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AN ASSESSMENT OF THE ECONOMIC IMPACT OF CLIMATE CHANGE ON THE TOURISM SECTOR IN ARUBA

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Executive Summary

In this study, an attempt is made to assess the economic impact of climate change on Aruba. This study has three main objectives. The first is to examine the factors that influence the demand and supply of tourism in Aruba. The second is to forecast the cost of climate change to the tourism sector until 2050 under the A2 and B2 climate scenarios with the Business as Usual (BAU) as a comparator climate scenario, and the third is to estimate the cost of adaptation and mitigation strategies that can be undertaken by Aruba to address climate change in the tourism sector.

A tourism demand model is employed to determine the variables that impact tourism demand in Aruba during the 1975-2009 period using an error correction model within a cointegration framework and employing both economic (per capita income in the destination country, GDP, oil prices) and climatic (temperature and precipitation) variables. The results suggest that per capita income, the Gross Domestic Product in the United States, temperature and precipitation influence tourism demand in Aruba. To estimate the total cost of the impact of climate change on the tourism industry two other layers of costs were aggregated: (a) the cost of sea level rise with respect to loss of beach and tourism infrastructure (exclusive of hurricane damage) along the shoreline; and (b) coral reef loss due to rising sea levels and temperatures.

Projections of tourism demand from 2010 to 2050 are done on the basis of two climate scenarios: the International Panel on Climate Change (IPCC) A2 and B2 scenarios (BAU is the comparator). Apart from temperature and precipitation there are other climate variables that have the potential to negatively affect the tourism sector in Aruba. As a result, the costs were calculated taking into consideration changes in temperature and precipitation, sea level rise and destruction of ecosystems (specifically coral reef loss) due to ocean acidification.

It was found that under the two climate change scenarios there is a decline in tourist income to the island. Specifically, by mid-century Aruba can lose over US$12 billion under the A2 scenario and US$13 billion under the B2 scenarios in the tourism sector.

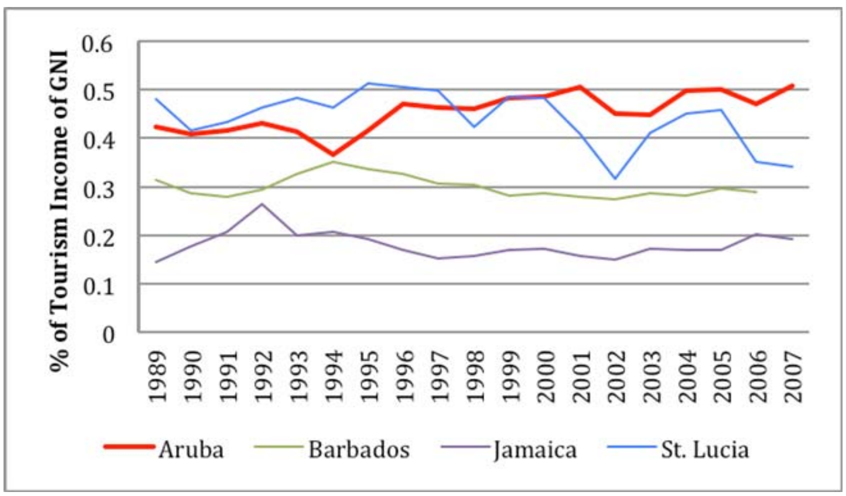
The next phase of the study examines mitigation and adaptation strategies that the tourism sector can adopt and also estimates the cost of these strategies. Of the five mitigation options one had a cost-benefit ratio over 1 and of the seven adaptation strategies selected, six had cost-benefits ratios over 1. It is recommended that Aruba implement these seven mitigation and adaptation options as a matter of priority and undertake further studies to determine when and how the other five mitigation and adaptation strategies should be implemented, since these are country-specific strategies and may bring many indirect and non-economic benefits to Aruba in the longer term. This signals that it is beneficial for Aruba to begin mitigating and adapting to climate change to increase income in the tourism sector.

I. INTRODUCTION

According to the Economic Commission for Latin America and the Caribbean (ECLAC) Preliminary Overview of the Economies of Latin America and the Caribbean (2009), tourism in Latin American and Caribbean countries sharply decreased in the earlier part of 2009 and the prognosis for 2009, as a whole, was that it was expected to fall by 5-10%. The report suggested that the general reason for this stemmed from an accumulation of factors linked to the contraction of global activity. The Caribbean region is highly tourist-dependent and for most of the countries tourism is the primary source of income and foreign currency. This study has three main objectives. The first is to examine the factors that influence the demand and supply of tourism in Aruba. The second is to forecast the cost of climate change to the tourism sector until 2050 under the A2 and B2 climate scenarios with the BAU climate scenario as a comparator, and the third is to estimate the cost of adaptation and mitigation strategies that can be undertaken by Aruba's tourism sector to address climate change.

Figure 1 shows the contribution of tourism to the economy for selected countries in the region for the period 1989 to 2007. In comparison to the countries shown, tourism constitutes the largest part of Gross Domestic Income (GNI) for Aruba, with Saint Lucia and Barbados following, especially in the 2000s.

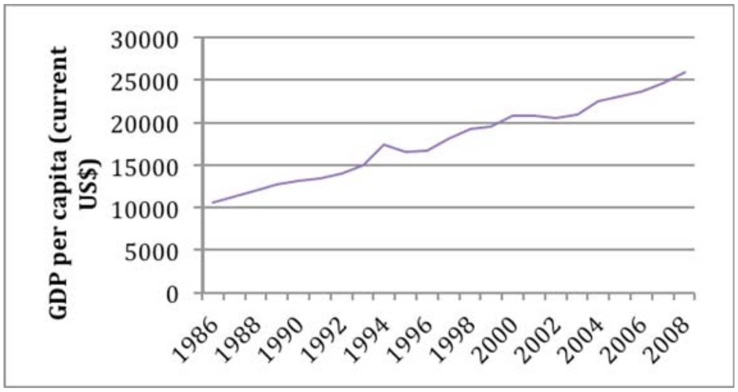
Figure 1: Tourism income as a % of GNI for selected Caribbean countries



Source: Author's Calculations (Tourism income - Caribbean Tourism Organisation, GNI – UN Stats)

Aruba is a prosperous country and one of the most developed islands in the Caribbean. Since gaining self-government in 1986, Aruba's GDP per capita moved from US$10,513.04 in 1986 to US$25,831.1 in 2008 (see figure 2). This was mainly due to the high investments in the tourism industry, an industry which today is Aruba's main source of income.

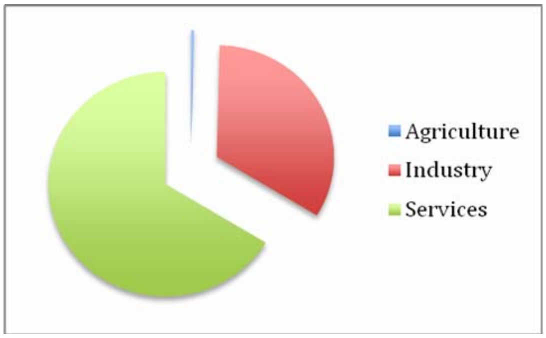
Figure 2: Aruba - GDP per capita



Source: UN Stats

Figure 3 indicates that the services sector in Aruba (of which tourism and related services are included) form a major part of GDP.

Figure 3: Sectoral components of GDP in Aruba



Source: CIA World Factbook (Available at: https://www.cia.gov/library/publications/the-world-factbook/fields/2012.html)

Previous to the rise of the tourism sector, Aruba was mainly dependent on oil. But by 1985 two of its main refineries had closed, one being re-opened at a scaled down level in 1991. Oil revenue continues to contribute to the economy but to a lesser degree.

Aruba's high dependence on its tourism sector makes it decidedly vulnerable to external shocks. Added to this most of its tourists come from one country - over 70% of its tourists come from the United States, which makes it highly susceptible to fluctuations in that economy. Another vulnerability of the tourism sector has to do with climate change. Climate change presents an increasing threat to the tourism industry. As Caribbean countries look to further growth in the tourism sector, it is important to take advantage of the near-term opportunities to reduce operating costs and increase efficiencies in the sector. As an example, improving energy efficiency represents one such opportunity, to reduce both costs and environmental impacts. This would fall in line with the 1.5 To Stay Alive[1] goal being pursued by Caribbean nations. Climate change also poses a potential threat to

[1] This objective was expressed in the Liliendaal Declaration on Climate Change and Development which supports a line of action in which states that "… global average surface temperature increases to be limited to well below 1.5° C of pre-industrial levels; that global greenhouse gas emissions should peak by 2015; global

the health and safety of tourists in relation to changes in temperature and precipitation and extreme events.

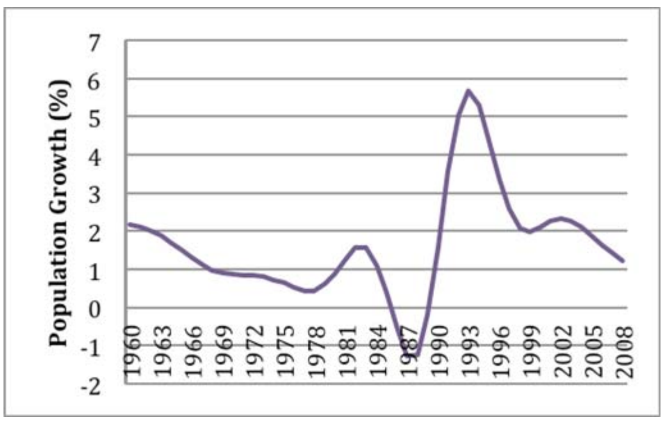
This paper is structured as follows. In Section 2 stylized facts on tourism and climate change are examined. Section 3 reviews the literature on tourism demand and climate change. Section 4 outlines and defines the theoretical framework. In Section 5 the variables used in this analysis and the statistical sources are explored. Section 6 specifies the econometric model and methodology. In Section 7 the results of the model are presented. Section 8 outlines the approach to forecasting the cost of climate change. Section 9 provides the forecasted cost of climate change. Section 10 initiates the discussion on the approaches to adaptation and mitigation in the tourism sector. Finally, Section 11 presents a summary of the work done.

II. STYLIZED FACTS ON ARUBA

A. TOURISM

Aruba is a Dutch island located 15 miles off the coast of Venezuela. Its present population is 105,300 (2008 figure) and as shown in figure 4, after experiencing negative population growth in the late 1980s, the country experienced its highest population growth rate in 1993 (5.67%). This growth rate has been attributed to migration from the United States and other Caribbean countries primarily due to the higher paying jobs available in Aruba.

Figure 4: Aruba – Annual Population Growth (%) – 1960-2008

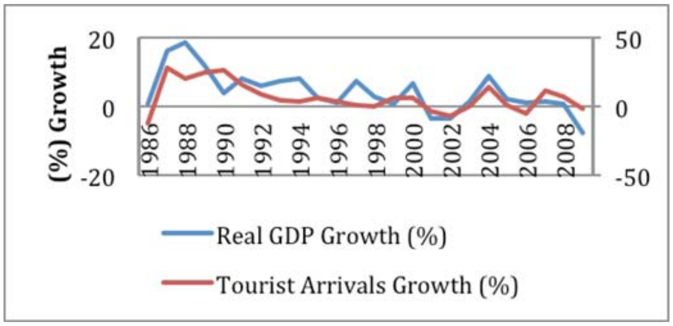


Source: World Bank Open Data (http://data.worldbank.org/)

Aruba has one of the highest per capita incomes in the Caribbean. As shown in figure 5, real GDP growth has attained some very high rates during the 1986-2009 period, the highest being in 1988 (20%). Also shown in the figure is the growth in tourist arrivals and from the data on both variables, it is clear that Aruba's economy depends heavily on the tourism sector.

CO2 reductions of at least 45 percent by 2020 and reducing greenhouse gas emissions by more than 95 per cent of 1990 CO2 levels by 2050 …" (see copy of Liliendaal Declaration at: http://www.caricom.org/jsp/communications/meetings_statements/liliendaal_declaration_climate_change_development.jsp

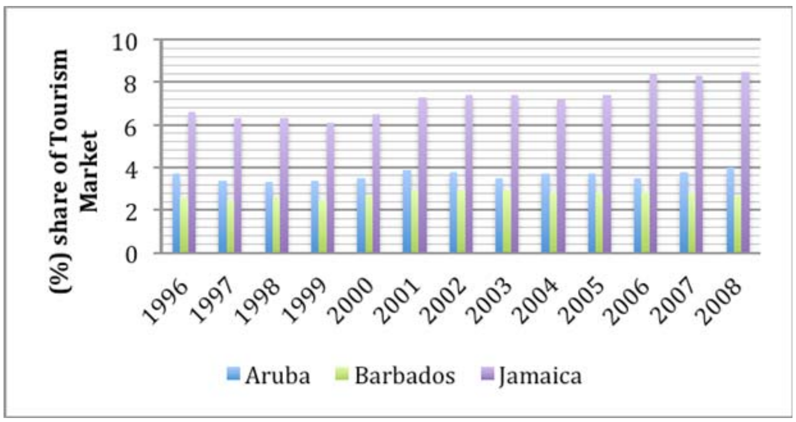
Figure 5: Real GDP growth and growth in tourist arrivals – 1986-2009



Source: Central Bank of Aruba Annual Statistical Digest 2009

Aruba's market share of tourism, along with other selected countries in the Caribbean for the 1996-2008 period, is shown in figure 6. The figure indicates that of the three countries shown, Aruba's market share is only higher than that of Barbados and that throughout the period it remained at an average figure of approximately 3.6% of the market share.

