The Supply Side Effects of Climate Change on Tourism

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Abstract

Assuming nothing is done to address greenhouse gas emissions, sea levels across the world are anticipated to rise by between 0.2m and 1m over this century. Higher sea levels can be particularly devastating to small states. It is expected that rising sea levels will result in coastal squeezing and the loss of their main tourist attraction, beach tourism. Climate change is also forecasted to result in more severe storm activity, which could also lead to flooding and damage from storm force winds. This study attempts to quantify the potential supply-side effects of climate change on tourism in the small island state of Barbados. Using a database of 181 hotels, a model is employed to evaluate the effects of coastal squeezing and storm activity on accommodation establishments.

JEL Classification: Q54; L83; O54

Keywords: Climate Change; Tourism; Caribbean

1. Introduction

Most Caribbean countries have embraced tourism as one of the key planks of their development strategy. The main motivations behind this approach relate to the advantages the industry provides relative to other exports of goods and services. First, it allows the destination to obtain economic benefits from characteristics that normally could not be traded, for example natural and other cultural attractions. Second, locally produced goods can be sold at a premium to visitors. Finally, goods that could not be exported due to insufficient export capability can be sold to tourists (Mihalic, 2002). As a result of these characteristics, the industry accounts for a one-third of all trade, a quarter of foreign exchange receipts and one-fifth of total employment in the Caribbean (de Albuquerque and McElroy, 1995). Numerous authors have also attributed most of the region's growth to the industry (see for example Latimer, 1985; Modeste, 1995).

Like many other small island developing states, the tourism industry played a major role in the early development of Barbados. After its independence in 1966, the newly formed state was facing a number of internal and external challenges. The sugar industry, which in the previous era generated more than one third of total value-added, rapidly declined due to technological obsolescence at most factories and competition from other areas of the economy for scarce land resources. As a result, the contribution of sugar fell from about 40 percent of GDP in the 1950s to less than 5 percent of value-added during the 1970s. With the decline of sugar, alternative areas of economic activity had to be promoted. Greater funds were therefore directed toward the marketing of Barbados as a tourist destination. As a result, real value-added in the industry experienced double-digit rates of growth during the 1970s.

The ability of policymakers during this period to diversify the economy away from sugar, allowed Barbados to achieve an enviable level of development. Per capita income in Barbados at the end of 2006 was US$9850 or about US$5180 above the average for other small states and US$4575 more than the average for the rest of the Caribbean. These economic achievements have been levered to finance and ensure a high level of social development. In the most recent United Nation's Human Development Report, the nation was ranked 31st in the world, one of the highest for any small state included in the index.

Given the importance of the tourism industry to the future growth and development of Barbados, it is important to monitor and evaluate potential risks to the industry. One potential risk factor is climate change. The Intergovernmental Panel on Climate Change (IPCC) has projected that for the period 1990 to 2100, average global temperature is likely to rise by 1.4-3.2ºC, while sea levels should increase by 9-88 centimetres. Barbados and SIDS in general are highly susceptible to higher sea levels since this might lead to significant beach erosion resulting from the combination of higher sea levels and increased storm activity. Coastal erosion could have significant effects on the coastal infrastructure such as roads and hotels. This perception seems to be the consensus in the industry based on the results of a survey conducted by Belle and Bramwell (2005). Using semi-structured interviews and questionnaires, the authors collected the views on the likely impact of climate change on the Barbados tourism industry. Most respondents felt that damage to coastal tourism facilities was very likely, with large proportions also indicating that there will be beach changes, higher sea levels, and damage to the marine ecosystem. Industry managers and policymakers shared similar views.

Despite the potential impact that climate change could have on the tourism industry in Barbados, there exists little or no previous research quantifying the potential impact of climate change on the island. This paper therefore provides an empirical evaluation of the possible impact of climate change on the local tourist industry. The paper takes a microeconomic approach to looking at the issue of climate change. To undertake the simulations, a database of hotels, guesthouses, and apartments rented to tourists was constructed. This database was then employed to carry the simulations in relation to the likely impact of rising sea levels and greater storm activity on the ability of the island to supply accommodation services. The findings of the study would be of use to tourism officials within both Barbados as well as other small island developing states.

The remainder of the report is structured as follows. Following the introduction, Section 2 provides a brief review of related research while Section 3 outlines the methodological approach. Section 4 gives the empirical results and Section 5 concludes.

