (Mycoo, 2006) because these assessments are a helpful tool in forming the basis of taking preventative measures in environments sensitive to climate change and degradation from pollution. Most notably, the coastal areas in Barbados would benefit greatly from environmental

impact assessments done to mitigate and monitor the impacts of construction by the tourism sector.

Finally, Barbados must break free from the promise of short-term economic benefits if it is to achieve sustainable tourism standards. The appeal of predictable and fast money from the classic tourism model is tempting, but the country needs to realize that the danger of long-term environmental degradation from this model far outweighs any immediate benefits. One such way of implementing this mindset is to create a conversation with the community and give a voice to those most affected by the tourism industry. Barbados, like many other tourism-dependent, small island nations maintains no such dialogue, controlling the sector with only those involved in the politics and economics of the industry (Mycoo, 2006). In order to make any of the aforementioned changes, Barbados must involve its people. The benefits to community involvement are plentiful but the most important factor is giving Barbadian citizens a voice in the blatant unfairness in how their nation divides and controls it resources. The government already asks its citizens to conserve water and take steps within their own homes to combat the negative influences of climate change – should they not also take stake in the industry that both degrades their land and sustains their economy?

Chapter 6

Conclusion

This thesis has provided a case study of the current situation Barbados faces due to the dual influences of climate change and international tourism at the hands of developed nations with high levels of emissions. Many developing states, specifically small islands like those in the Caribbean face such a conflict. These developing countries emit relatively small amounts of greenhouse gases and their citizens are often expected to conform to suggested or mandatory conservation measures yet, the countries' characteristic economic sources' (tourism, industry, etc.) often exhibit noncompliance with the same conservation measures. Their combined size, low resources and heavy economic dependencies on environmentally harmful practices mean that these countries which contribute so little to the emissions behind climate change will suffer its consequences at a rate disproportionate to their contributions.

An understanding of Barbados' history, political system, economy, topography and climate are necessary to appreciate the analysis of Barbados' current freshwater shortage and the role of the government in preventing water-related disasters in the face of climate change. Additionally, the analysis of the country's economy emphasizes the importance of the tourism sector to the economy, infrastructure and well-being of the Barbadian people among other things.

Background information on the availability and geographic distribution of Barbadian freshwater are important to trace water from its source to disposal and to

reflect upon the implications of the effects of climate change on future usage. Droughts and storm surges seem to be the biggest problems climate change will bring to the Barbadian freshwater supply. Droughts will obviously cause even more scarcity in a country already without enough water to meet the needs of its people and cyclones and sea level rise may lead to erosion and salt water intrusion polluting the primarily groundwater supply. As it stands, Barbados is taking a great deal of care to protect its delicate water resources including a new desalination facility to serve as supplementary gray water, new legislation requiring rainwater collection tanks and, most provocatively, a drought management plan with voluntary and mandatory stages for citizens to conserve water in their homes. However, their drought management plan does not apply to the sector behind Barbadian economic success.

Finally, comprehension of the double-edged sword that the tourism industry represents in Barbados is crucial to the argument for climate justice in the face of double-exposure by developed nations with high emissions and many international tourists. The sector has a major influence on the economy and employment rates throughout the country but it also puts a major strain on the freshwater supply and significantly harms the natural environment. Tourism's overuse of the water supply is not only unfair to Barbadians who are under a voluntary mandate to conserve but it puts the country at a disadvantage for dealing with future effects of climate change by wasting a supply that will be sorely missed in the face of increased risk of drought due to climate change. In addition, the industry is also known to shirk its standards and pollute the environment; in Barbados many hotels drain waste water directly into the sea where the nutrients

contribute to coral bleaching and subsequent destruction of the reefs. This contributes to erosion, inundation and salt water intrusion due to sea level rise.

The circumstances in Barbados are a mirror for many countries like it whose populations and industries emit very small (almost non-existent compared to their developed counterparts) portions of the total global emissions but are facing similar or even more severe threats from global net warming and its various effects on the climate. Developed nations pollute the atmosphere and then travel thousands of miles to pollute and degrade their host nations' immediate environments. This double-exposure leaves the developing regions to not only deal with heightened effects from climate change despite their low level of contribution to the problem but also environmental degradation from the very sector of the economy they are highly dependent upon. Climate justice seeks to hold those at the root of the problem at a more proportionate level of responsibility for the effects their less responsible counterparts will need to adapt to in the face of climate change. The emergence of the climate justice movement is important because the actors living with the effects of environmental degradation and climate change effects are not always the same actors at the source and, as such, must not be held entirely accountable for mitigation and adaptation effort.

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ACADEMIC VITA

Josephine R. Farinelli

215 W. Fairmount Ave., Apartment 610, State College, PA 16801

jrf5211@psu.edu

Education

B.S., Geography, 2013, Pennsylvania State University, State College, Pennsylvania
- Human Geography Option
- Political Science Minor, College of Liberal Arts
- English Minor, College of Liberal Arts

J.D., Law, 2016, University of Miami School of Law, Miami, Florida

Honors and Awards

- Dean's List
  -Pennsylvania State University, 2009-2013
- Schreyer Honors Excellence Award
  -Schreyer Honors College, 2009-2013
- John & Elizabeth Holmes Teas Scholarship
  -College of Earth and Mineral Sciences, June 2010
- Balmat Family Scholarship
  -Department of Geography, April 2011
- Department of Geography Excellence Award
  -Department of Geography, August 2011
- G.D. Richardson Scholarship
  -Department of Geography, April 2012
- Donald W. Strickler Scholarship
  -College of Earth and Mineral Science, August 2012

Association Memberships/Activities

- EMSAGE Laureate
- Phi Beta Kappa Honors Society & Phi Kappa Phi Honors Society
- National Society of Collegiate Scholars
- Student Court, Penn State Homecoming 2012
- Captain, Penn State IFC/Panhellenic Dance Marathon 2012
- Captain, Penn State Homecoming 2011

Professional Experience

- Investigator: Edgar Snyder and Associates, L.L.C., Pittsburgh, PA, 2011-present
- Internship: Edgar Snyder and Associates, L.L.C., Pittsburgh, PA, 2011
- Teaching Assistant, ENGL 030, Pennsylvania State University, 2010-2011
- Teaching Assistant, ENGL 015A, Pennsylvania State University, 2011
- Research Assistant, Department of English, Pennsylvania State University, 2009-2011