Figure 6: Market share of tourism: selected countries in the Caribbean (Stay-over visitors)

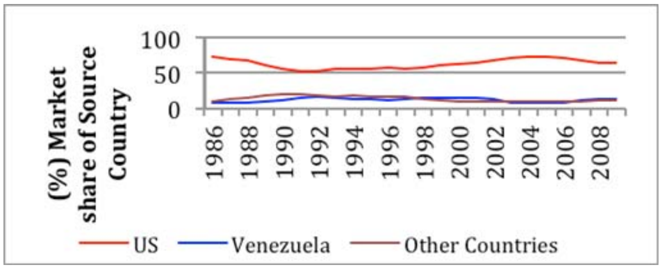


Source: Central Bank of Aruba Annual Statistical Digest 2009

Figure 7 shows key source countries and their market share of tourism in Aruba for the period 1986-2009. In terms of market share, it is clear that the United States throughout the period remains the principal source of tourism revenues for Aruba. The implication here is that events which discourage tourism, and which are linked to the United States, would impact negatively on Aruba's entire tourism sector[2]. Figure 7 also illustrates that Venezuela is another fairly key source country for tourist arrivals. These two countries make up close to 80% of all tourist arrivals to Aruba.

[2] For example, the events of September 11, 2001, the negative publicity generated by the missing US teenager (2005), and more recently the financial crisis.

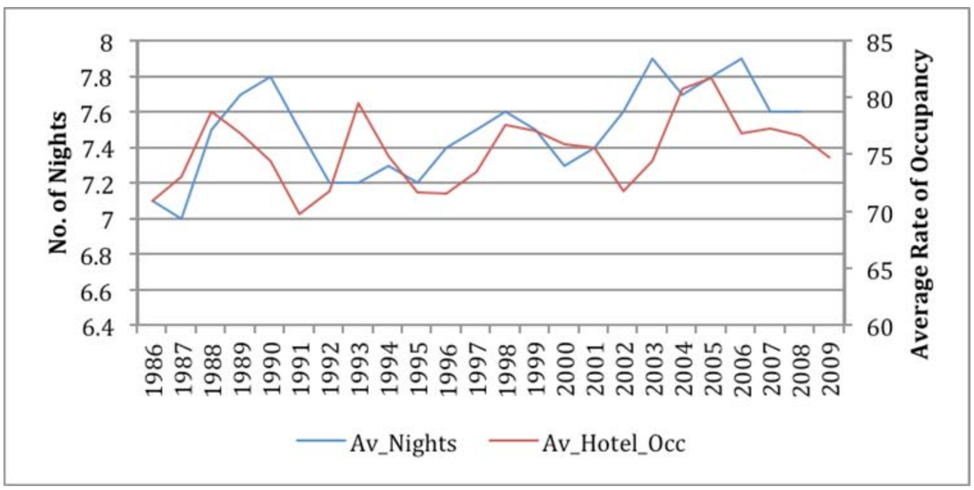
Figure 7: Source country market share of tourism



Source: Central Bank of Aruba Annual Statistical Digest 2009

Apart from the tourism sector's contribution to GDP and to government revenues, the sector has the potential to create jobs, encourage private investment and bring in foreign exchange. Two key indicators of tourism activity are the 'average nights stayed' and the 'average hotel occupancy rate'. During the 1986 to 2009 period the average amount of nights spent by a tourist in Aruba varied over the period but remained over seven days. The average hotel occupancy rate also fluctuated over the period but remained over 70% for the entire period except for 1991 (see Fig. 8).

Figure 8: Average nights spent and average hotel occupancy rate – 1986 – 2009



Source: Central Bank of Aruba Annual Statistical Digest 2009

B. CLIMATE AND CLIMATE CHANGE

Statistics on the various elements that constitute the region's climate are showing that the world's climate is changing: higher average temperatures (both air and ocean), rising sea levels and an increase in the intensity and frequency of storms and tropical cyclones are being experienced (IPCC Fourth Assessment Report, 2007). Other recent research is showing that future anthropogenic climate warning could change tropical storm and hurricane features (increase or decrease) such as frequency, intensity, size, duration and precipitation (see. Climate Change Science Program report (CCSP, 2008) for a comprehensive treatment of the subject). Historic information on temperature is showing that the Earth on average has already warmed by approximately 1°C from the start of the period of industrialization. As highlighted in the World Development Report (2010), each region in the world would be affected to a higher degree by certain aspects of climate change. For the Caribbean region the major weakness will lie in the warming and acidifying of the oceans and the coral reefs will suffer from bleaching and possible diebacks. These reefs provide protection against storm surges and equally important is the value of these reefs to the tourism industry. The coral reefs in Aruba are located along the coastline and are a key source of tourism activity; it is one of the natural resources that permits Aruba to compete successfully in the tourism industry. As mentioned by de Cuba (2007) the survival and sustainability of this resource is being threatened by climatic (temperature changes) and environmental (for example, pollution) impacts.

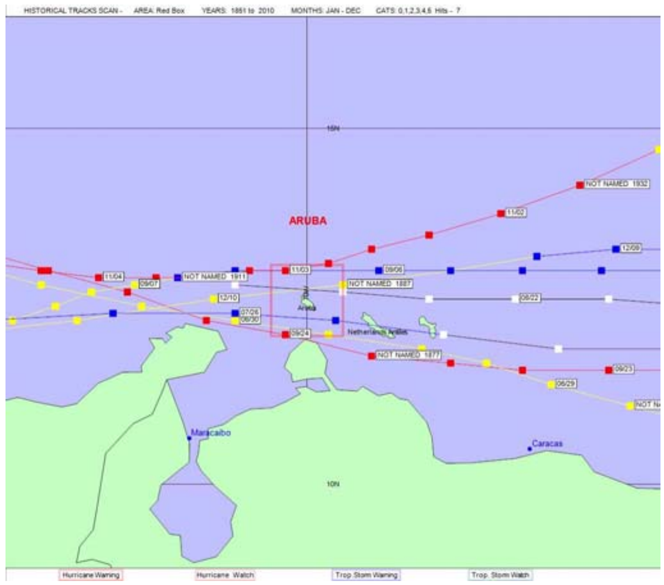
Aruba has a tropical climate where the average temperature is approximately 28°C and the average rainfall is about 39 mm per month[3], with most of the rainfall occurring during the months of October - January. Due to Aruba's location on the southern periphery of the hurricane belt, it does not have the experience of the other Caribbean islands with hurricanes. However, Aruba is affected by tropical systems that may develop in the vicinity, at times. According to the Meteorological Service of Netherlands Antilles and Aruba (2010)[4], these countries (Aruba, Bonaire and Curaçao) experience a severe tropical cyclone approximately once every 100 years, which may cause great damage to the islands. The report further states that on average a minor tropical cyclone occurs and this cyclone would normally pass mainly north of Aruba, Bonaire and Curaçao. When the category 4 hurricane (Hazel) hit the region in October of 1954 the immediate effects were not as damaging as it was to other countries in the Caribbean (Grenada, Haiti and the Bahamas) and North America. The Meteorological Service of Netherlands Antilles and Aruba (2010) Report also indicates that the damage sustained by the three islands (Aruba, Bonaire and Curaçao) was mainly due to flash floods and cost an estimated US$350,00. Figure 9 shows the tropical cyclones that passed within 60 nautical miles of Aruba from as early as 1851 through to 2010. There is also the issue of distant swells emanating from distant storms, which may cause damage to hotels and other buildings close to the coast. Information from the Meteorological Service of Aruba indicates that the more intense the storm, the higher the probability of destruction and/or floods, despite its distance from Aruba. As shown in figure 10, Category 4 storm, Dean, due to its larger fetch[5], caused more coastal flooding and beach erosion than Category 2 storm, Felix, which passed closer to Aruba.

3 The average monthly figure was calculated from historical data (1960-2006) on precipitation obtained from the Center for Climatic Research, Department of Geography, University of Delaware.

4 The publication is titled 'Hurricanes and Tropical Storms in the Netherlands Antilles and Aruba' and is available at: http://www.weather.an/reports/documents/HurricanesandTropicalStorms.pdf

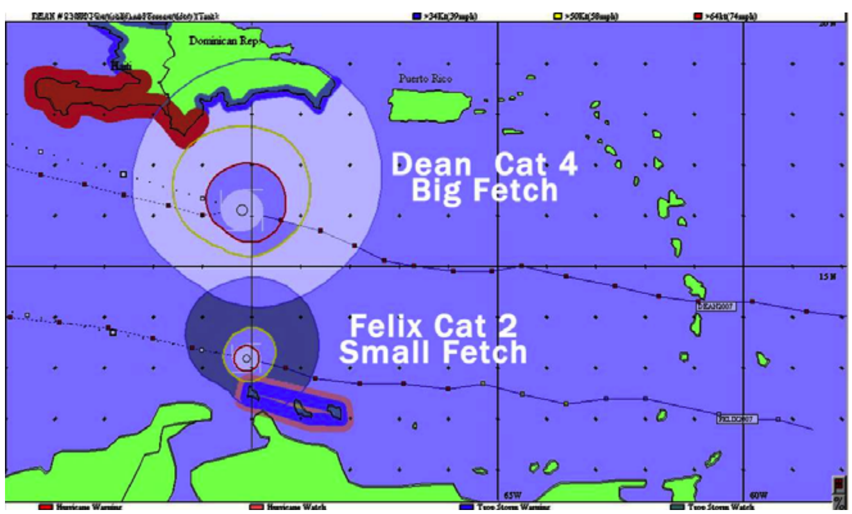
5 Fetch is the area in which ocean waves are generated by the wind. It also refers to the length of the fetch area, measured in the direction of the wind. (Definition available at: http://www.weather.gov/glossary/index.php?letter=f)

Figure 9: Tropical cyclones passing within 60 nautical miles of Aruba (through 2010)



Source: Marck Oduber, Research Meteorologist, Meteorological Service, Aruba

Figure 10: Comparison between a Category 4 Storm and a Category 2 Storm

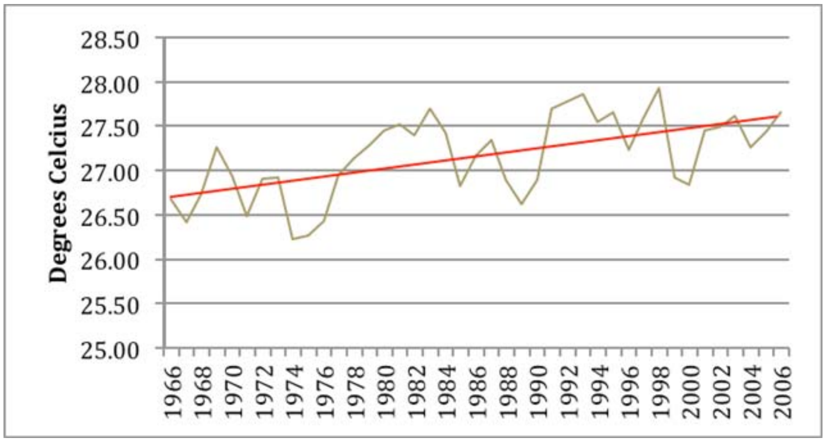


Source: Marck Oduber, Research Meteorologist, Meteorological Service, Aruba

As reported in the Annual Summary of Atlantic Hurricanes (http://www.nhc.noaa.gov/pastall.shtml#annual) in October 2008 Hurricane Omar produced large waves, which caused beach erosion and considerable damage to coastal facilities in Aruba, Bonaire and Curaçao.

Data on temperature in Aruba for the period 1966 to 2006 is shown in figure 11. The data for this and the following figure were compiled from the *Terrestrial Air Temperature and Precipitation: 1900-2006 Gridded Monthly Time Series, Version 1.01* (Matsuura and Willmott 2007). It is clear from the trend line that temperatures have been increasing steadily for the past 40 years.