2. Brief Review of Related Literature

Assuming nothing is done to address greenhouse gas emissions, sea levels around the world are anticipated to rise by 0.5 m by the year 2100 compared to an increase of between 10 to 25 cm in the previous century (Warrick, et al. 1996). The rise in sea levels is likely to have four main implications for island nations: (1) inundation of low-lying areas; (2) coastal erosion; (3) greater inundation during storm flooding, and; (4) salinisation (Barth and Titus, 1984). In addition to issues surrounding higher sea levels, McLean and Mimura (1993) also note that many countries could also be affected by damage caused by more intense storms. Nicholls and Mimura (1998), however, reports that the geographic impact of climate changes is likely to vary significantly across regions, with the coastal implications being significantly more severe in some regions.

Given that most tourist activities takes place along the coastline, Moreno and Becken (2009) provides a five-step vulnerability assessment methodology for tourism in coastal areas: (1) undertake an analysis of coastal tourism and the attributes of the industry; (2) identify potential climatic hazards and their effects on tourism activities; (3) identify vulnerable areas of the tourist industry and ways to quantify them; (4) evaluate the overall impact of climate change on the destination, and; (5) communicate the results to stakeholders. While the approach presented is useful for developing an understanding of vulnerability assessment, the study did not address the issue of measurement of impacts.

To provide some assessment of the shoreline impact of climate change in small island states, Schleupner (2008) therefore uses a GIS model to conduct a spatial analysis for the island of Martinique. The first part of the approach evaluates the impact of sea level rise for coastal erosion for beaches, mangrove forests, deltaic and estuarine areas as well as coastal swamps. In the second stage, the detection and location of the most vulnerable tourist areas are identified. The study finds that whereas only 29 percent of mangrove forests are rated as highly sensitive to coastal squeeze, the majority of beaches were highly vulnerable. These findings suggest that Martinique could lose its prestige as a beach tourist destination as the majority of its beaches disappear.

Coombes et al. (2009) conducts a similar assessment using the case of the East Anglian coastline. The authors developed a model to: (1) evaluate how visitors respond to spatial and temporal changes along the coastline; (2) determine the effects of sea level rise associated with climate change on the coast, and; (3) predict future visitation based on four climate change scenarios. The study reports that the relationship between climate change and tourism is complex, i.e. while changes to the weather conditions are likely to positively impact on arrivals (extending the tourist season), the reduction in beach widths could negatively influence low lying beach sites.

One of the few studies to quantify these supply-side impacts is provided by Bigano et al. (2006), which uses a multi-country world CGE model, to evaluate the supply-side effect of rising sea levels. Climate change is assumed to impact on national endowments of labour, capital, land, natural resources, and multi-factor productivity. Three scenarios are considered: (1) sea level rise alone; (2) tourism alone, and; (3) sea level and tourism combined. In the first scenario, climate change leads to land loss due to erosion, flooding and salt-water intrusion. In the second scenario, the impact of climate change on tourism arises owing to the reduction in demand for tourism due to shifting demand patterns. The authors report that developing countries are more likely to be significantly affected given their high dependence on land, limited ability to substitute away from the land loss with other factors of production and greater capital outflows attributable to reduced rates of return.

While many of the previous studies focus on the likely impacts of climate change on tourism, Endler et al. (2009) attempt to identify how can tourism adapt to modified climate conditions. In the first stage of the approach, a regional climate model is utilised to provide predicted values for the physical, thermal and aesthetic aspects of climate. These climatic features are then employed to assess the attractiveness of tourism destinations. These climatic changes are anticipated to lead to shorter winters and longer summers. These altered seasons may bring about heat stress and sultriness for tourists, greater energy costs for cooling, infectious diseases, and greater natural hazards. The authors therefore recommend that for winter sports, adaptation measures such as snowmaking should be considered, while for destinations that rely on sea and sand, greater costs might be incurred for cooling.

In addition to sea level rise, small island states also have been cognisant of the effects of extreme weather events such as storms and hurricanes on tourism activity. Bigano et al. (2005) therefore considers the impacts of extreme climatic events such as storms, heat waves, and drought. Using regional climate data for Italy between 1966 and 1995, the study estimates regression models to identify the impact that climatic variables have on tourism activity. The regression model is then augmented with dummy variables to capture the effects of extreme climatic events. The estimated models suggest that climatic extremes can have a significant and negative effect on the number of bed nights of domestic tourists during the summer season.

