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Assessment of Global Climate Change on the Caribbean Region

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Report Highlights:

Caribbean nations are very heterogeneous in terms of history, culture, and GDP. Each country will face different challenges and pursue different solutions as the entire region will feel the effects of climate change. While some nations are more vulnerable than others, global warming and Sea Level Rise (SLR) will slowly undermine the natural advantages and infrastructure these nations have to draw tourists.

Climate change and SLR will also slowly degrade agricultural conditions in what is already a low-production area.

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Introduction

One of the defining challenges of this century will be our preparations for and adaptations to climate change. Countries that are best prepared to deal with the new conditions that climate change will create will have a definite advantage. By forecasting what effects climate change will have on trade with the Caribbean region, the Caribbean Basin Agricultural Trade Office (CBATO) will be able to plan for the future and adequately prepare. But before US-Caribbean Basin trade implications can be discussed, a brief understanding of what climate change means, what its effects will be, and what impact those effects will have on Caribbean nations is necessary.

This report focuses exclusively on the island nations in the Caribbean. This comprises the countries of Antigua & Barbuda, the Bahamas, Barbados, Cuba, the Dominican Republic, Dominica, Grenada, Haiti, Jamaica, Saint Kitts & Nevis, Saint Lucia, Saint Vincent & the Grenadines, and Trinidad & Tobago. It also covers the islands Anguilla, the British Virgin Islands, the Cayman Islands, Turks & Caicos, and Montserrat, all of which are overseas territories or protectorates of the U.K.; Guadeloupe, Martinique, Saint Barthélemy, and Saint Martin, all of which are either territories of or members of France proper; and Aruba, Bonaire, Curaçao, Saba, Saint Eustatius, and Sint Maarten, all of which are territories of or members of the Kingdom of the Netherlands proper. It also includes Bermuda, a British territory in the Atlantic Ocean.

Climate Change

The Intergovernmental Panel on Climate Change (IPCC), is the leading international body for the assessment of climate change and defines climate change as “a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.” USDA’s 2013 report entitled Climate Change and Agriculture: Effects and Adaptation, indicates that increases in atmospheric carbon dioxide, rising temperatures, and altered precipitation patterns that will affect agricultural productivity. Climate change will exacerbate the stresses already occurring from weeds, insects, and disease. Increases in the incidence of extreme weather events will have an increasing influence on agricultural productivity. Over the next 25 years, the effects of climate change on agricultural production and economic outcomes for both producers and consumers in the United States are expected to be mixed, depending on regional conditions.

The Greenhouse Effect

The temperature on the Earth’s surface is the result of a balance between solar radiation entering the atmosphere and the energy being reflected back into space by clouds, small particles in the atmosphere, snow ice and deserts. In the atmosphere, not all thermal radiation emitted by the Earth reaches outer space, part of it is absorbed and reflected back to the Earth’s surface by greenhouse gas (GHG) molecules and clouds (the greenhouse effect). Concentrations of some GHGs such as carbon dioxide (CO₂) are significantly influenced by humans and during the last millennium, increased concentrations of GHGs in the atmosphere has been among the largest contributors to surface warming.

Sea Level Rise (SLR)

One of the most marked impacts climate change will have globally is a general rising of the sea level. According to the IPCC, both the melting of glaciers globally and the expansion of the oceans as they warm will contribute to sea levels rising anywhere from 0.15 meters to 0.4 meters by 2045. By 2100, the average sea level rise is projected to be roughly 0.5 meters with the worst case scenario being a full one meter. The Caribbean Community’s (CARICOM) ^[1] projections are higher, expecting one meter of SLR by 2100, with a worst case scenario of two meters. ^[2] While there is a chance that SLR could be less than the IPCC’s predictions, SLR has been steadily accelerating over the past two decades and with the current rate of glacial melt, it seems certain that at least the lower projections of the IPCC will be met.

Sea level rise will have big effects on the Caribbean; the most dramatic would be a redrawing of the map. Several Caribbean islands formed as the result of accumulation of sediments into a sandy bar, some of which rose high enough to create dry land in shallow, barrier-type islands. An example of this is the incredibly flat Bahamas. According to CaribSave, a Caribbean not-for-profit organization that focuses on sustainable development in the face of climate change, “with 80 percent of the land lying less than one meter [three feet] above sea level, all sectors in the Bahamas are highly vulnerable.”