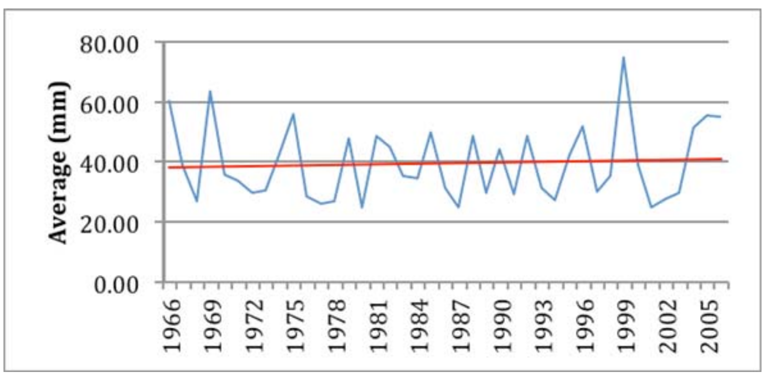
Figure 11: Average temperature in Aruba: 1966-2006



Source: Data compiled by author

For the past few years there have been increases in precipitation in certain areas of the world, while in other regions the droughts have become more frequent and intense. Aruba is typically semi-arid, and the precipitation data from Aruba is showing that total annual rainfall has been increasing, albeit to a very minute degree[6] (see figure 12).

Figure 12: Total annual rainfall for Aruba: 1966-2006



Source: Data compiled by author

Table 1 shows the carbon dioxide emissions for selected Caribbean countries. From the information it can be seen that Aruba, the Netherlands Antilles and Trinidad and Tobago are the main emitters of carbon dioxide in the region. The table also shows that for Aruba and the Netherlands Antilles the emissions come from fossil fuel consumption and liquid fuel consumption. It is accepted that there may be certain refineries established in Aruba without adequate environmental protection policies.

6 Desalination plants fulfill most of Aruba's water needs – one of these plants is the world's third largest of such plants.

Table 1: Carbon dioxide emissions for selected Caribbean countries (2006)

Country	Total Emissions by Activity (thousand metric tons)					
	Per capita Emissions (metric tons)	Fossil Fuel Consumption	Solid Fuel Consumption	Liquid Fuel consumption	Gas Fuel Consumption	Cement Production
Anguilla	1.00	14	-	14	-	-
Antigua and Barbuda	1.38	116	-	116	-	-
Aruba	**6.12**	**630**	**-**	**630**	**-**	**-**
Barbados	1.33	365	-	307	-	-
Dominica	0.47	32	-	32	-	-
Grenada	0.62	66	-	66	-	-
Guyana	0.54	411	-	411	-	-
Haiti	0.06	494	-	453	-	41
Jamaica	1.24	3,314	23	3,187	-	103
Netherland Antilles	**6.21**	**1,176**	**-**	**1,176**	**-**	**-**
St. Kitts and Nevis	0.86	37	-	37	-	-
St. Lucia	0.62	104	-	104	-	-
St. Vincent and the Grenadines	0.53	54	-	54	-	-
Trinidad and Tobago	**6.90**	**9,164**	**-**	**1,365**	**7,679**	**120**

Source: USAID 2009 Latin America and the Caribbean Selected Economic and Social Data

Table 2 gives data on the amount of threatened species and protected areas in both Aruba and the Netherlands Antilles. While Aruba has threatened animal species and one protected Marine area, the Netherlands Antilles have both threatened animal and plant species and protected marine and other areas.

Table 2: Threatened species and protected areas

	Aruba	Netherlands Antilles
Animal Species Threatened (number) 2008	22	37
Plant Species Threatened (number) 2003		2
Protected Area % of Surface Areas 2006		1.0
Protected Areas (hectares) 2006	*	200
Protected Areas (number) 2006	*	4
Protected Marine Areas (number)	1*	11
Protected Marine Areas (sq. km) 2004	0	78

Source: USAID 2009 Latin America and the Caribbean Selected Economic and Social Data
* Protected terrestrial area: 34 Km^2 (2003), Protected Marine Areas
Source: http://www.dcnanature.org/conservation/aruba.html

C. SRES A2 AND B2 SCENARIOS

In 2000 the IPCC published a set of climate scenarios in the Special Report on Emissions Scenarios (SRES). SRES climate scenarios were constructed to explore future developments in the global environment with distinct reference to the production of greenhouse gases and aerosol precursor emissions. Defined in the SRES storylines (narrative description of a scenario) are four scenarios identified as A1, A2, B1 and B2. Each scenario characterizes different demographic, social, economic, technological and environmental developments that move in progressively irreversible directions. For the purpose of this study, the forecasted cost to the tourism sector in Aruba would be based on the projections of the A2 and B2 climate scenarios. A brief explanation of the A2 and B2 scenarios is given in table 3.

Table 3: Brief description of the SRES storylines used for calculating future greenhouse gas and other pollutant emissions

Storyline	Description
A1	Very rapid economic growth; population peaks mid-century; social, cultural and economic convergence among regions; market mechanisms dominate. Subdivisions: A1F1 – reliance on fossil fuels; A1T – reliance on non-fossil fuels; A1B - a balance across all fuel sources
A2	Self reliance; preservation of local identities; continuously increasing population; economic growth on regional scales
B1	Clean and efficient technologies; reduction in material use; global solutions to economic, social and environmental sustainability; improved equity; population peaks mid-century
B2	Local solutions to sustainability; continuously increasing population at a lower rate than in A2; less rapid technological change than in B1 and A1

Source: Table A.2, page 107 of the UKCIP02 climate scenarios technical report

The A2 scenario envisages that by the year 2100 the population would have reached a figure of 15 billion, with generally slow economic and technological development. It predicts a little lower greenhouse gas emissions (GHG) than other scenarios. The B2 scenarios forecasts a slower population growth of 10.4 billion by 2100 with a rapidly developing economy and greater stress on environmental protection and so lower emissions and less future warming is produced.

III. REVIEW OF THE LITERATURE

A. TOURISM DEMAND AND CLIMATE CHANGE

Studies on the relationship between the climate and tourism demand began in the 1930s with researchers such as Selke (1936), who examined the impact of certain geographic aspects of tourism in Germany. These studies were few at first, but within recent times there has been a surge in the literature due to the impending risks that changes in the climate is expected to have on tourism. Hamilton and Tol (2007) noted that the modelling process focused primarily on economic factors and considered climate to be an unchanging variable.

Gossling and Hall (2006) identified two different strands in the literature dealing with climate change and tourism. One examines the results of the impact of climate change on the tourism sector of various countries, destination countries, tourist attractions, and niche tourism activities. In the second strand, the concentration is on the response of tourists to changing climatic variables (increases in temperature and rainfall). Further and originating from the latter strand are the direct and indirect impacts of climatic variables on regions that have a high dependence on tourism.

Examining first the initial strand, Agnew and Viner (2001) investigated the possible impact of climate change on tourism at 10 international destinations, which included both developed and developing countries. One of their important conclusions is that small island States will be gravely affected by sea level rise. Also, looking at international destinations, Hamilton et al. (2005) used an econometric simulation model to investigate the impact of climate change on tourist flows among 207 countries for the period 2000-2075 under the A1B climate scenario[7]. They found that with the projected changes in the climate, tourists would tend to choose countries with higher latitudes and altitudes, and that tourists from temperate countries would eventually prefer to vacation at home.

Richardson and Loomis (2005) employed survey data to gauge the effect of two types of variables on nature-based tourism demand, climate variables (temperature, precipitation etc.) and resource variables (wildlife, vegetation composition of the Rocky Mountain National Park). They analyzed contingent behaviour responses (change in the number of trips, change in the length of stay) as a function of climatic variables, demographic variables and travel costs under different climate scenarios. One of their main findings is that temperature was found to be a significant determinant of visitation levels.

Some of the studies on climate change and tourism demand investigate particular tourism activities or particular sectors of tourism. There are certain studies that investigate winter tourism (see for example, Beniston (2003), Breiling and Charamza (1994), and Burki et al. (2003)). One of the first studies of this nature employed temperature to estimate the effect of forecasted changes in temperature on the ski industry in Switzerland (Koenig and Abegg, 1997). The study revealed that under the present conditions with prevailing temperature and a snow line of 1200 m[8], there was a 85% chance that there would be snow to keep the industry functioning. However, if temperatures were to increase by 2 C, then only 65% of all Swiss ski areas would be snow reliable. This would clearly have serious implications for the growth of that sector of the industry.

The second strand of the literature concentrates on the tourist and his or her response to changing climatic variables and therefore includes weather and climate since they are significant influences on the tourism industry. It has been stated that the climatic factors that have the most

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[7] The A1B scenario is a subset of the A1 scenarios and emphasizes the technological element of the A1 scenarios; in particular A1B incorporates a balanced weighting on all energy sources.

[8] In this study it was mentioned that Pfund (1993) illustrated that a minimum altitude of 1200m (the line of snow reliability) is necessary for the ski industry to be a feasible undertaking.

impact on tourism are temperature, sunshine, radiation, precipitation, wind, humidity and fog (Stern 2006, Hamilton and Lau 2004). These factors are significant to the tourist's assessment of his or her well-being and health and the tourism industry. It is therefore essential that these elements be evaluated and measured since they form an important resource for tourism.

The literature has shown that temperature could potentially have positive implications for the length of the season and the environment, while other studies have found results to indicate that it has negative implications for tourism. Lise and Tol (2002), using cross-section data, undertook a cross-section analysis on tourists emanating from the Organization for Economic Cooperation and Development (OECD) set of countries, and found that the optimal temperature for their destination countries was 21 C. The implication of this finding is that the predicted increasing global temperature in certain regions of the world would have devastating effects on the tourist industry in those countries.

Another study, Berrittella et al. (2006) used a computable general equilibrium model to measure the potential effects of climate change. They employed two pathways to capture the impact of climate change i.e. modifications in the composition of final consumption and international income transfers. The rationale for doing this stemmed from the fact that when visitors spend in the domestic economy it impacts on consumption and income transfers. The Berrittella et al., study predicted that at the international level changes in the climate would eventually lead to a loss in welfare and that loss will be disproportionately spread across various regions in the world.

Temperature is considered to be the most important climate variable in the analysis of tourism demand because beyond a certain range it affects comfort. There is evidence to show that other climate parameters are also important, for example rain, wind and hours of sunshine (Scott and McBoyle, 2006). If any of these parameters are to be included in the analysis of tourism flows, they must be included as a determinant or in an index. Many studies include both temperature and precipitation to examine the impact of climate on tourism demand (see for example, Scott and McBoyle, 2006).

There have been few studies on the impact of climate change on tourism demand in the Caribbean. Of note is the study by Uyarra et al. (2005) in which a micro-analysis was undertaken to examine the significance of environmental characteristics in influencing the choice of tourists. The study used a self-administered questionnaire on tourists visiting Bonaire and Barbados, 316 from Bonaire and 338 from Barbados. The study established that warm temperatures, clear waters and low health risks were the main environmental attributes that were important to tourists visiting the islands. The study found that visitors to Bonaire placed additional importance on marine wildlife attributes while tourists going to Barbados had a preference for certain characteristics related to the beach characteristics. Uyarra et al., examined the impact of climate change by asking respondents about the likelihood of their returning to these islands in the event of coral bleaching and sea level rise. They found that more than 80% of the visitors to Bonaire and Barbados would not be expected to return to the islands in the event of these occurrences. Mather et al. (2005) examined the attraction of the Caribbean as a tourist destination for travellers from North America. He established that the Caribbean region would likely be less attractive to tourists due to factors such as increased temperatures, beach erosion, deterioration of reef quality and greater health risks.

Belle and Bramwell (2005) employed questionnaires and semi-structured interviews to acquire the views of policymakers and private sector tourism industry managers on their opinion on the effect that climate change would have on the tourism industry in Barbados. Most of the respondents were of the opinion that climate change would impact the tourist industry in Barbados negatively and that actions (for example, raising awareness and infrastructure) must be taken to deal with the expected damaging impacts of climate change.

Recently, Sookram (2009) estimated the cost of climate change to nine countries in the region using a fixed effects panel tourism demand model amplified by temperature and precipitation variables for the period 1989-2007. The model was used to forecast the cost to the selected countries under the A2 and B2 climate change scenarios until 2100. It was found that under both the scenarios the selected countries would suffer significant losses both, directly and indirectly.

Even more recently, Moore (2010) examined the potential impact of climate change on 18 Caribbean countries during the 1980-2004 period under various climate scenarios using a panel error correction model with fixed cross-country effects. He augmented the tourism demand model with a Tourism Climate Index[9] and found that changes in the climate could cost the region between US$118 million - US$140 million and that some countries would be affected more negatively than others.

The climate change variables being used in this study (temperature and precipitation) are considered to be important determinants of tourism in the Caribbean for important reasons. Trenberth et al. (2007) has highlighted the fact that the Caribbean region has shown a warming of temperatures ranging from 0 – 0.5 C per decade for the period 1971-2000. Relatedly, Peterson et al. (2002) has reported that in the Caribbean the percentage of days with cold temperatures has decreased while the percentage of days with very warm maximum or minimum temperatures has increased significantly since the 1950s. In relation to precipitation, it was found that the amount of heavy rainfall occurrences have been on the increase (Trenberth et al., 2007).