These extreme weather events can also have important supply side effects in small island economies. In this regard, Chandler (2004) conducted an analysis of the effects of the three hurricanes that affected the state of North Carolina on the lodging industry in this area. The study reports that these storms would have resulted in physical damages and loss revenues of between $96 and $125 million between September and October of 1999. Burrus et al (2002) notes that even for low intensity storms, the per-storm regional impact of business interruption is about 0.8 and 1.2 percent of regional output.

3. Empirical Approach

While in manufacturing there is an actual product being produced, in tourism output is the provision of a service. As a result, tourism supply is normally measured in terms of (carrying) capacity. The World Tourism Organisation defines the capacity of a particular destination as "the level of visitors' use an area can accommodate…" (WTO/UNEP, 1992). There are three main conceptual bases for carrying capacity: (1) social; (2) economic, and; (3) ecological. Social capacity refers to the visitor density at which the number of unplanned interactions among individuals begins to reduce their enjoyment of the experience. Economic carrying capacity, on the other hand, is the number of visitors that maximises the net revenue of the destination (number of visitors *times* per capita payment *less* infrastructure and support costs), while ecological carrying capacity is the number of visitors that produces no irreversible ecological change to the ecosystem of the particular destination.

As argued by Buckley (1999), all three of these concepts are difficult to measure. Social carrying capacity may increase over time and change for each destination. In some destinations, visitors may be craving solitude, thus the social carrying capacity of its beaches may just be one person, while in others, the number might be significantly higher. In relation to ecological carrying capacity, all visitors create some impact; therefore, setting the threshold at zero may be impractical. Moreover, detecting the impact of a tourist on a particular destination can be highly variable, depending on the detection technologies employed and sampling design. If visitors are asked to pay the economic cost of their visit, the economic carrying capacity can therefore be measured by some indicator such as the number of rooms or beds in the destination. While conceptually easy to measure, maximizing revenues can produce overcrowding and ecological damage.

Bearing in mind its shortcomings, this study employs the economic measure of carrying capacity. Climate change can impact on the economic carrying capacity of Barbados, since it is likely to lead to the loss of some hotel plants due to sea level rise, flooding as well as increased storm activity. The Ministry of Physical Development Environment (2001) predicts that the sea level is likely to rise by 0.2m by 2020, 0.5m by 2050 and 1m by 2100 for the south and west coasts of the island. In addition, on the south coast a zone of flooding is predicted in excess of 1 km inland, while on the west coasts it could be up to 300m in some areas. To simulate the effects of these various scenarios, information on the location and distance of hotels, guesthouses and apartments in Barbados is collected. This information is then employed to identify the hotels as well as the potential number of rooms that could be affected in the scenarios described above.

Climate change is also expected to lead to a rise in extreme hurricane events. Elsner (2007), through the use of granger causality analysis, finds that as climate change causes seas to warm, the ocean stores more energy that could be converted to hurricane wind. Bengtsson et al. (2007) go even further and examine how tropical storms may change as a result of a warmer climate using global climate models. The authors find that while the total number of hurricanes is unlikely to change by the end of the 21st century, the total number of category five hurricanes (wind speeds greater than 155 mph) are expected to increase by a third to 5, the number of category four hurricanes to 36 and the number of category three storms to 92. Based on estimates by Williams and Sheets (2001), the probability of any these hurricanes affecting Barbados is 8.3 percent, while the probability of a major hurricane is 2.3 percent.

Because of the rarity of hurricane events impacting on Barbados, there is little historical data to use regarding the potential impact of these climatic conditions on the economy. As an alternative, therefore, one can use the experiences of other Caribbean islands to draw inferences regarding the impact of these events. Table 1 compares hurricane strength to the normalised damage estimates for various Caribbean countries. The results suggest that category 1 storms are likely to cause a loss of GDP of about 5 or less percent. In contrast, a category 5 storm causes damage over and above the country's total national income.