Other Caribbean islands, like Jamaica, were formed volcanically giving them higher elevations and firmer foundations. While not in any imminent danger of slipping into the depths, SLR will lead to coastal erosion, washing away beaches and flood low-lying parts of these islands. This land is often the most valuable, populated, and fertile land available.

Warmer Oceans

The temperature of the sea is projected to increase dramatically. The rising temperature of the ocean is rather straight forward. As the temperature of the globe rises, there is more heat for the oceans to absorb. A moderate temperature change has already been measured from the surface of the ocean to a depth of 2,300 feet. Unfortunately, most marine life is extremely sensitive to heat and even the slightest persistent rise can kill off a large number of species. Also, as this warmth continues to permeate deeper into the ocean, patterns of ocean currents, like the Gulf Stream, which drive ecosystems, could be permanently altered.

More Extreme Weather Events

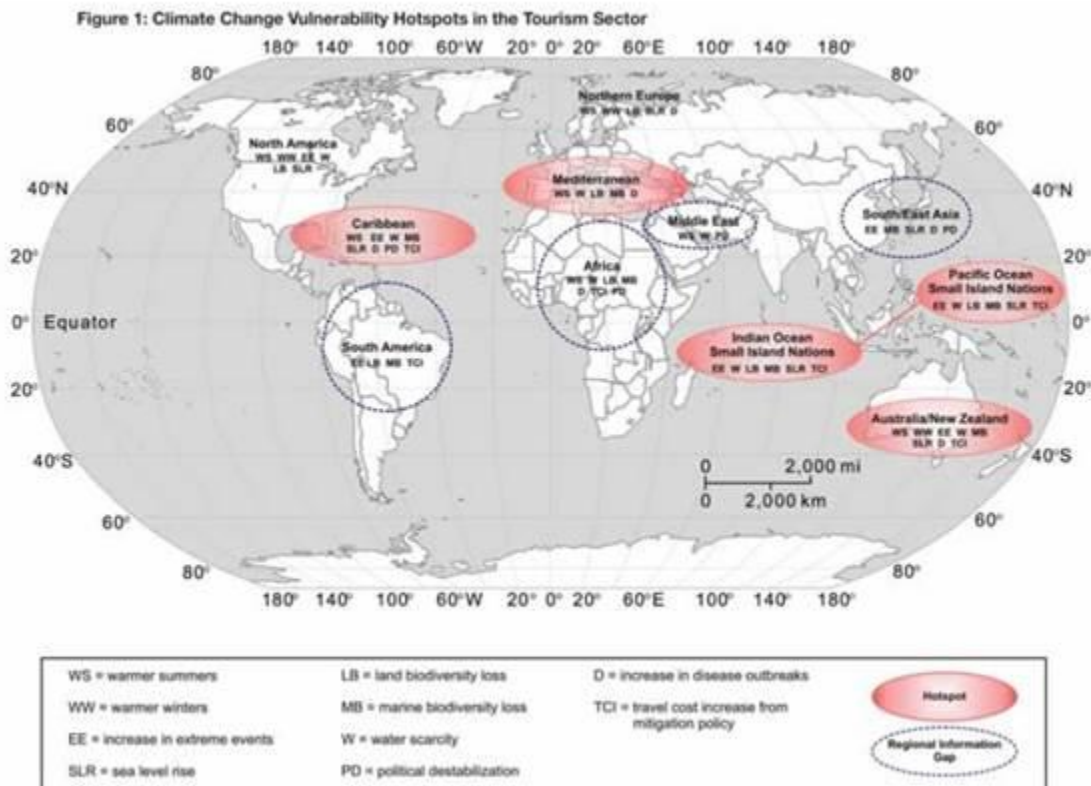
The warming of the ocean's surface will also affect weather patterns. Warm surface water dissipates more easily into vapor. This vapor is what fuels tropical storms and hurricanes, making them stronger and last longer. As the oceans are now warmer longer, favorable conditions for hurricanes has extended hurricane season by an entire month. Finally, as ocean levels rise, it increases the likelihood of storm surge flooding, which in turn leads to saltwater intrusion (explained below). This combination of factors will render hurricanes and tropical storms even more potent, an ominous development for a region that already struggles with these storms. Regular rainfall patterns will also shift, becoming less predictable, disrupting farming patterns that have existed on the islands for centuries.