The main weaknesses of the existing models are shown below and ranges from the databases being used to estimate the models to forecasted levels of personal disposable income of travelers.

Major weaknesses of current models in predicting travel flows

Validity and structure of statistical databases
Temperature assumed to be the most important weather parameter
Importance of other weather parameters largely unknown (rain, storms, humidity, hours of sunshine, air pollution)
Role of weather extremes unknown
Role of information in decision-making unclear
Role of non-climatic parameters unclear (e.g., social unrest, political instability, risk perceptions)
Existence of fuzzy-variables problematic (terrorism, war, epidemics, natural disasters)
Assumed linearity of change in behaviour unrealistic
Future costs of transport uncertain
Future levels of personal disposable income (economic budget) and availability of leisure time (time budget) that are allocated to travel uncertain

Source: Gossling and Hall (2006)

Some of the weaknesses observed above can be identified in the modelling technique employed in this study. As an example, in this study temperature and precipitation are assumed to be the two most important climate parameters in modelling tourism demand. Other climate parameters, such as hours of sunshine, humidity, air pollution, were not included in the tourism demand model due to lack of data on these parameters and the relatively short time series available for Aruba. Although a proxy was employed for transportation costs, predictability of this variable and any of the other variables (for example, income) are subject to uncertainty.

9 Mieczkowski (1985) conceptualized the tourism climate index using 12 monthly climate variables thought to be relevant to the quality of the tourist experience.

A thorough analysis of the impact of climate change on the tourism sector involves both demand and supply issues. Apart from the analysis of the tourism industry using climate variables (temperature and precipitation) to study demand, it is important to also consider climatic events such as extreme events (hurricanes, tropical cyclones, storm surges), sea level rise and coral reef loss, which addresses both demand and supply concerns. These have been dealt with in the literature by various researchers, research groups and institutions examining the impact of climate change. Empirical results from some of these studies, which include Caribbean countries, are also presented.

B. EXTREME EVENTS

The IPCC synthesis report (2008) indicates that it is possible that tropical storms surges (cyclones and hurricanes) in the future would become more intense (higher wind speeds and greater precipitation levels). As mentioned above, and as pointed out by Knutson et al. (2010), it is difficult to make such predictions accurately due to large fluctuations in the frequency and intensity of hurricanes in the few global historical records of tropical cyclones. This study also pointed to the fact that based on the global warming projections of this century, it is expected that while there will be increases in the intensity of cyclones (with amplified wind speeds and precipitation), there is the potential for the frequency of these extreme events to decrease. Both the demand and supply of tourism would be affected by increases in the intensity of tropical cyclones as these events would lead to more storm surges and flooding with the accompanying damage to infrastructure, loss of life and heightening of the spread of vector-borne disease.

Stern (2006) points to a powerful feedback loop which could accelerate future warming. The tourism sector may suffer even more damage if the predicted effects are combined with such a climate feedback loop. It may be found that the lack of natural barriers, along with increases in storm surges and higher sea levels could have multiplicative negative effects on the tourism sector and indeed the entire country.

Curry et al. (2009) used data on historical hurricane losses for the period 1979-2006 to examine the damage that may occur from future hurricanes. They employed a normalized loss approach to account for inflation (deflation), wealth and the population. Adopting a technique similar to Pielke et al. (2000), the damage caused by each hurricane was determined by employing the following equation:

$$Normalized\ Loss = Reported\ Damage * I * W * P$$

Where,

Reported Damage = Damage in US$

I = inflation factor (U.S. GDP Deflator in 2007/U.S. GDP Deflator in the year of hurricane landfall)

W = wealth factor (GDP per capita for a country in 2007/ by the GDP per capita in the year of hurricane landfall)

P = population factor (2007 population of a country by the population in the year of hurricane landfall)

From the above damage function Curry et al. (2009) were able to obtain the Maximum Considered Events (the single tropical cyclone that caused the most damage and loss of life) and the Cumulative Loss (the accumulated damage from tropical cyclones over a 20-year period). This data was then used to estimate the potential future loss from predicted hurricane activity under different climate scenarios. Table 4 presents an extract of the results obtained under the A2 and B2 climate scenarios for selected Caribbean countries.

Table 4: Projected hurricane damage (2020-2025) for selected Caribbean countries under A2 and B2 climate scenarios (2007 US$ millions)

Country	A2		B2	
	Maximum Considered Events	Cumulative Loss	Maximum Considered Events	Cumulative Loss
Antigua and Barbuda	2294	793	2294	1020
Barbados	19	5	19	7
Grenada	1611	494	1611	632
St. Kitts and Nevis	1187	713	1187	917

Source: Data compiled by author

As mentioned in Curry et al. the method is data intensive and this was the reason given for the short time series and the number of countries included in the analysis.

C. SEA-LEVEL RISE

Sea levels rise because increases in global temperatures bring about thermal expansion of water, melts glaciers, polar ice caps and polar ice sheets (IPCC, 2008). According to the IPCC (2008), sea levels rose at an average rate of 1.8 mm per year from 1961-2003, with the greater average rise being from 1993-2003 (3.1mm), under the A1F1 emissions scenario. The IPCC expects that sea levels will rise between 0.26-0.59 m by 2100. With respect to the Caribbean region, it is anticipated that sea level rise will differ across the region since various factors may influence the rise (for example, the rate of warming, local atmospheric effects and currents) (Haites et al. 2002). In addition, Haites et al. (2002) further points that any rate of rise in the sea level is expected to have disastrous effects on most Caribbean countries. In many of the cases rises in the sea level would probably involve relocation and rebuilding since the infrastructure in these territories is mainly located in exposed coastal areas. Haites et al. also pointed out that certain countries in the Caribbean (for example, Barbados, Grenada) would be affected to an even higher degree since they rely on groundwater resources, which would likely be destroyed by the invasion of salt-water in these resources.

Specific to the tourism sector, sea level rise would bring about direct impacts involving:

a) Coastal erosion (loss of land)
b) Loss of hotel infrastructure
c) Destruction of coral reefs

Each of these issues is discussed in more detail below.

1. Coastal erosion (loss of land)

According to Church et al. (2008), the global average of sea level rise over a 51-year (1950-2000) period was approximately 1.8 ± 0.3 mm per year and according to the United Nations Development Programme (UNDP) (2010) report, there is evidence to suggest that the rise in the Caribbean is near to the global mean. The IPCC AR4 (2007), projects a rise in the sea level from .089 m to .238 m by 2050. Regional climate simulations suggest that sea level rise can range from 0.1 m (B2 scenario) to 0.3 m (A2 scenario). Nicholls and Toll (2006) calculated that 1% of land is likely to be lost under the B2 scenario and 2% under the A2 scenario by the 2080s. Using the costing of land from the Haites (2002) World Bank study, and applying an average land value of US$70 million per km^2 (the report used US$40 million in the low case scenario and US$100 million in the high case scenario) the cost of land loss in Aruba due to sea level rise under the A2 and B2 climate scenarios until 2050 is shown in Table 5.

Table 5: Projected value of land lost in Aruba due to sea level rise

	A2 Scenario	B2 Scenario
Total Land Area (km^2)	180	180
Land Loss (km$^{2)}$	3.6	1.8
Value of Land Loss (US$ million)	252	126

Source: Data compiled by author

2. Loss of hotel infrastructure

Haites et al. (2002) estimates that replacement costs for building and infrastructure due to sea level rise in the Caribbean region could lie between US$960 million to US$6.1 billion on an annual basis. Aruba has about 131 hotel/resorts/guest houses and most of these lies close to or very near to the coastline. Figure 13 shows a map of Aruba with just a fraction (20%) of the hotels and resorts highlighted. It is clear to see that the majority of structures are situated close to the coast.

Figure 13: Map of Aruba showing hotels/resorts

Source: Google Earth

An approximate estimation of hotel room replacement cost can be made for Aruba using the costing from the Haites et al. (2002) study and employing the same sea level rise assumptions for the Caribbean. Similar to Toba (2009), if an assumption is made that 8% of hotel rooms[10] are destroyed due to sea level rise and the average cost per room is approximately US$80,000, then in the case of Aruba the annual hotel room replacement cost is approximately US$20 million.

3. Coral reef loss

Hoegh-Guldberg et al. (2007) examined the impact of rapid climate change and ocean acidification on coral reefs and found that temperature increases of 1-2°C for a period of 2-4 weeks can cause coral

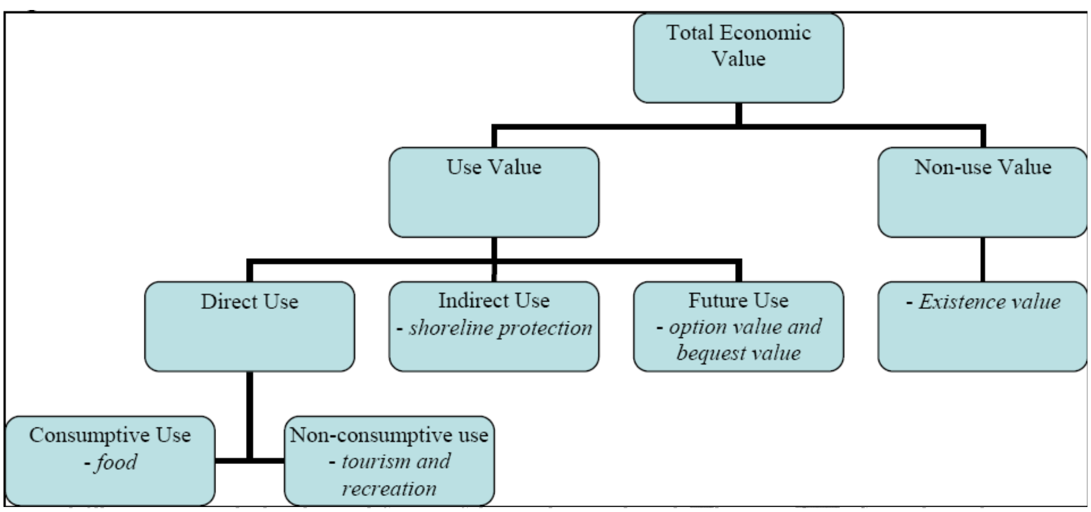
[10] A further assumption is that there are on average 65 hotels/resorts (each with approximately 50 rooms on average) near the coastline that have the potential to be affected by rises in the sea level.

bleaching. The United Nations Environment Programme (UNEP) (2008) has pointed out that there have already been many instances of coral bleaching in the Caribbean region and that as much as 80% of living coral reefs in the Caribbean have already been lost. There is no doubt that coral reefs are a key resource for Caribbean nations. They provide protection along the coastline for many Caribbean countries and they represent a significant source of biodiversity for the region. They are also a very important tourism resource in the region.

There have been many studies that attempt to value coral reefs both nationally and internationally (McAllister (1991), Spurgeon (1992), Wright (1994), Dixon (1993) and many others. As pointed out by the World Resource Institute (2008), while such valuation studies can be very useful, one must be cognizant that in general most economic valuation studies contain a high degree of uncertainty which can be linked to the valuation methods used, the assumptions made and the limitations attached to the results. Figure 14 shows one of the more frequently used frameworks, which divides the valuation activity into use and non-use values. Tourism and recreation is one of the non-consumptive uses of the 'Direct Use Values' of coral reefs.

In their assessment of the economic value of coral reefs in the Caribbean, Burke and Maidens (2004) determined that these reefs ranged in value between US$3.1 million and US$4.6 billion. This estimation was based on the ecosystem services of the reefs, which include shoreline protection, the production of fishery and income from tourism.

Figure 14: Total economic value framework



Source: World Resource Institute (2009)

Dixon et al. (1993) used the Contingent Valuation Method[11] to value recreation and tourism at the Bonaire Marine Park. Using data from a survey of tourists, they estimated a mean annual expected 'willingness to pay' for more coral in the Park (or coral reef improvement) of US$27.4 for diving. Tourists actually paid US$10.00 in 1992 for this service - the estimated consumer surplus being US$17.4. Parsons and Thur (2007), also attempted to value Bonaire National Marine Park (visibility, coral cover and diversity of species), and found that a reduction in quality from the present level to a level still considered 'good' represented an average cost of $45 per person, a further decline in quality to 'medium' cost $142 per person and a decline to 'poor' quality was estimated at approximately $192 per person. They employed a 3% discount rate and assessed the cost at each level

[11] Depending on the type of value (direct or indirect) being assessed, different valuation techniques can be employed, for example, Effect of Production (EoP), Damage Costs (DC), Replacement Costs (RC) or Travel Costs (TC).

for 28,000 users. They found the cost at each level to be: 'good'-quality' level – $42 million; 'medium-quality' level - $132 million and 'poor-quality' level - $179 million. A valuation study by Brander et al. (2009) estimated that reefs in the Caribbean were more valuable that many other reefs in various parts of the world.