Table 1: Hurricane Strength Normalised Damage Estimates for the Caribbean

Country	*Name of Hurricane/Date*	*Saffir/Simpson (SS) scale*	*Normalised Damage Estimates (1998 US Dollars)*	*GDP (US Dollars)*	*% of GDP*
St. Kitts and Nevis	Georges/September-October 1998	Category 2	$800 million	$287 million	279%
US Virgin Islands	Georges/September-October 1998	Category 1	$100 million	$1.8 billion	5%
Puerto Rico	Georges/September-October 1998	Category 1	$3.5 billion	$57 billion	6%
US Virgin Islands	Marilyn/September 1995	Category 3	$3.1 billion	$1.8 billion	172%
St. Maarten	Luis/August-September 1995	Category 3	$2.7 billion	n.a.	n.a.
Puerto Rico	Hugo/September 1989	Category 3	$1.5 billion	$57 billion	3%
St Lucia	Allen/August 1980	Category 3	$617 million	$658 million	94%
Puerto Rico	Claudette/July 1979	Tropical Storm	$2 million	$57 billion	<1%
Puerto Rico	Kendra/October-November 1978	Tropical Depression	$17 million	$57 billion	<1%
Puerto Rico	Eloise/September 1975	Tropical Storm	$458 million	$57 billion	<1%
Puerto Rico	Carmen/August-September 1974	Tropical Storm	$8 million	$57 billion	<1%
Belize	Hattie/October 1961	Category 5	$1 billion	$689 million	145%
Belize	Abby/July 1960	Category 1	$11 million	$689 million	2%

Source: Pielke, et al. (2003)

Table 2 provides a summary of the characteristics of various classifications of storms as well as potential infrastructural damage estimates. The table suggests that while a category 1 storm is likely to cause storm surges up to 1.7 meters and damage of about 5 percent of the infrastructure, a category 5 storm could affect more than 75 percent of the hotel plant and cause surges of more than 6 meters.

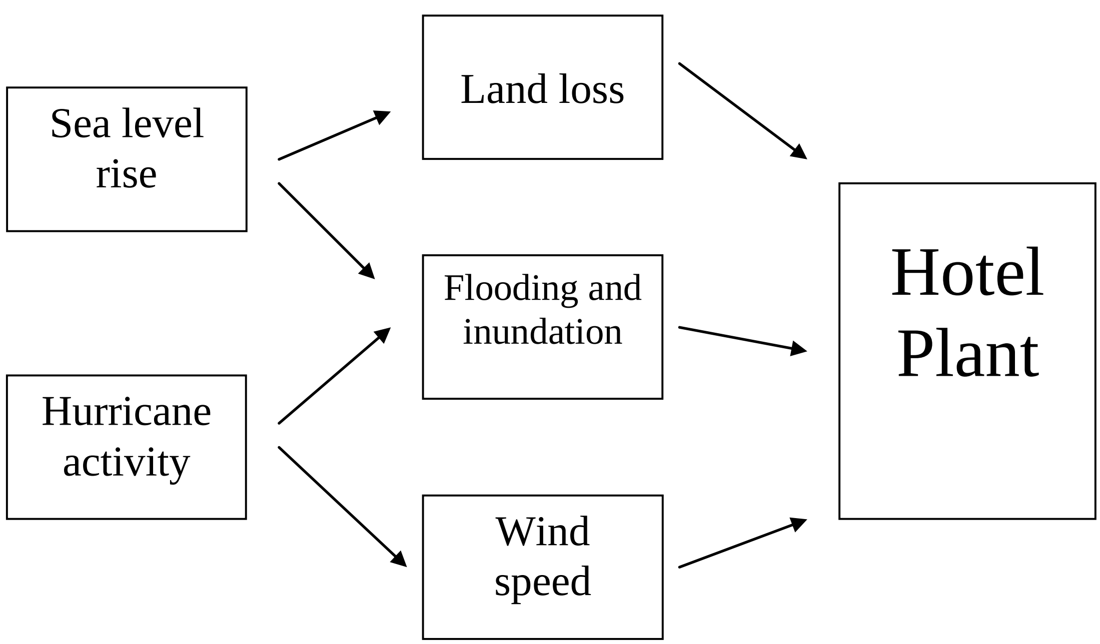
Table 2: Hurricane Strength and Potential Infrastructural Damage

Saffir/Simpson (SS) scale	*Maximum Sustained Wind Speed (m/s)*	*Storm Surge(m)*	*Potential Infrastructural Damage*
Category 1	33-42	1.0-1.7	No major damage to buildings (5%)
Category 2	43-49	1.8-2.6	Moderate damage to buildings (10%)
Category 3	50-58	2.7-3.8	Extensive damage to buildings (35%)
Category 4	59-58	3.9-5.6	Extreme damage (50%)
Category 5	>69	>5.6	Catastrophic damage (75%)

Source: Gray, et al and Author's estimates.