More Acidic Oceans

The oceans have also grown increasingly acidic as well. The ocean is a key part in the globe's carbon cycle, absorbing large amounts of carbon dioxide. However, as the concentration of carbon dioxide in the atmosphere continues to rise, so does the amount that gets absorbed into the ocean. This carbon dioxide reacts chemically with the water to acidify it. This has had dire consequences for fish, shellfish, and coral reefs in the region.

Impact of Climate Change on Caribbean Countries

The impacts of these effects will be felt across the globe, but the Caribbean, as this graphic from the UN shows, is particularly vulnerable. This report examines the impacts of climate change on three categories: tourism, agriculture, and food security.



Tourism

Tourism is the driving economic force of the Caribbean. According to the United Nations Economic Commission for Latin America and the Caribbean (UN ECLAC), tourism directly and indirectly generated roughly 39 percent of the region's GDP and is the primary source of foreign reserves for these countries (Ref 11, p. 96). Caribbean nations as diverse as The Bahamas, Jamaica, and Antigua & Barbuda all rely on tourism for over half their GDP. Tourists come to the Caribbean from all over the world for its famous endless beaches, for snorkeling and SCUBA diving in its vibrant coral reefs teeming with life, and for the perfect weather.

Climate change and rising sea levels threaten all of these natural advantages the Caribbean region enjoys. The simplest effect to track is as the islands become warmer, they could become less attractive destinations. No one wants to spend time at the beach when it is 100° F. Also, as the rest of the globe warms, winters could become milder, driving down the number of snowbirds.

Sea level rise will have the most far reaching effects. Obviously as sea levels rise, some beaches will be inundated and simply cease to exist. Others may be washed away as increased tidal surges and raised sea levels contribute to accelerated coastal erosion. Resorts, hotels, and other beach centered infrastructure could be lost as the ground upon which they are built is washed out from under them. The results could be dire. A survey done in 2005 suggested that 77 percent of visitors to Barbados would be unwilling to return for the same price if the "beaches largely disappeared." (Ref 8, p. 887)

Tourism infrastructure, such as hotels, resorts, restaurants, airports, and seaports, is often built right on

coast. According to a study in the *Journal of Sustainable Tourism*, 266 major resorts (roughly 29 percent) throughout CARICOM countries are at risk of inundation with a one meter SLR. (Ref 8, p. 895) The loss of these buildings would not only be costly from an investment standpoint, but it would cripple these islands' ability to house tourists. Even a slight drop in tourism revenue could have a negative impact on the economy of the region as a whole. ^[3]

Recreational fishing and dive tourism are major revenue sources for the Caribbean. According to estimates reported by the Stockholm Environmental Institute (SEI), a non-profit, independent research and policy institute specializing in sustainable development and environmental issues, SCUBA diving on coral reefs brought approximately \$2.1 billion to the region in the year 2000. For Tobago alone divers visiting coral reefs drew \$43.5 million in 2006. That was 15 percent of their GDP. (Ref 7) Yet the all coral reefs in the Caribbean are under threat. Coral requires cool water to survive. In warmer water, a process known as "coral bleaching" takes place, so named because coral grows paler as it dies. The death of these reefs is an ecological tragedy but also a deep blow to the local tourism industry. If the reef collapses, the fish would leave or die and there would be little left to draw customers.



Hurricane season has always started on June 1st but it used to end October 31. Then it was pushed back to mid-November, and now to the end of November. Peak tourism season runs from December through April. If hurricane season continues to extend later and later into the year, it will cut down the length of time tourists are able to visit.

The degradation of the beaches and coral reefs along with the interruption of the tourist season by tropical storms and hurricanes will all have significant impacts on the amount of tourists visiting Caribbean nations. The UN ECLAC analyzed data from three countries (Montserrat, Saint Lucia, and the Bahamas) and estimated that as a result of a moderate climate change (an increase of roughly 1.27° C by 2030) these countries could expect to lose an average of 6 percent of their tourist arrivals by 2050. (Ref 11, p. 100) Without that revenue and foreign cash, the economies of many Caribbean nations will constrict.