While it is important to estimate the total economic value of any such resource, of relevance to this study is the cost of climate change to the tourism sector. One of the latest studies that attempt to assess the value of coral reef to tourism (Gill, 2010) estimates that about 22% of tourist expenditures can be attributed to reef-related activities. The Gill (2010) study did not capture the value of consumer surplus in the estimation. Using an average annual tourism income in the case of Aruba, this can be estimated to be approximately US$94 million per year.

D. AGGREGATION OF COSTING

The aggregation of layers of cost has been used in much of the work on costing climate change. Bueno et al. (2008) undertook an estimation of the cost of climate change for the Caribbean in the absence of action by these countries to counteract the effects of climate change. They combined the cost of hurricane damages, the loss to the tourism sector and sea level rise and estimate a low impact scenario and a high impact scenario for 2025, 2050, 2075 and 2100. The low impact scenario is the optimistic scenario where the world takes action in the near future and where emissions are significantly reduced by mid-century, and continue to decrease by the end of the century. The high impact scenario is one which is pessimistic in nature and one in which business-as-usual takes place i.e. GHG emissions continue to increase drastically throughout the twenty-first century.

Table 6 shows an extract of the table presented in their study[12]. The data in the table reveals that under the high impact (business-as-usual) scenario, all of the Caribbean countries have much to lose in the tourism industry. The figures indicate that under the low impact scenario Aruba loses 4% of GDP by 2050 and 20% of GDP under the high impact scenario.

Table 6: Cost of low-impact and high impact scenarios for tourism in selected Caribbean countries

Country	GDP ($US bns)	Low Impact Scenario ($US bns)				High Impact Scenario ($US bns)			
		2025	2050	2075	2100	2025	2050	2075	2100
Aruba	2.35	0.02	0.04	0.06	0.08	0.10	0.20	0.30	0.40
Barbados	2.54	0.02	0.03	0.05	0.07	0.09	0.17	0.26	0.35
Dominican Republic	20.52	0.07	0.14	0.21	0.28	0.36	0.71	1.07	1.43
Jamaica	8.77	0.04	0.07	0.11	0.15	0.18	0.37	0.55	0.74
Montserrat	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Netherland Antilles	2.70	0.02	0.04	0.06	0.07	0.09	0.18	0.28	0.37
Saint Lucia	0.70	0.01	0.01	0.02	0.02	0.03	0.05	0.08	0.11
Trinidad & Tobago	12.61	0.01	0.02	0.02	0.03	0.04	0.08	0.12	0.16

Source: Bueno et al. (2008)

Using low and high impacts climate scenarios[13], and examining the impact of rising temperatures in the region, a study by Margaree Consultants Limited (2002) suggests that for the low impact scenario, the Caribbean stands to lose on an annual basis US$715 million in tourist

[12] Guyana was not included in the Bueno et al. (2008) study.

[13] Figures for temperature were based on the IPCC Third Assessment Report (2001) - an increase of 2°C for the low impact scenario and an increase of 3.3°C for the high impact scenario.

expenditure, while for the high impact scenario tourism expenditures are reduced by US$1,430 million annually. With respect to the cost in terms of tourist facilities due to sea level rise[14], it was determined that on an annual basis it would cost US$9 million and US$80 million to replace hotels due to sea level rise under the low and high impact climate scenario, respectively. An evaluation of the loss in tourism income due to the loss of beaches and ecosystems was also carried out in the same study. In this case they looked at the fraction of beach area lost in conjunction with the amount that tourists spend on enjoying the 'sun, sea and sand'. At an annual rate they calculated that in the low case scenario the loss would be US$550 million and in the high case US$2.4 billion.

IV. METHODOLOGY FOR ANALYSIS

This study will model, forecast and cost climate change on the tourism industry to 2050 taking into consideration both demand and supply factors. The costing to be undertaken in this paper shall not be inclusive of all possible climate change impacts to Aruba's tourism sector, since some of the more indirect costs (for example, unemployment due to destruction of a hotel by a cyclone) are not estimated. To undertake this analysis the study will aggregate three layers of costing to estimate the total of climate change on the tourism sector for Aruba. The report will analyze and cost tourism demand using two climate variables: temperature and precipitation. The other two layers include approximating: (a) the cost of sea level rise with respect to loss of beach and tourism infrastructure (exclusive of hurricane damage) along the shoreline; and (b) coral reef loss due to rising sea levels and temperatures.

For the purposes of this study (a) and (b) will be taken as a whole and one figure will be used to account for the losses due to sea level rise. This methodology was adopted from Toba (2009). As discussed in the literature review, it is assumed that tourists spend a certain sum of their expenditure for activities related to the sea. Toba (2009) assumed that to be about 30% of their total expenditure. With climate change occurring due to rising sea levels and loss of beach and tourism infrastructure along with coral reef destruction, it is assumed that this amount would be lost due to non-participation in these activities. This figure is a reasonable one given that in two other studies (UNDP 2010) and (Gill 2010); approximately 20% of tourism expenditure was calculated to have been lost due to the rising sea level. In the case of the UNDP (2010) study resort loss was used to proxy beach loss and it was estimated that tourist expenditures would decrease by 20% due to the impact of sea level rise on beach loss. In Gill (2010), 22% of tourism expenditure was attributed to the participation of tourists in sea related activities (reef related accommodation and diving, snorkeling, boating and marine parks).

V. MODELLING TOURISM DEMAND IN ARUBA

A. THE TOURISM DEMAND FUNCTION: A REVIEW OF THE LITERATURE

The tourism demand model used in this study is consistent with demand theory and is augmented by two climate variables. The literature on the demand for tourism indicates that tourist flows between the destination and source countries can be explained using a demand function. A review of the literature shows that different measures of tourism flows have been used, but that the majority of tourism demand studies use either the number of arrivals to the destination country or the amount of expenditure undertaken by tourists. Some researchers suggest that the dependent variable in the tourism demand equation should be tourist expenditure, and according to Crouch and Shaw (1992),

[14] According to the estimates by Margaree Consultants Limited (2002) the sea level is expected to rise between 0.5 (low impact scenario) and 2.0 (high impact scenario) metres by 2100.

approximately 70% of the studies that estimated tourism demand functions have employed tourist arrivals as the dependent variable. In this study tourist expenditure has been used as the dependent variable. This is because one of the main objectives of the study is to calculate the cost of climate change to the tourism industry. By directly employing the expenditure variable it means the process of calculating forecasted cost is not complicated by the transformation of tourist arrivals to tourist expenditure after the model is estimated. The literature on tourism demand suggests that a number of explanatory variables can be used to investigate tourism demand. The independent variables used in this study are as follows: Gross Domestic Product in the destination country (in constant 1990 US$), per capita income (PCY) in the source country (in constant 1990 US$), transportation costs (in US$), temperature (C) and precipitation (mm).

It is expected that a higher level of income is desirable by tourists visiting a country, since it translates to a higher standard of accommodation and facilities for tourists to enjoy. In tourism demand functions income (either per capita income or GDP) in the origin country is included as a key explanatory variable. Since travel is expensive and considered a luxury good, it is anticipated that high-income countries would have a high amount of travellers. In this study, the tourism expenditure figure includes the expenditure of all tourists coming to the island (i.e. for pleasure and business). In light of this and similar to some studies, the more comprehensive measure of income, i.e. GDP, is therefore employed in this study to reflect income levels in the source country.

Transportation costs, usually measured by the cost of a return airline ticket between the source country and the destination country, have been used in many tourism demand studies. Other studies have used various proxies for the transportation cost variable such as the cost of gasoline between the source and major destination countries. Since the price of oil is a key determinant of air-fare (Lim, 1997), it is reasonable that oil prices could be used to proxy travel costs (Halicioglu, 2004) due to the unavailability of travel cost data (price of gasoline or airline tickets) over the sample period (1975-2009).

VI. DATA

Several sources were used to collect the data used in the study. Information on tourist expenditure was obtained from the Caribbean Tourism Organization. The income variables were collected from the International Financial Statistics website (http://www.imfstatistics.org/imf/) and the World Bank Open Data Source (http://data.worldbank.org/). Oil prices were obtained from the InflationData.com website (http://www.inflationdata.com) and the two climate variables (temperature and precipitation) were obtained from the Center for Climatic Research, Department of Geography, University of Delaware.

Annual data was employed in this study primarily because monthly data was not available for most of the variables used in the tourism demand model. There is support in the literature for the use of annual data in a study on tourism demand. According to Song and Guo (2008), empirical research is still governed by the use of annual data. They further stated that different data frequencies (monthly, quarterly, annual) have varied properties and that the forecasting performance of the different models also varies widely[15]. They noted that the more advanced econometric models (for example, error correction and time varying parameter models) make better use of annual data and that these techniques have superior forecasting performance over the more basic time series models. Forecasting performance is also impacted by data frequency and modelling techniques. According to Song, Witt and Li (2009), the more advanced the forecasting techniques the better the forecasting accuracy over the simple time series models. Witt et al. (1996) in their study on forecasting

[15] A cubic spline interpolation was undertaken to derive monthly data from the annual data at hand. It must be noted that the model performed in the same general way as when annual data was used, specifically negative coefficients was obtained for USGDP, oil prices and temperature and positive figures for Aruba's per capita income and precipitation.

international tourist flows noted that the results received by employing annual data also hold for seasonal data.

VII. ECONOMETRIC METHODOLOGY

This section outlines the economic framework and methodology used in the paper. A review of the literature indicates that several statistical techniques have been employed to estimate the demand for tourism and to forecast such demand (see Lim, (1999) for a comprehensive review of the various techniques used). Tourism demand in Aruba is estimated by applying a cointegration analysis according to the procedure proposed by Engle and Granger (1987) and expanded by Johansen (1988) and Johansen and Juselius (1990). In broad terms, cointegration analysis attempts to verify the presence of a long-run relationship between the dependent variable (tourism demand) and a series of independent variables which, in in this case, are per capita income, GDP in the source country, oil prices, temperature and precipitation. Cointegration analysis requires that all of the variables employed in the estimation be integrated of an identical order that is higher than 0. By employing Johansen's technique, it is possible to obtain the long-run relationship by means of a multivariate analysis which functions with a structure of interrelated equations. It was decided that the vector error correction model would be used in this study since the time series are not stationary in their levels (they are in their differences) and the variables are cointegrated. This technique has been employed in other studies examining tourism demand; see for example Dritsakis (2004) and Querfelli (2008). Cointegration and error correction models have a close relationship, in that the error correction model relates the change in a variable to its past equilibrium errors. As defined by Engle and Granger (1987, p. 254), error correction is when "a proportion of the disequilibrium from one period is corrected in the next period". The vector error correction mechanism is ideally suited to this study in that the specification, while accommodating short-run dynamics, forces the long-run behavior of the endogenous variables to converge to their cointegrating relationships.

Johansen's (1988, 1995) unified maximum likelihood framework is employed to test for the existence of cointegration by estimating a VAR (2) model[16]. Johansen's ML-framework uses a rank test to identify the number of co-integrating vectors '*r*' that can be found in the dataset. The findings of the cointegration analysis, based on the trace of the stochastic matrix, support the rejection of the null hypothesis $r=0$ and indicates that there is one cointegrating relationship (r=1). The results of the cointegration analysis, based on both the trace and maximum eigenvalue of the stochastic matrix, indicates that there is at most, one cointegrating relationship. Table 7 presents the results of the cointegration test based on a trace of the stochastic matrix.

Table 7: A cointegration analysis of tourism expenditure

Null	Alternative	Trace Statistics	95% Quantile
r=0	*r>=1*	83.03*	68.52
r<=1	*r>=2*	46.69	47.21

Source: Data compiled by author

[16] All of the variables are treated as endogenous in the VAR system. - there are 35 observations and each equation is fitted with six parameters, leaving 29 degrees of freedoms for the variance.

Similar to Johnson and Ashworth (1990), Song and Witt (2000) and Bigano et al. (2006), and according to the fundamental principles of economic theory, a tourism demand model is used to determine the variables that affect tourism demand in the Aruba.

$$te = f(pcy,\ \ sgdp,\ \ op,\ \ t,\ \ p)$$

Where,

te is the total tourist expenditures
pcy is the per capita income in the destination country
sgdp is the Gross Domestic Product in the source country
op is the price of oil
t is the temperature
p is the precipitation

Annual time series data for the 1975 – 2009 period was collected for Aruba and the empirical methodology employed is based on Johansen's (1995 and 1998) system of cointegration analysis. The estimation is undertaken employing a double-logarithmic specification. The results of the model are outlined and analyzed in the following section.