Combining the information on the projected number of storms and strike probabilities, allows the researchers to simulate the possible impact of increased hurricane activity on tourism capacity in the Caribbean. A schematic representation of the model in provided in Figure 1.

Figure 1: Schematic Representation of Supply-Side Simulation Model



The estimated national loss estimates can be calculated using the following expression:

$$NE=I*P*L$$

where NL are national loss estimates, I is the intensity of the storm, P the probability that the storm impacts on the country and L the loss factor associated with the type of storm. The simulation utilises data on the number of rooms and the proximity of each hotel to the shoreline. Therefore the loss to a particular hotel is weighted not only by the strength of the storm but also its proximity to the shoreline. Sensitivity analyses are done for all the variables included in the expression above.

4. Results

4.1 Coastal Squeezing

This section of the report provides an analysis of the potential impacts that climate change can have on the tourism plant in the island. The Ministry of Physical Development Environment (2001) have the following expectations for increases in sea levels: (1) 0.2 metre rise in sea levels (2020) estimated to lead to a maximum of 3.3 metres of land loss; (2) 0.5 metre rise in sea levels (2050) estimated to lead to a maximum of 8 metres of land loss, and; (3) 1 metre rise in sea levels (2100) estimated to lead to a maximum of 32 metres of land loss. Three scenarios are developed to match these geographical predictions of the Ministry of Physical Development and Environment (Scenarios 1 – 3). In addition to these three scenarios, two other scenarios are also considered that assume land loss scenarios of 50 and 100 metres respectively.

The simulated results for these five scenarios are given in Table 3. The model implies that given the proximity of most hotels to the beach, a 0.2-0.5 metre rise in the level, (Scenarios 1 and 2) is unlikely to impact on any hotels in the island. With regards to a rise in sea levels of 1 meter, scenario 3, an estimated 13 establishments could be affected (7 hotels, 1 guesthouse, and 5 apartments) or 7% of such establishments in Barbados. These account for 370 rooms or 8% of the room stock on the island. Assuming a 57 percent occupancy rate (historical average), this translates into a reduction in revenue of about US$ 14 million and approximately US$ 11 million in value-added. Additionally, given the impacts on hotels, apartment and guest houses, it is anticipated, that approximately 260 jobs would be lost.

Table 3: Potential Impact on Hotel Plant of Various Land Loss Scenarios

Land Loss Scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
Establishments Affected					
Hotels	0	0	7	14	42
Guest Houses	0	0	1	3	7
Apartments	0	0	5	6	21
Total	0	0	13	23	70
Percentage of Establishments Affected					
Hotels	0%	0%	12%	23%	70%
Guest Houses	0%	0%	4%	13%	29%
Apartments	0%	0%	5%	6%	22%
Total	0%	0%	7%	13%	39%
Number of Rooms Affected					
Hotels	0	0	325	502	2673
Guest Houses	0	0	5	17	41
Apartments	0	0	40	52	214
Total	0	0	370	571	2928
Percentage of Rooms Affected					
Hotels	0%	0%	10%	15%	78%
Guest Houses	0%	0%	4%	14%	33%
Apartments	0%	0%	5%	6%	26%
Total	0%	0%	8%	13%	67%
Loss Revenue (US $Mil)					
Hotels	0.0	0.0	14.5	28.2	143.4
Guest Houses	0.0	0.0	0.0	0.2	0.6

Apartments	0.0	0.0	1.0	1.2	6.3
Total	0.0	0.0	15.6	29.6	150.3
Value-Added Lossed (US $Mil)					
Hotels	0.0	0.0	10.9	21.1	107.5
Guest Houses	0.0	0.0	0.0	0.2	0.4
Apartments	0.0	0.0	0.8	0.9	4.8
Total	0.0	0.0	11.7	22.2	112.7
Jobs Losses					
Hotels	0	0	140	280	840
Guest Houses	0	0	3	9	21
Apartments	0	0	15	18	63
Total	0	0	260	460	1400

For the two worst-case scenarios, Scenarios 4 and 5, the anticipated effect on the industry, as should be expected, is quite severe. Coastal squeezing of about 50 metres would affect 23 establishments, while a 100 metre loss would affect 70 properties or about 40 percent of accommodation establishments (about two-thirds of the room stock). Assuming hotel occupancy remains at its historical average, this reduction in the room stock would result in a fall in revenue from these establishments by between US$ 40 million and US$ 130 million. Additionally, given the impacts on hotels, apartment and guest houses, it is anticipated, that approximately 460-1400 jobs would be lost.