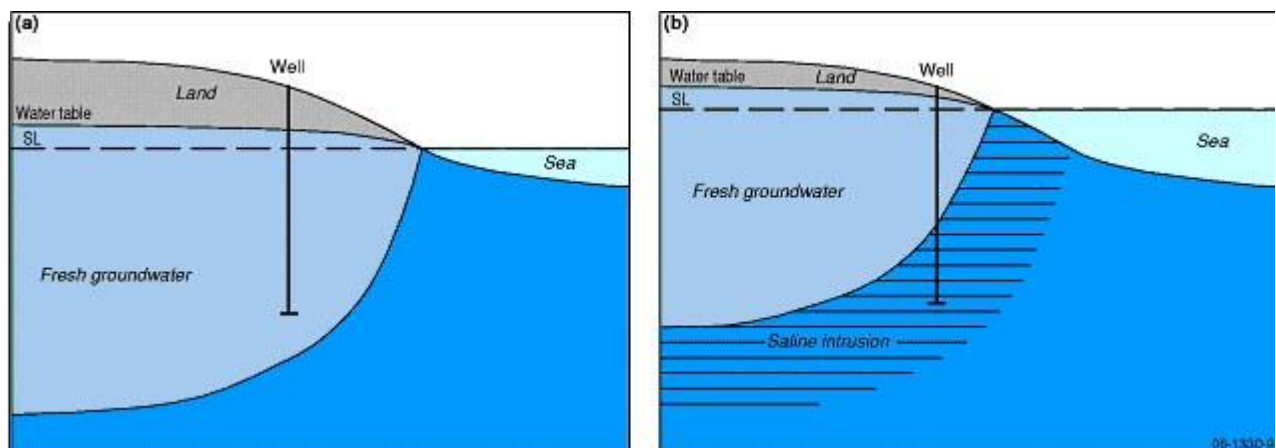
Agriculture

Most Caribbean islands are, for obvious reasons, net food importers. The size and soil composition of countries like the Bahamas and the Cayman Islands simply cannot support large-scale, intensive agriculture. Even larger islands that were formed through volcanic activity – and thus have more nutrient-rich soil – are too mountainous (Dominica) or have traditionally been dominated by a sugarcane monoculture (Jamaica, the Dominican Republic, or Cuba) and so never developed a strong agricultural base. That being said, primary agriculture generates roughly 10 percent of the region's GDP. (Ref 11, p. 31)

The agriculture sector itself is less vulnerable than others, namely tourism. In fact, climate change may have both positive and negative ramifications for agriculture in the region. Higher levels of carbon dioxide in the atmosphere will promote plant growth^[4] while warmer climates may open up land in higher altitudes (like in Cuba and the Dominican Republic) to cultivation and some islands may receive more precipitation than they do currently. This means certain countries may actually benefit agriculturally from climate change in the near term.

However, as a region agricultural production will almost certainly decrease as the negative impacts outweigh the good. Warmer temperatures will overheat what are currently ideal conditions and promote pest, weed, and disease proliferation. Most areas will receive less rainfall and what rain does come will fall in torrential storms which lead to soil loss. Finally, extreme weather events such as hurricanes and droughts will likely increase in frequency and intensity. What is more, the regional reliance on monocultures and the lack of widespread use of industrial agricultural technologies means that Caribbean nations have compounded their previously existing structural vulnerabilities.

Sea level rise will also have an effect on agriculture and again, low-lying islands like the Bahamas come up as the biggest losers. The Bahamas alone have six percent of their agricultural land vulnerable to flooding with a one meter SLR. Low-lying islands and countries with long coastlines experiencing SLR are also susceptible to saltwater intrusion. This happens when saltwater begins to enter the underground aquifers of the island, contaminating the groundwater. Sometimes the groundwater can turn brackish enough to kill off plant life. The higher sea levels rise, the harder it becomes to prevent the infiltration of saltwater.



There have been developments towards creating salt tolerant crops, but as it stands, the only way to recover from saltwater intrusion is to pump the saltwater back out to sea and then stop all fresh water

extraction while the aquifers replenish so the saltwater can no longer seep in. This process is expensive, water intensive, and can take a long time before the ground is ready for growing again.

Coastal areas have always dealt with saltwater intrusion, but any increase could quickly become calamitous. Many islands already have shortages of potable water so all fresh groundwater is precious. The alternatives to prevention of saltwater intrusion are uniformly costly. Pumping fresh water back into the aquifers as mentioned above, desalinating ocean water and storing it, or building levees and dikes to prevent the saltwater from reaching the fresh water table are all exorbitantly expensive for these small island states.