VIII. RESULTS OF DEMAND ANALYSIS

The results for the error correction model are provided in table 8. All of the variables proved to be significant, except for the oil price variable. The R^2 shows a relatively good fit of the model and it is observed that the model can predict approximately 72% of the variation of tourist expenditures in Aruba. The model will eventually be used to generate forecasts of the dependent variable (tourism expenditure) and the independent variables (Aruba per capita income, United States GDP, oil prices) and temperature and precipitation (to examine the A2 and B2 scenarios). This, therefore means, that the predictive adequacy of the VEC model is important. The forecasting power of the model was evaluated by comparing the forecasts with the actual tourist expenditure demand function over the ex-post forecasting period i.e. 2000-2009. The mean absolute percentage error and Theil's U statistic were used to quantitatively measure how closely the forecasted variable tracks the actual data. The out-of-sample predicted values and the actual values of tourist expenditure are shown in the chart in Annex I.

An examination of the results indicates that the coefficient estimates were generally in agreement with expectations and, of importance, the results obtained for the climate variables were highly significant. Specifically United States GDP, temperature and precipitation have a negative relationship with tourism expenditure and Aruba's per capita income has a positive relationship; this is explained in more detail below.

Table 8: Long- run coefficients for VEC model

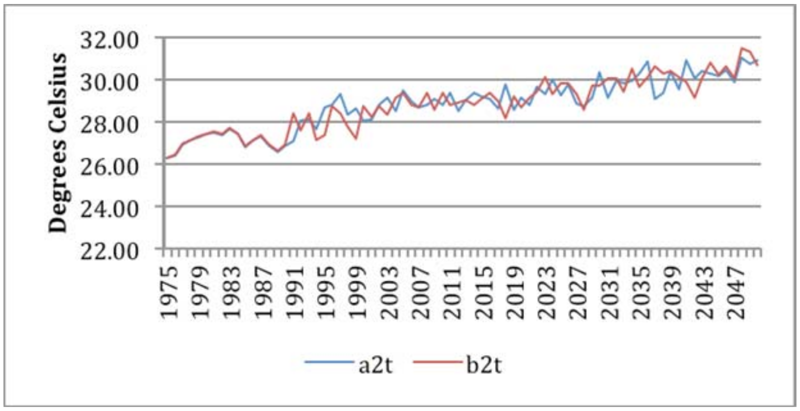
Variable	Coefficient Estimates
ln(Aruba per capita income)	2.45*** (0.358)
ln(US GDP)	-0.90*** (0.392)
ln(oil prices)	0.03 (0.073)
ln(temperature)	-3.29*** (0.462)
ln(precipitation)	-0.58*** (0.207)
Observations	35
R^2	0.7249
Theil U statistic	0.031
MAPE	13.769%

Notes: (1) Standard Errors in parentheses
(2) *** p < .001, ** p < .01, * p < .05
Source: data compiled by author

As expected, and similar to findings in the literature, increases in per capita income translate to increases in tourist expenditures. Tourists visiting a country relate higher standards of living with more superior facilities to be enjoyed. It was found, however, that as the income in the origin countries decreases, tourist arrivals increased to Aruba. Specifically, the coefficient obtained is highly significant and negative indicating that when GDP in the United States decreases, tourist expenditures by United States tourists increase in Aruba. With respect to the sensitivity of tourist expenditure to United States GDP, the magnitude of the GDP coefficient is lower than both that for the temperature and the per capita income variable, indicating that while US GDP does impact on tourist expenditures in Aruba, the sensitivity is more heightened in the case of temperature and Aruba's per capita income on its tourism income. This finding is similar to the findings obtained by Sookram (2009) in her analysis of the impact of climate change on the tourism sector in selected Caribbean countries. A possible explanation for this could be that as income decreases in the origin countries (in this case, the United States), it becomes more affordable to visit the Caribbean rather than other, more expensive, alternatives, for example Europe or Asia. Another explanation is related to the tourism product that is being sought (for example, diving and coral reefs) and the fact that tourists visit Aruba to participate in these specific activities.

An expected result was obtained for the temperature variable, essentially, as temperature increase, tourist arrivals decrease. This has serious implications for tourism and by extension to the economic well-being of Aruba given the predicted increases in temperature under the various climate scenarios put forward by the Intergovernmental Panel on Climate Change (IPCC) in their Special Report on Emissions Scenarios (SRES). As Figure 15 indicates, under both the A2 and B2 climate scenarios temperatures are expected to increase in the future.

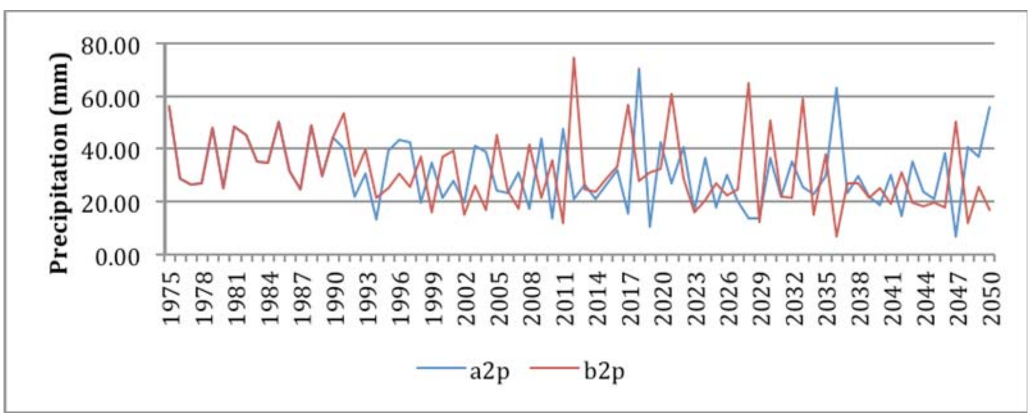
Figure 15: Forecasted Temperature under A2 and B2 scenarios (1975-2050)



Source: INSMET's forecasted temperature for the A2 and B2 storylines in Aruba

The results of the model indicate that precipitation is expected to affect tourism to a much smaller degree than temperature (the model yielded a temperature coefficient of -3.29, whereas the precipitation coefficient was -0.58), and the result was as expected. It was found that as precipitation increased, tourist expenditures are expected to decrease. We see from figure 16 that in Aruba precipitation is expected to decrease under both A2 and B2 scenarios. The fact that Aruba is expected to become more arid in the coming years is of great concern to the tourism industry. The literature shows that hotels and their guests consume vast quantities of water. According to the United Nations Educational, Scientific and Cultural Organization Water Portal Weekly Update No. 155 – Water and Tourism (2006) (Available at: http://www.unesco.org/water/news/newsletter/155.shtml) tourists in Granada, Spain on average use seven times more water than persons living in the area and they further stated that this difference is common in many developing tourist areas.

Figure 16: Forecasted precipitation under A2 and B2 scenarios (1975-2050)



Source: INSMET's forecasted precipitation for the A2 and B2 storylines in Aruba

IX. FORECASTING THE COST OF CLIMATE CHANGE FOR ARUBA ON TOURISM DEMAND

A tourism demand model was estimated to determine the factors that impact tourism demand in Aruba. The model fulfilled the tenets of demand theory and passed the diagnostic tests. In this phase of the analysis the model is used to generate forecasts of tourism expenditure for Aruba until 2050 when both demand and supply are constrained due to climate conditions, extreme events, sea level rise and coral reef loss. The forecasted tourist expenditure data is used to obtain the cost to the tourism sector under two climate scenarios: A2 and B2. Similar to other sectoral studies, BAU in this study reflects a scenario where economic factors and environmental elements are not influenced by changes in the climate. Similar to Moore (2011), the BAU scenario is determined by assuming that tourist arrivals continue to grow based on historical trend growth rates.

The tourism demand model estimated earlier is employed to cost the effects of climate change under the A2 and B2 scenarios. To obtain a forecast of the expected tourist expenditure under the two climate scenarios, forecasts were made of the variables used in the model: Aruba per capita income, US GDP, oil prices, temperature and precipitation. With respect to the climate variables, forecasts for both variables were received from the Institute of Meteorology in Cuba (INSMET) for the A2 and B2 scenarios. The predictions from INSMET were obtained from the European Centre Hamburg Model, an atmospheric general circulation model developed at the Max Planck Institute for Meteorology. The annual cost of climate change impacts to 2050, are estimated in Aruba florins (AWG) using the tourism expenditure estimates as generated under a BAU scenario as the comparator, and 2008 as the base year. Again, similar to Moore (2011), while the BAU scenario assumes that climate change will not affect coral reefs, it is expected that human activity will put stress on these reefs, and as mentioned in Moore (2011), Hoegh-Gulberg et al. (2007), assumes that 10% of coral reefs are likely to be lost by 2050 and this loss is factored in this study by way of reduction in tourism expenditure by 22% (Gill, 2010). In relation to rising sea levels and expected land loss, it is assumed that no land will be lost under the BAU climate scenario.

This part of the study adds the other layer to the costs to the tourism sector due to sea level rise[17] and destruction of coral reefs due to ocean acidification under the A2 and B2 climate scenarios.

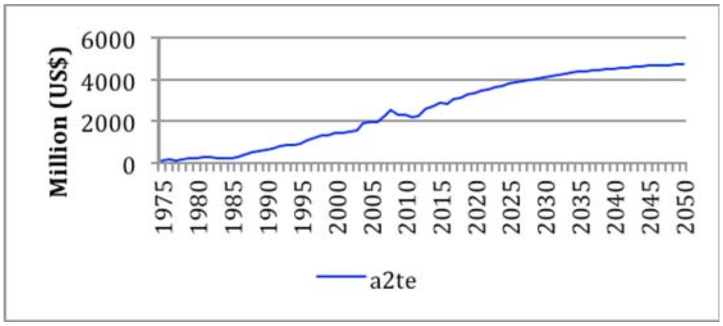
X. FORECASTING RESULTS

To obtain the annual level of tourism expenditure in Aruba based on forecasted changes in temperature and precipitation, the tourism demand model was estimated under A2, B2 and BAU conditions until 2050. Figure 17 shows the forecasted tourism expenditures[18] in Aruba until 2050 under the A2 climate scenario and clearly indicates that under the A2 scenario tourism expenditure, while on the rise, appears to increase at a decreasing rate as year 2050 approaches and has started to level off after 2040.

[17] According to the IPCC's emissions scenarios the mean sea level rise by 2050 is expected to be 0.08m (low impact scenario) and 0.44 m (high impact scenario).

[18] The figures forecasted for tourist expenditure (at 2008 prices) under the A2, B2 and BAU climate change scenarios are shown in Appendix II.

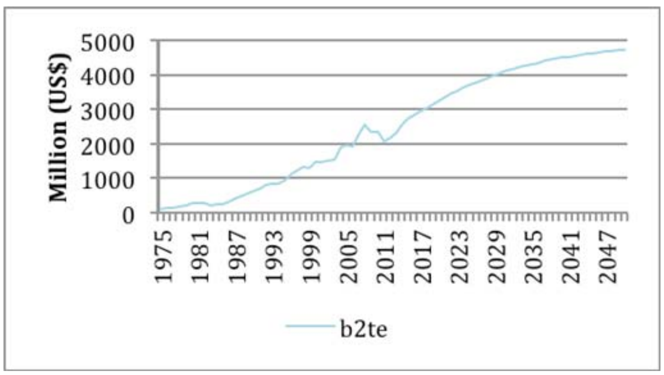
Figure 17: Forecasted tourism expenditures under A2 Climate Scenario



Source: Data compiled by author

Figure 18 gives an indication of what the level of tourism expenditures in Aruba would look like until year 2050 under the B2 climate scenario. Again, even though tourism expenditures continue to increase, it does so very slowly after a certain period and until year 2050.

Figure 18: Forecasted tourism expenditures under B2 Climate Scenario



Source: Data compiled by author

Using the generated tourism expenditure figures (table 9) a costing[19] was undertaken for Aruba until 2050, the results of which are outlined in table 10[20]. Table 9 shows the aggregated expenditures under the A2, B2 and BAU climate scenarios for four different points in the half-century period: 2020, 2030, 2040 and 2050.

[19] All future earnings under the A2 and B2 scenarios are compared to the earnings in the tourism sector under the BAU scenario.

[20] A point of observation is that the A2 and B2 cost figures do not vary widely. It is more than likely that these results were obtained due to the forecasted temperature and precipitation figures under the A2 and B2 scenarios. An examination of Figures 12 and 13 indicates that these forecasted values did not vary from each other in any marked way on the whole, but rather there were inter-year variations.