4.2 Extreme Weather Events

It is also likely that climate change can lead to greater tropical storm activity. To account for these effects the model combines information on the projected number of hurricanes, strike probabilities, and likely devastation to evaluate the impact on the local industry. Although the numbers of devastating hurricanes are likely to rise, the total number of storms is not anticipated to change appreciably. To account for such effects, the model combines data on the expected number of hurricanes, their probabilities of affecting the island, and the likely devastation that will be caused. This information is summarised in Table 4. The damage estimates are 0.1, 0.3, and 0.5 for category 3, 4 and 5 storms respectively.

Table 4: Summary of the Hurricane/Tropical Storm Activity Assumptions

	Scenario 1	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*
Prob. of Category 3	0.083	0.100	0.150	0.200	0.300
Prob. of Category 4	0.083	0.100	0.150	0.200	0.300
Prob. of Category 5	0.023	0.050	0.100	0.150	0.200
No. of Category 3	96	106	116	128	141
No. of Category 4	36	40	44	48	53
No. of Category 5	5	6	6	7	7

Table 5: Potential Impact of Increased Hurricane Activity on Hotel Plant (2071-2100)

Storm or Hurricane Scenario	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
Number of Rooms Affected (per year)					
Hotels	60	81	137	202	331
Guest Houses	58	78	132	195	319
Apartments	57	77	130	192	314
Total	174	237	398	589	964
Loss Revenue (US $Mil)					
Hotels	308.9	420.1	706.6	1046.1	1709.9
Guest Houses	3.0	4.1	6.9	10.2	16.7
Apartments	43.8	59.6	100.3	148.5	242.7
Total	355.7	483.9	813.8	1204.8	1969.3
Value-Added Lossed (US $Mil)					
Hotels	231.7	315.2	530.1	784.8	1282.8
Guest Houses	2.3	3.1	5.2	7.7	12.6
Apartments	32.9	44.7	75.2	111.4	182.1
Total	266.9	363.0	610.5	903.8	1477.4

Under scenario 1, a total of 174 rooms are likely to suffer some damage as a result of the forecast of hurricane activity in the region. Given this best-case scenario, the revenue lost would amount to US$356 million for all accommodation establishments or about US$232 million in lost value-added. For scenarios 2 and 3, which assume a larger number of category 3 and category 4 storms, the revenue lost rises by US$128 million and US$458 million, respectively. These higher revenue losses occur primarily due to the higher strike probabilities for the island, which under these two scenarios are almost twice the islands historical average. The final two scenarios can be considered worst-case simulations and assume that the strike probability for the island is almost three times greater than the historical average. For these final two scenarios, the losses that the industry could encounter over the current century could amount to between US$1.2 billion to US$2 billion, primarily due to the possibility that a major hurricane (category 4 or 5) could strike the island.

5. Conclusions

The purpose of this article was to examine the potential supply-side effects of climate change on the tourism industry in Barbados, using data on 181 establishments in the island. To simulate the effects of sea level rise under various climate change scenarios, information on the location and distance of hotels, guesthouses and apartments in Barbados is collected. This information is then employed to identify the hotels as well as the potential number of rooms that could be affected in the scenarios. Climate change is also expected to lead to rise in extreme hurricane events. Combining the information on the projected number of storms and strike probabilities, allows the researchers to simulate the possible impact of increased hurricane activity on tourism capacity in the Caribbean.

An examination of the potential impact of sea level rise and the future effects of extreme climatic events suggest that the losses possible for the latter are more severe. For example, when modest assumptions are employed regarding storm activity in the region, the potential losses to the industry are estimated at US$356 million, or almost twice the amount obtained under the worst case scenario for land loss. Given the potential level of reduced revenue and value-added combined with the number of job losses, there is a relatively high risk to the tourism sector and the economy as a whole due to extreme climatic events.

To encourage practitioners within the industry to minimise the damage to the environment and to promote ecologically safe practices, the government should continue to support companies that utilise energy saving devices through the use of tax waivers and other fiscal tools. In addition, there should be active encouragement of companies that demonstrate a commitment to adapting their establishment to mitigate the impact of climate change as this bodes well for the entire industry; this could be done through some type of national award or recognition.

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