Finally, many of these countries rely heavily upon seafood, not just to export or to serve to tourists, but for daily sustenance and employment. According to SEI estimates, fisheries employ nearly 200,000 people in the Caribbean Community, and earn these small countries between \$5 billion and \$6 billion per year in foreign exchange. SEI also estimates that fish and shellfish provide about 10 percent of the region's protein intake. (Ref 7) As the oceans warm, coral reefs will collapse, and fish and shellfish that citizens of the Caribbean have been catching and eating for centuries will migrate to cooler waters or die out. This would drive up the cost of living as a cheap provider of sustenance would have to be replaced by a more expensive imported food.

Food Security

All aspects of the region's food security are potentially affected by climate change, including food production, access, use, and price stability. No country in terms of food production, not even Cuba or the Dominican Republic, is close to being self-sufficient nor do any countries export enough agriculture goods to cover their food import bills. The vast majority of the Caribbean imports nearly all their consumer agricultural goods, which means the prices of their goods must include the expense of shipping, storage, and duty tax, all of which drive the prices up. This means that even incremental price increases on the good itself can lead to large price difference for the Caribbean consumer. This reliance upon imported goods also exacerbates structural constraints of the islands, namely the limited area of arable land, the reliance on ports, and the frequency of tropical storms that can disrupt trade flows.

The current situation means that when ports and the forecast are clear and tourists are bringing money to the islands, food security is still compromised, not by availability but by price. A large portion of Caribbean citizens cannot afford fresh produce and more nutritious food, so they must buy discount and processed foods. This has led to proliferation of dietary diseases like obesity and diabetes across the region. Climate change will aggravate this situation as most Caribbean nations' already minor agricultural production will shrink further, reducing the availability of affordable, domestic produce and the revenue from exported agricultural goods. At the same time global agricultural patterns will be disrupted, sending short term shocks through the market. Global agricultural production is likely to decrease in the long run as well. Both these situations will lead to more expensive goods, further stretching Caribbean budgets that will be depleted from decreasing tourism revenue.

This all assumes steady trade, which is not always a given. Hurricanes often cut shipping lanes or render ports inoperable and these effects will likely grow worse as sea levels rise and the storms become stronger. As these trends continue U.S. and Caribbean ports could begin flooding more regularly and frequent interruptions of trade could become the norm. Since most Caribbean islands have limited food storage capacity, this would further stress the food security situation of these islands.

Political Ramifications

There is also the likelihood of political destabilization and the possibility of mass emigration from these islands. Throughout the Caribbean region, 70 percent of the population lives along the coast. (Ref 12, p. 7) Several islands are particularly susceptible to destabilization. The Bahamas, Turks and Caicos, the U.S. and British Virgin Islands, St. Kitts & Nevis, Antigua & Barbuda, and the Cayman Islands due to their geographic vulnerabilities and Haiti due to its impoverishment.

Even countries that are relatively well suited to deal with sea-level rise will suffer. Jamaica has a higher elevation than other barrier islands but their port at Kingston along with numerous resorts around the island sit very low along the water. Even a moderate rise in sea level would flood the port and these resorts, costing the country hundreds of millions. The Dominican Republic also has a much higher flood plain than many of its neighbors, but its capital, Santo Domingo, sits very low and is built on the Ozama River estuary. The World Bank predicts it will be one of the cities most affected by rising sea levels in the world.

According to the Caribbean Community Climate Change Center (CCCCC) a one meter SLR could displace up to 110,000 people from CARICOM countries alone. ^[5] (Ref 10, p 74) Most Caribbean countries do not have the space or resources to deal with any number of refugees. Many of these countries already have inefficient and underfunded governments. Without tourism, the governments will become insolvent (or more insolvent in some cases) and there will be mass unemployment (or more mass unemployment in some cases).

These islands already struggle to respond to hurricanes and tropical storms; as sea levels rise and tropical storms grow stronger, flooding and storm surges will become more devastating. Long term flooding would likely stress these governments beyond their breaking point. Mass emigration would likely lead to thousands of people fleeing the islands for the U.S., Mexico, South America, and the larger Caribbean islands, placing an undue stress upon these countries as well.