Table 9: Forecasted tourist expenditures from 2010-2050 for Aruba (USD) under A2, B2 and BAU scenarios

Year	A2	B2	BAU
2020	12,858.36	13,465.46	15,291.21
2030	24,393.52	25,262.83	33,189.59
2040	33,889.56	34,872.98	54,894.89
2050	41,048.82	42,069.85	80,407.13

Source: Data compiled by author

As expected, Aruba's tourism would benefit greatly if the climate did not change (BAU), since under this assumption tourists continue to visit Aruba without having to deal with climate change issues such as increasing temperatures, sea level rise and coral reef loss. However, under the assumption of either an A2 or a B2 scenario the benefits accruing to Aruba diminish significantly under these two scenarios.

Table 10: Costing For A2 and B2 Scenarios: temperature and precipitation (Costs in US$ millions - 2008 dollars)

Year	A2	B2
2020	13.62	18.63
2030	46.89	53.40
2040	94.01	100.98
2050	144.34	151.43

Source: Data compiled by author

The results in table 10 illustrate that under the A2 climate scenario, changes in temperature and precipitation costs the tourism industry approximately US 144 million. Under the B2 climate scenario, Aruba's tourism sector will lose an estimated US$151 million due to the higher income earned under this sector. The results in the table indicate that under either of the two scenarios, Aruba's tourism sector loses substantial sums of money by the middle of the decade.

Table 11 presents the loss in the tourism sector in Aruba due to the predicted rise in sea level and the destruction of ecosystems due to occurrences such as ocean acidification. As explained Similar to Toba (2009), it is assumed that tourists spend about 30% of their total expenditure for activities related to the sea. With climate change occurring due to rising sea levels[21] and ecosystem destruction, it is assumed that this amount would be lost due to non-participation in these activities. The costs calculated in table 11 represents the loss that would occur when tourist refrain from sea-related activities. The figures under the BAU scenario were calculated assuming no land loss under sea level rise and that the only loss would be as a result of coral reef loss due to human activity (22%) and not due to any of the impacts of climate change on the coral reefs.

[21] According to Haites et al. (2002) by 2050 the sea level is expected to rise as follows: 0.08 metres (low case scenario); 0.44 metres (high case scenario).

Table 11: Costing For A2, B2 and BAU Scenarios: sea level rise and destruction of ecosystems (Costs in US$ millions - 2008 dollars)

Year	A2	B2	BAU
2020	4,237.01	4,419.14	74.38
2030	7,697.56	7,958.35	124.45
2040	10,546.37	10,841.40	162.00
2050	12,694.15	13,000.46	189.02

Source: Data compiled by author

Table 11 shows, under the A2 climate scenario, Aruba's tourism sector losses at US$12 billion due to rises in the sea level and the destruction of the ecosystem. Under the B2 scenario, the sector is poised to lose US$13 billion while the cost is just a bit higher, under both scenarios the losses are substantial. Under the BAU climate scenario the cost is US$189 million.

Table 12 illustrates the total costs that Aruba will incur under the three scenarios. The total costs include figures from costs due to changes in temperature and precipitation and those occurring due to sea level rise and destruction of ecosystems.

Table 12: Total costs incurred for Aruba under A2, B2 and BAU Scenarios (Costs in US$ millions - 2008 dollars)

Year	A2	B2	BAU
2020	4,255.65	4,432.76	74.38
2030	7,750.96	8,005.24	124.45
2040	10,647.36	10,935.40	162.00
2050	12,845.58	13,144.80	189.02

Source: Data compiled by author

The total figures (table 12) show that Aruba has to take some decisive and positive actions within the tourism sector to help with the reductions of these future costs, which are amounting a considerable US$12 billion under the A2 scenario and US$13 billion under the B2 climate scenarios. In each of these cases the results represents an annual loss of between 1.5%- 2% of Aruba's GDP until mid-century.

Table 13 presents the discounted future aggregate costs of climate change to Aruba's tourism industry for the years 2020, 2030, 2040 and 2050.

Table 13: Net Present Value of Aggregate costs in the tourism sector under Scenarios A2, B2 and BAU - Discount rate: 0.1%, 2% and 4% (Costs in US$ millions - 2008 dollars)**

Year	A2			B2			BAU		
	1%	2%	4%	1%	2%	4%	1%	2%	4%
2020	3,649.90	3,442.24	3,075.58	3,817.98	3,601.95	3,220.35	68.55	60.13	57.41
2030	6,620.06	6,178.94	4,924.09	6,854.04	6,188.35	5,110.48	109.65	96.45	82.34
2040	8,850.71	7,695.95	5,963.52	9,110.86	7,932.42	6,162.33	137.45	118.82	94.94
2050	10,384.20	8,770.36	6,497.66	10,652.21	9,012.38	6,699.26	154.00	132.04	100.61

Source: Data compiled by author

Note: The discount rates used in this table were recommended by ECLAC for calculating the net present values of the forecasted costs to the tourism industry.

The next phase of this study goes on to examine the adaptation and mitigation strategies that can be employed by the tourism industry and then proceeds to cost these strategies.

XI. APPROACHES TO MITIGATION AND ADAPTATION IN THE TOURISM SECTOR

Rogner, 2007 has asserted that mitigation and adaptation can complement each other, act as substitutes or be independent of one another. A discussion of mitigation measures to cope with climate change of necessity must include technological, economic and social changes and substitutions that can be employed to attain a reduction in greenhouse gas (GHG) emissions (UNWTO-UNEP-WMO 2008; Hall and Williams, 2008). The IPCC report has asserted that human activity has been a major contributor to climate change, which may have started as early as the mid-1700s. There are many GHGs and carbon dioxide (CO_2) emission is just one, However, it becomes important when released in large quantities (as can happen due to human activity), such as the burning of solid waste, wood and wood products and fossil fuels (oil, natural gas, and coal).

UNWTO-UNEP-WMO (2008) has outlined four key mitigation measures that can be used to deal with GHG emissions from tourism:

1. Reducing energy use: (i.e. energy conservation): this can, for example, be achieved by changing transport behaviour (e.g. more use of public transport, shift to rail and coach instead of car and aircraft, choosing less distant destinations), as well as changing management practices (e.g. videoconferencing for business tourism).

2. Improving energy efficiency: this refers to the use of new and innovative technology to decrease energy demand (i.e. carrying out the same operation with a lower energy input).

3. Increasing the use of renewable or carbon neutral energy: substituting fossil fuels with energy sources that are not finite and cause lower emissions, such as biomass; hydro, wind, and solar energy.

4. **4.** Sequestering CO_2 through carbon sinks: CO_2 can be stored in biomass (e.g. through afforestation and deforestation), in aquifers or oceans, and in geological sinks (e.g. depleted gas fields). Indirectly this option can have relevance to the tourism sector, considering that most developing countries and SIDS that rely on air transport for their tourism-driven economies are biodiversity rich areas with important biomass CO_2 storage function. Environmental-oriented tourism can play a key role in the conservation of these natural areas.

The UNWTO-UNEP-WMO (2008, p.81) defines adaptation as "….. an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harms or exploits beneficial opportunities". There is little doubt that the tourism sector will be unable to adopt adaptation strategies to cope with changes in the climate. UNWTO-UNEP-WMO (2008) maintains that the tourism industry is dynamic and flexible enough to implement measures of an adaptive capacity to deal with climate change. As an example, this is an industry that tends to have jolts, which could come in the form of, for example, illness or civil unrest, but it has shown an ability to cope. However, the changing climate must be recognized as such and strategies must be adopted and put in place before it is too late.

The literature on adaptation strategies shows a wide range of measures that Caribbean countries can implement and the ones that Aruba, in particular, adopts would depend on the different climate change impacts due to factors such as increasing temperatures, changes in precipitation, increasing intensity of hurricanes and other extreme events and sea level rise. There is a broad scope of climate change adaptation strategies that Aruba can utilize to deal with the varying effects of climate change. Becken and Hay (2007) outlined some possible adaptation measures, along with the barriers to implementation in small, island countries (see table 14).

The Stern Review (2006) emphasized that it is more cost-effective to implement techniques that are proactive rather than reactive and to support no-regrets measures. In the event that there is no major change in the climate, the proactive, no-regrets strategies will still be valuable and economical. As an example, the literature on climate change risk assessment of tourism operators (Elsasser and Burki, 2002; Scott et al., 2002; Becken, 2004) has revealed that they have minimal knowledge of climate change and that there is a subsequent lack of long-term planning in the event of future climate changes. This indicates that there is an urgent need to educate and ensure that tourism policy makers, who formulate policies for both the private and public sectors, are aware that the climate is changing and the tourism industry has to adapt to the change or suffer a failure.

An estimation of the costs of adaptation is a complex one and it depends significantly on the determinants of the adaptive capacity of Aruba. The IPCC (2001) drawing from Smit (1999) categorized determinants of adaptive capacity including issues such as, the availability of technological resources, the organization of essential institution and decision-making bodies, the stock of human and social capital, information management and public perceptions.

Although Aruba has not signed the UNFCC and the Kyoto Protocol (ECLAC, 2010) as yet, the government of Aruba has recognized the growing importance of the changing climate and the need to respond. In this context, they have began to address climate change through their "National Integral Strategic Plan 2025" – a plan which includes developmental policies and strategies (for example, a spatial development plan and a framework for environmental legislation) to engender sustainability. There have been some climate change-relevant programs and projects that have been started in Aruba (Sustainable Aruba, Ban the Plastic Bag Awareness Group, Eagle Beach Area Coalition for Aruba's Sustainable Tourism) and seven hotels in Aruba have received Green Globe 21 certification (ECLAC, 2010)

Table 15 examines some of the possible adaptation measures for the tourism sector in Aruba, along with the evaluation criteria for each one.

Table 14: Possible adaptation measures for tourism in Small Island Countries and barriers to implementation

Adaptation Measures	Relevance to tourism	Barriers to Implementation	Measures to Remove Barriers
Mainstreaming adaptation in planning	Currently adaptation is not mainstreamed in tourism planning	Lack of information on which to base policy initiatives	Improve targeted information, e.g. climate-risk profile for tourism
Include climate risk in tourism regulations, codes	Currently such risks are not reflected in tourism-related regulations	Lack of information on which to base regulatory strengthening	Improve information, such as climate-risk profile for tourism
Institutional strengthening	Shortfall in institutional capacity to coordinate climate responses across tourism-related sectors	Lack of clarity as to the institutional strengthening required to improve sustainability of tourism	Assess options and implement the most appropriate strategies
Education/awareness raising	Need to motivate and mobilize tourism staff and also tourists	Lack of education and resources that support behavioural change	Undertake education./awareness programmes
Shade provision and crop diversification	Additional shade increases tourist comfort	Lack of awareness of growing heat stress for people and crops	Identify, evaluate and implement measures to reduce heat stress
Reduce tourism pressures on coral	Reefs are a major tourist attraction	Reducing pressures without degrading tourist experience	Improve off-island tourism waste management
Reduce tourism pressures on other marine resources	Increased productivity of marine resources increases well-being of tourism-dependent communities	Unsustainable harvesting practices and lack of enforcement of regulations and laws	Strengthen community-based management of marine resources, including land-based issues
‘Soft’ Coastal Protection	Many valuable tourism assets at growing risk from coastal erosion	Lack of credible options that have been demonstrated and accepted	Demonstration of protection for tourism assets and communities
Improved Insurance Cover	Growing likelihood that tourists and operators will make insurance claims	Lack of access to affordable insurance	Ensure insurance sector is aware of actual risk levels and adjust premiums
Desalination, rainwater catchments and storage	Tourist resorts are major consumers of fresh water	Lack of information on future security of freshwater supplies	Provide and ensure utilization of targeted information, based on climate risk profile.
Drainage and pumping systems	Important services for tourist resorts and for tourism-dependent communities	Wasteful practices; Lack of information to design adequate systems	Provide and ensure utilization of targeted information, based on climate risk profile.
Enhanced design and siting standards	Many valuable tourism assets at growing risk from climate extremes	Lack of information needed to strengthen design and siting standards.	Provide and ensure utilization of targeted information.
Tourism activity/product diversification	Need to reduce dependency of tourism on ‘sun, sea and sand’	Lack of credible alternatives that have been demonstrated and accepted	Identify and evaluate alternative activities and demonstrate their feasibility.