Unemployment will become another challenge. Both the agriculture and tourism sector – two of the largest sources of employment in the region – will suffer adverse effects from climate change. Farming and agricultural employment varies from country to country, from as few as three percent of Bahamians directly involved in farming all the way up to 62 percent of Haitians. However, across the region roughly 30 percent of rural inhabitants make their living in the agricultural sector. (Ref 11, p.32) Similarly tourism industries, both direct and indirect, provided 40 percent of the region's employment in 2010. (Ref 11, p. 96)

This means that roughly half of the region's source of GDP and roughly three-quarters of its source of employment are set to contract significantly in the coming years. This means the governments of the Caribbean will have to stretch budgets constricted by declining revenues and shrinking economies to provide services for the large numbers of displaced persons and unemployed; fix their severely compromised infrastructure; and prepare for stronger tropical storms and hurricanes. It could prove to be too much for some of these small island nations.

Trade

Effects of Climate Change

Before the region as a whole is investigated, this paper will first examine the Bahamas as an example. The Bahamas is the 5th largest agricultural importer from the U.S. in the region, importing \$380 million in goods in 2014. ^[6]

The Bahamas is a particularly pertinent example since, due to their size, lack of significant agriculture, and geologic formation, they are an extreme representation of the trends seen throughout the Caribbean. Now, if one meter of SLR by 2100 is assumed, the Bahamas economy would find itself in distress. According to CARICOM projections (whose mid-range projections for SLR are one meter by year 2100, but whose assessment of financial damages is for the year 2080), the nation's GDP would be \$58 billion but would be dealing with \$2.7 billion in annual losses and would be facing over \$26.3 billion in capital costs due to damage to resorts, the airport, roads, and the flooding of several islands.

The damage done to the airport and resorts would not only cost the government but would lead to a sustained climb in unemployment as the country's economy relies upon tourism. Under these conditions, the Bahamas would be hard pressed to generate funds to import goods from the U.S. Even if the Bahamas were able to afford agricultural goods, Freeport, one of the largest ports in the Caribbean is vulnerable to flooding. If ships cannot berth and unload at Freeport other less efficient and more expensive methods would have to be taken.

The Caribbean region as a whole imported \$4.118 billion of agricultural and related goods from the United States ^[7] and had a GDP of roughly \$467 billion ^[8] (PPP) in 2014. The U.S.'s largest trading partner in the region is the Dominican Republic, followed by Jamaica, Trinidad & Tobago, Haiti, and the Bahamas. According to the same CARICOM forecasts mentioned above, a one meter SLR by 2100 could cost CARICOM countries (which crucially exclude both the Dominican Republic and Cuba) \$13.5 billion in annual losses and \$68 billion in capital losses in 2080. (Ref 10, p. 106)

Every Caribbean country would be affected and tourism, the economic lifeblood of the region, would be drastically curtailed as beaches are flooded or swept away, coral reefs are bleached, hurricane season extends, hurricanes themselves become more damaging, beachfront resorts are flooded, and transportation costs increase. Similar to Freeport, several of the largest ports in the region, like Kingston and Puerto Caucedo (just outside Santo Domingo in the Dominican Republic) are also vulnerable to flooding, further endangering a halt to trade in the region.

As the economies and populations of these countries shrink, so will the demand for (or at least the ability to pay for) foreign trade.

Adaption ^[9] vs Mitigation ^[10]

Adapting to the effects of global climate change is an existential imperative for the Caribbean. However, the most immediate economic effects to these countries will likely arise not from climate change itself but from any measures put in place to mitigate it. Carbon taxes, shifting travel patterns, and the cost of coast maintenance will all be more damaging to the Caribbean economy and trade over the next twenty years than rising oceans will be. But the alternative could be ruinous. If no precautions are taken and the sea rises more than one meter, several governments in the Caribbean would be severely taxed, possibly to the point of collapse. The remaining islands will have had their meager agriculture capability further depleted, their tourism industry severely diminished, and there will not be enough jobs to support a sizeable population. In short, the Caribbean market will shrink drastically. However, if ocean levels rise less than a meter, while there would still be a sizeable disruption of the market, the majority of Caribbean nations would continue the same as today.

Carbon taxes or anything that causes a long-term rise in the cost of fuel or transportation would distress

the Caribbean economy. The Caribbean tourism sector relies upon visitors coming from Canada, the United States, Brazil, Europe, even as far off as China and Japan. Which means the Caribbean tourism industry is incredibly dependent upon long haul air travel. Unfortunately, this is one of the most polluting means of travel at our disposal. Air transport alone contributes roughly 40 percent of tourism's total carbon dioxide emissions. (Ref 5, p. 71) These types of emissions will have to be curbed, likely through taxes. Any measure that makes flying more expensive or dissuades people from traveling will have deleterious effects on the Caribbean economy. According to UN ECLAC, by 2020 if moderate climate policies were enacted the Caribbean region could lose 1.3 to 4.3 percent of its annual tourists due to the increased price of traveling. If "serious" policies were adopted (strict carbon tax, oil and fuel subsidies dropped, etc.) a 24 percent drop in tourists is possible. (Ref 11, p. 104)

However, while transportation may have the most immediate effect on tourism, it is unlikely to be the harshest. Technological advances such as more fuel efficient jet engines, electric planes, and altered travel patterns can mitigate the effect of higher prices. There is no such technological fix for a flooded beach or a degraded landscape.

The Caribbean has already taken several steps to alleviate the effects of climate change. CARICOM has set up the Caribbean Community Climate Change Center (CCCCC) to study the effects of and advise national governments about climate change. Several countries, including the Dominican Republic, Haiti, Jamaica, and Trinidad & Tobago have already implemented regulatory provisions governing energy efficiency. Unfortunately for most Caribbean islands, their fate is outside their hands. Even if, somehow, all Caribbean nations were to become carbon neutral overnight, they would hardly make a dent in the global carbon production. This means that the best course of action for the Caribbean will be to prepare for the oncoming deluge. This preparation will be extremely expensive. According to the UN, Turks & Caicos and Anguilla will have two of the highest ten costs in relation to their GDP.

This is where the true problem arises. Despite several countries have energy efficiency regulations, only the Dominican Republic and Jamaica have national funds available to promote energy efficiency. Furthermore, several Caribbean countries carry a high debt/GDP ratio. Jamaica, Barbados, and Grenada all had debt that exceeded their GDP in 2014. (Ref 2, p. 10) The measures necessary to protect these countries from encroaching seas, such as "beach nourishment" and seawalls, are prohibitively expensive. According to UNESCO estimates, dredging sand from further out in the ocean to bring and dump upon the beach ("nourishing" them) can cost anywhere from \$6 to \$15 per cubic meter of sand, not including mobilization costs. Considering this could potentially be an annual task and that it would have to cover miles of coast, it is not surprising that beach nourishment is almost unheard of in the Caribbean. Seawalls represent a one-off investment. However, they do not offer any protection to beaches, only to inland areas.

To afford these types of projects, most Caribbean nations would have to significantly alter their tax structure. (Several nations, including the Bahamas and the Cayman Islands, do not even collect an income tax.) This would likely drive up costs within the region, aggravating what an already stratified economic class system. The other option would be to rely upon foreign grants and loans. France has already promised to engage in assisting the Caribbean region (they have a vested interest in the region represented by Guadeloupe and Martinique) but no concrete plans have come forward. Similarly the UN and the Inter-American Development Bank have noted both that the Caribbean will suffer effects of climate change disproportionate to its production of greenhouse gases and that most countries are not in a position to afford climate change adaptations themselves, but there is no proposal of large scale funding.

U.S. Ports

This report has mostly focused on how climate change will affect the islands of the Caribbean, but when discussing trade it is important to also consider the damage that the U.S. may suffer as well. There are four main ports that serve the Caribbean region from the United States: Houston/Galveston, Savannah, Port of the Everglades (just north of Miami), and Miami. All four are vulnerable to sea level rise, Galveston and Miami especially. If these ports are impaired, U.S.-Caribbean trade will suffer. If they are completely flooded, the trade patterns of the entire region will shift dramatically, possibly to countries besides the United States.

Conclusion

Caribbean nations are very heterogeneous in terms of history, culture, and GDP. Each country will face different challenges and pursue different solutions. That being said, the entire region will feel the effects of climate change. While some nations are more vulnerable than others, global warming and SLR will slowly undermine the natural advantages and infrastructure these nations have to draw tourists. Global warming and SLR will also slowly degrade agricultural conditions in what is already a low-production area.

These effects of climate change will have disparate effects on agricultural trade over the long and short term. As the islands' traditional ecology and weather breaks down, they will become more reliant upon importing foodstuffs from outside countries. However, as tourism falls, whether due to higher prices or degraded destinations, there will be less demand and less cash to purchase these imported goods. When all impacts are accounted for, it seems likely that trade will diminish as Caribbean countries lose the tourists that drove up the demand for food and financed the region. In the long term, if countries' governments cannot develop replacement industries and mass emigrations ensue, then entire markets could disappear.