Source: Becken and Hay (2007) – Tourism and Climate Change

Table 15: Potential adaptation measures and evaluation criteria for the tourism sector in Aruba

Risks	Source	Risk Mitigation or Transfer Options	Evaluation Criteria									
			Cost	Effectiveness	Acceptability to Local Stakeholders	Acceptability to Financial Agencies	Endorsement by Experts	Time Frame	Institutional Capacity	Size of Beneficiaries Group	Potential Environmental or Social Impacts	Potential to Sustain over Time
Increased wind speed	Greater Number of Category 4 and 5 hurricanes	Increase recommended design wind speeds for new tourism-related structures								X	X	
		Offer incentives to retrofit tourism facilities to limit the impact of increased wind speeds								X		
		Retrofit ports to accommodate the expected rise in wind speeds								X		
		Catastrophe insurance for those governments buildings that are used by tourists								X		
		Insurance for adaptive re-buildings								X		
Decreased availability of fresh water	Increased frequency of droughts	Construction of water storage tanks	X	X	X	X	X	X	X	X	X	X
		Irrigation network that allows for the recycling of waste water	X							X	X	
		Retrofit hotels to conserve water	X	X				X	X	X	X	X
		Redesign										

Risks	Source	Risk Mitigation or Transfer Options	Evaluation Criteria									
			Cost	**Effectiveness**	**Acceptability to Local Stakeholders**	**Acceptability to Financial Agencies**	**Endorsement by Experts**	**Time Frame**	**Institutional Capacity**	**Size of Beneficiaries Group**	**Potential Environmental or Social Impacts**	**Potential to Sustain over Time**
		desalination plants. (The existing plants were constructed more than 70 years ago) http://www.webaruba.com/index.php?lang=US										
		Drought insurance	X			X	X		X	X		X
Land Loss	Sea level rise	Build sea wall defenses and breakwaters	X		X	X	X			X	X	
		Replant mangrove on reef in front of Oranjestad harbour and eroded coastline	X	X	X		X	X	X	X	X	x
		Raise the land level of low lying areas (There should be no new buildings in salt margins and on the beaches)	X	X	X	X	X	X	X		X	
		Build tourism infrastructure further back from coast	X				X	X			X	X
		Beach renourishment	X				X				X	X
		Limit sand mining for building materials		X	X					X	X	
		Introduce new		X	X		X	X		X	X	

Risks	Source	Risk Mitigation or Transfer Options	Evaluation Criteria									
			Cost	Effectiveness	Acceptability to Local Stakeholders	Acceptability to Financial Agencies	Endorsement by Experts	Time Fram e	Institutiona l Capacity	Size of Beneficiaries Group	Potential Environmental or Social Impacts	Potential to Sustain over Time
		legislation to change planning policies, zoning and land use priorities as needed. (At present the AUA zoning plan takes climate as a fixed parameter.)										
Loss of coral reefs	Inhibition of aragonite formation as carbonation concentration falls	Coral nurseries to help restore areas of the reef that have been damaged due to the effects of climate change	X	X			X	X	X		X	XX
		Enhanced reef monitoring systems to provide early warning alerts of bleaching events	X	X	X	X			X		X	
		Strengthen the scientific rigor and ecological relevance of existing water quality programs					X	X			X	
		Develop innovative partnerships with and provide technical guidance to landowners and users to reduce land-based sources of pollution		X	X			X	X	X	X	
		Control discharges from known point		X			X				X	

Risks	Source	Risk Mitigation or Transfer Options	Evaluation Criteria									
			Cost	**Effectiveness**	**Acceptability to Local Stakeholders**	**Acceptability to Financial Agencies**	**Endorsement by Experts**	**Time Frame**	**Institutional Capacity**	**Size of Beneficiaries Group**	**Potential Environmental or Social Impacts**	**Potential to Sustain over Time**
		sources such as vessel operations and offshore sewage										
		Artificial reefs or fish-aggregating devices	X		X	X	X		X		X	
		Enhancing coral larval recruitment	X	X			X	X			X	
		Enhancing recovery by culture and transportation of corals	X	X			X		X		X	
		Establish special marine zones					X		X	X	X	
		Implement pro-active plans to respond to non-native invasive species					X		X	X	X	
Extreme climate events	Climate change	Provide greater information about current climate events		X	X				X	X	X	X
		Expand existing national guidelines (There are existing guidelines in place that are employed)		X	X				X	X		X
		Develop national evacuation and rescue plans		X	X				X	X		X
		More stringent insurance conditions for the tourism industry	X							X		
		Flood drainage protection for hotels	X	X			X			X	X	

Risks	Source	Risk Mitigation or Transfer Options	Evaluation Criteria									
			Cost	**Effectiveness**	**Acceptability to Local Stakeholders**	**Acceptability to Financial Agencies**	**Endorsement by Experts**	**Time Frame**	**Institutional Capacity**	**Size of Beneficiaries Group**	**Potential Environmental or Social Impacts**	**Potential to Sustain over Time**
		Accelerated depreciation of properties in vulnerable coastal zones			X					X		
		Supporting infrastructure investment for new tourism properties										
Reduction in travel demand	Climate change	Increase advertising in key source markets	X	X						X		
		Fund discount programme run by airlines	X			X	X		X	X		
		Fund discount programmes run by hotels	X	X		X	X			X		
		Expand “green certification” programmes to other hotels and tourism facilities		X			X	X		X	X	
		Conducting energy audits and training to enhance energy efficiency in the industry	X	X						X	X	
		Introduce built attractions to replace natural attractions (should be done cautiously to avoid “concrete jungle” façade.	X		X				X	X	X	
		Recognition of the vulnerability of some eco-systems		X	X		X			X		

Risks	Source	Risk Mitigation or Transfer Options	Evaluation Criteria									
			Cost	Effectiveness	Acceptability to Local Stakeholders	Acceptability to Financial Agencies	Endorsement by Experts	Time Fram e	Institutiona l Capacity	Size of Beneficiaries Group	Potential Environmental or Social Impacts	Potential to Sustain over Time
		and adopt measures to protect them										
		Introduction of alternative attractions. Dr. Ernie Lasten (University of Aruba) has explored some new attractions)		X	X							
		Provide retraining for displaced tourism workers					X		X	X	X	
		Revise policies related to financing national tourism office to accommodate the new climatic realities					X		X	X		

Source: Data compiled by author

The author acknowledges the advice and assistance of Gisbert Boekhoudt (National Climate Change Committee) in revising the table.

A. SHORT-LISTED OPTIONS FOR COST-BENEFIT ANALYSIS

This section of the study provides an analysis of the costs and benefits regarding the alternative actions available to Aruba for addressing climate change. Similar to traditional cost-benefit analysis, in this study an attempt is made to compare the costs and benefits that can be expressed in monetary units and should serve to offer a practical framework for dealing with the consequences of climate change.

By employing the evaluation criteria in table 15, listed below are suggested options for mitigation and adaptation to climate change in Aruba. These suggested options are listed under the headings of Mitigation (5 options) and Adaptation (7 options).

Mitigation Strategies:

Option 1 – Restrict GHG emission of Refinery, desalination water and power plant, sewage treatment facility and solid waste management facility to international set requirements.
Option 2 – Encourage participation on the voluntary carbon market.
Option 3 – Implement planted Linear Park taking in consideration climate change (mitigation and adaptation).
Option 4 – Reforest mangrove on Oranjestad harbour.
Option 5– Incentivize sustainable energy producing projects to reach Aruba's goal of 50% sustainable energy generation (extend windmill capacity with another 20%, voltaic solar energy 5 % and 5 % out of biogas generation from the sewage and solid waste management plants).

Adaptation Strategies:

Option 1 – Offer incentives to retrofit tourism facilities to limit the impact of increased wind speeds
Option 2 – Catastrophe insurance for those government buildings that are used by tourists
Option 3 – Build tourism infrastructure further back from coast
Option 4 – Beach re-nourishment. Protect salt margins and beaches as nature reserve
Option 5 – Coral nurseries to help restore areas of the reef that have been damaged due to the effects of climate change
Option 6 – Enhance reef-monitoring systems to provide early warning alerts of bleaching events. Organise and regulate the beach activities and limit the area of these activities, to protect and to give the nature the possibility to reactivate, revive, the marine lives in the northwest-side of the island.
Option 7 – Flood drainage protection for hotels

The cost-benefit analysis of the above options is presented in table 16. This analysis shows that one of the mitigation options and most of the adaptation options have cost benefit ratios over 1 through the 20-year horizon.

Table 16: Cost-Benefit analysis of proposed options for Aruba (US$)

Options	Details	Cumulative Net Present Value of Benefits	Cumulative Net Present Value of Costs	Benefit Cost Ratio	Net Benefits/(Costs)
MITIGATION OPTIONS					
M1	Restrict GHG emission of refinery, desalination water and power plant, sewage treatment facility and solid waste management facility	$73,497,007.66	$51,162,463.91	1.44	$22,334,543.75
M2	Encourage participation on the voluntary carbon market	$73,497,007.66	$108,642,508.23	0.68	($35,145,500.57)
M3	Implement planted Linear Park taking into consideration climate change	$146,994,015.32	$179,302,606.89	0.82	($32,308,591.57)
M4	To restore mangrove in front of Oranjestad harbour	$26,610,217.23	$52,553,746.90	0.51	($25,943,529.67)
M5	Incentivize sustainable energy producing projects to reach goal of 50% sustainable energy generation	$36,748,503.83	$71,302,386.19	0.52	($34,553,882.36)
ADAPTATION OPTIONS					
A1	Offer incentives to retrofit tourism facilities to limit the impact of increased wind speeds	$3,860,833.42	$2,110,521.54	1.83	$1,750,311.89
A2	Catastrophe insurance for those government buildings that are used by tourists	$6,725,961.80	$3,592,089.50	1.87	$3,133,872.30
A3	enhanced reef monitoring systems to provide early warning alerts of bleaching events	$53,220,434.45	$44,788,360.10	1.19	$8,432,074.36
A4	Beach re-nourishment	$53,220,434.45	$51,614,645.48	1.03	$1,605,788.97
A5	Build tourism infrastructure further back from coast	$73,497,007.66	$56,027,673.36	1.31	$17,469,334.30
A6	Coral nurseries to help restore areas of the reef that have been damaged due to the effects of climate change	$73,497,007.66	$28,920,995.49	2.54	$44,576,012.17
A7	Flood drainage protection for hotels	$73,497,007.66	$131,459,367.09	0.56	($57,962,359.43)

Source: Data compiled by author

XII. CONCLUSION AND RECOMMENDATIONS

In this study the impact of climate change on the tourism sector in Aruba was examined taking into consideration both demand and supply factors. Three layers of costs were aggregated to determine the total cost of climate change to the tourism industry. In the first layer of costs, a tourism demand was modeled for Aruba using an error correction model within a cointegration framework and employing economic and climatic variables. The model was then employed to predict the impact of climate change under three climate scenarios (A2, B2 and BAU) until the mid-century mark (2050). Supply issues were addressed in the second and third layers and were related to sea level rise and coastal erosion, loss of hotel infrastructure and destruction of coral reefs. The results specify that Aruba can lose over US$12 billion under the A2 scenario, US$13 billion under the B2 scenarios and US$338.33 million under the BAU (absence of climate change) scenario. This represents an annual loss of between 1.5-2% of Aruba's GDP. Aruba therefore has to put measures in place to adapt and mitigate against impending climate change if growth is to be sustained in the tourism sector.

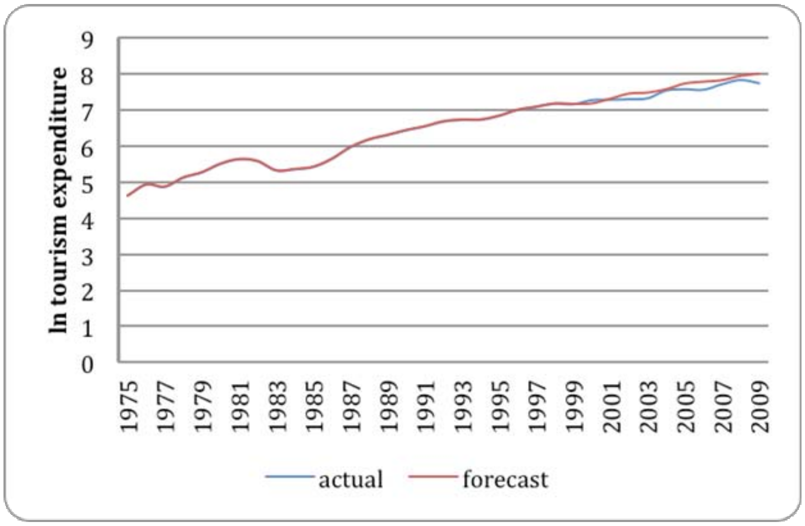
There are certain options that would be more viable for Aruba to propel its drive to adaptation and mitigation. A cost benefit analysis was undertaken on five mitigation strategies and seven adaptation strategies. It was found that one of the mitigation strategies had a benefit cost ratio over 1 and six of the adaptation had a benefit cost ratio over 1.

It is therefore recommended that these seven mitigation and adaptation options be implemented as a matter of priority since there are net positive benefits during the period of execution. The other options, which do not show net positive economic benefits in the short and medium-term, should also be pursued since these are country-specific strategies and may bring many indirect and non-economic benefits to Aruba in the longer term.

It is clear that further and more in depth work has to be undertaken on climate change and its impact on the tourism sector in Aruba. Aruba has initiated a few projects to tackle climate change and it is especially important that further strategies be examined specific to the tourism sector, since this is a key sector that drives the economy.

Annex

Predictability of the VEC Model



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