Adaptation to these effects will be crucial if countries wish to avoid debilitating economic developments in the future. However, the measures taken to protect these nations from climate change and SLR will be costly, and could impede economic growth and drive up the cost of living in the short term. (These measures include beach nourishment, construction of seawalls, carbon taxes, and efforts to make tourism more carbon neutral.) The costs of these measures will likely lead to many economies in the region achieving less growth than otherwise anticipated. This will lead to marginal growth – and in some cases contraction – in trade with the U.S. However these measures will secure the tourism business for the medium and long term and will help these nations avoid some of the more calamitous effects of climate change.

Failure to put in place these costly precautions would allow the economies to grow unimpeded for some time, but decreases the prospects for sustained tourism in the medium term and opens up the window for greater economic challenges in the long term.

For many of these islands, the United States represents the closest and cheapest source of agricultural goods, consumer, bulk, and otherwise. The U.S. also already controls approximately 55 percent of the Caribbean market for agricultural goods. Climate change will do nothing to change that. In fact, as transportation becomes more expensive due to the necessity to decrease carbon emissions, the U.S. could face less competition in the area as products from further off countries become too expensive to compete. However the higher cost of transportation will also cripple the tourism that fuels the Caribbean

market. The end result being the United States would get a larger slice of a smaller pie.

From a trade standpoint, it may prove worthwhile for the United States to help Caribbean nations prepare for a rising sea level by offering technical assistance, grants or loans for infrastructure enhancements, such beach nourishment, sea walls, and floating docks. By offering minor economic support now, the U.S. would be adding long term resilience to a market that is already dominated by U.S. goods. Another area where the United States could help Caribbean nations address projected food security and climate change challenges is by encouraging, in as many opportunities as possible, the increasing need for Caribbean nations to adopt science-based policies/oversight that can allow for innovations to be used safely and judiciously, and that can provide for reliable trade of imported products derived from modern biotechnologies.

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Footnotes

[1] CARICOM is a political and economic organization of 15 Caribbean countries and dependencies. Antigua & Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts & Nevis, Saint Lucia, St. Vincent & the Grenadines, Suriname, and Trinidad & Tobago are all full members.

[2] While this discrepancy is large, members of the IPCC have come out since the study and said the report might be too conservative in its predictions. However, even after slightly revising their numbers the IPCC projections are still far below those of CARICOM. For this paper IPCC projections are used unless otherwise stated as they are the global authorities. There is also a general inconsistency going through the paper as certain studies have focused on SLR rises while other studies look at the changes in avg. temperature. Since this paper is a synthesis of these reports, its disjointed, disorganized nature can

be taken as a reflection of the disagreements on the specifics of climate change and a consensus on the broader fundamentals: climate change is happening, humans are responsible, and it will have large and widespread effects.

[3] This scenario already played out as the 2008/2009 economic contraction meant fewer people could afford a Caribbean vacation. The region is still recovering from that lost revenue.

[4] This is conditional - While increasing CO₂ in the atmosphere has a positive effect on plant growth and decreases soil water use rates (Kimball 2011), the magnitude of influence of increasing atmospheric CO₂ on crop yields also depends on the status of other constraints such as nutrient and water limitations, and timing of crop exposure to temperature and water extremes. Further, the overall effects on crop production, depends on the relative response of the crop versus the response of most weeds and other competitors for resources; changes in climate will affect both the crop and the pathogen, and understanding these changes will be critical to avoid increased losses in crop productivity. Quality of crop may also be affected; in forage and grain crops, exposure to increased CO₂ causes a reduction in grain and forage quality (Morgan et al. 2004).

[5] The worst affected countries being the Bahamas (since portions of Nassau and Freeport would be flooded) along with St. Kitts & Nevis and Antigua & Barbuda.

[6] According to trade data from the USDA GATS system

[7] According to trade data from the USDA GATS system

[8] According to the IMF

[9] ADAPTATION - is the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

[10] MITIGATION - is defined as a human intervention to reduce the sources or enhance the sinks of GHG (sink - any process, activity or mechanism that removes a GHG or precursor from the atmosphere).