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

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Note: Countries covered in this report are Bonaire, Curaçao, Saba, St. Eustatius and St. Maarten, which constituted the former Netherlands Antilles. The research was conducted prior to the dissolution of the Netherlands Antilles on 10 October 2010.


Dominican Republic
Virgin Islands
Puerto Rico
Anguilla
Atlantic Ocean
Sint Maarten
Barbuda
Saba
Antigua
St. Eustatius
St. Kitts and Nevis
Guadeloupe
Netherlands Antilles
worldatlas.com
Dominica
125 mi
125 km
Caribbean Sea
Martinique
St. Lucia
St. Vincent and the Grendines
Aruba
Curacao
Colombia
Grenada
Bonaire
Isla de Margarita
Trinidad
Venezuela
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Acknowledgement

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Executive Summary

In this study, an attempt is made to estimate the economic impact of climate change on the tourism sector in the (former) Netherlands Antilles. There are three main objectives in this study. The first is to examine the factors that influence the demand and supply of tourism in Netherlands Antilles. 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) as a comparator climate scenario, and the third is to estimate the cost of adaptation and mitigation strategies that can be undertaken by the tourism sector in the Netherlands Antilles to address climate change.

A tourism demand model is employed to determine the factors that impact tourism demand in the Netherlands Antilles during the 1977-2008 period using an error correction model within a co-integration framework and employing economic (per capita income in both source and destination countries) and climatic (temperature and precipitation) variables. This initial investigation suggests that per capita income in the Netherlands Antilles, per capita income in the United States of America, temperature and precipitation influence tourism demand in the Netherlands Antilles.

There are other factors, other than temperature and precipitation that have the potential to negatively affect the tourism sector in the Netherlands Antilles. As a result, the costs were calculated taking into consideration not only changes in temperature and precipitation but also extreme events (frequency and intensity), sea level rise and the destruction of ecosystems (particularly coral reef loss) due to ocean acidification. Projections of tourism demand from 2009 to 2050 are estimated on the basis of two climate scenarios: the International Panel on Climate Change's A2 and B2 scenarios and a 'baseline' or a Business as Usual (BAU) scenario as a comparator.

It was found that under the two climate scenarios there is a decline in tourist income to the countries that make up the former Netherlands Antilles. Specifically, it was found that the costs associated with the various scenarios (2008 prices) amount to considerable sums: US$9.27 billion (A2 scenario) or US$11.67 billion (B2 scenario).

The next phase of the study examined mitigation and adaptation strategies that the tourism sector can implement and also estimates the cost of these strategies. Eleven adaptation and mitigation options were selected and a cost benefit analysis was undertaken on the selected options. These estimations indicate that at least three of the eight options (adaptation and mitigation) had cost-benefits ratios over 1, signalling that it is beneficial for the Netherlands Antilles to vigorously pursue adaptation and mitigation strategies in the tourism sector.

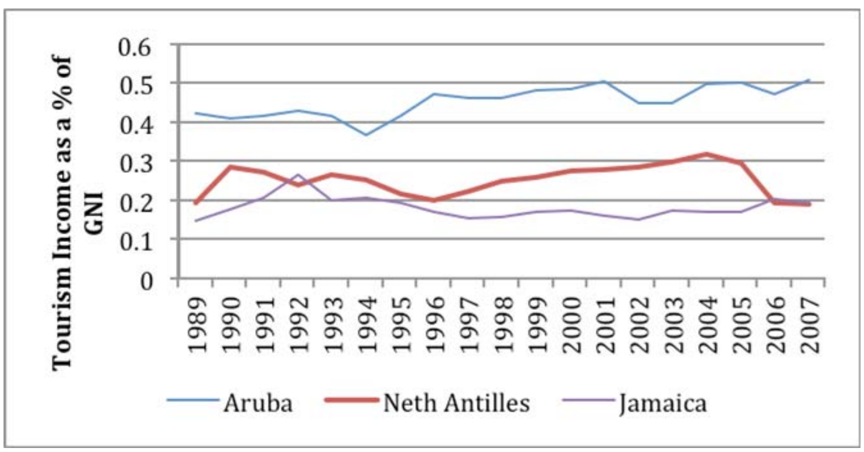
I. INTRODUCTION

According to the Preliminary Overview of the Economies of Latin America and the Caribbean (2009),published by the Economic Commission for Latin America and the Caribbean (ECLAC), 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 the Netherlands Antilles. The second is to forecast the cost of climate change to the tourism sector until 2050 under the A2 and B2 climate scenarios, with a BAU (Business as Usual) scenario as a comparator, and the third is to estimate the cost of adaptation and mitigation strategies that can be undertaken by the Netherlands Antilles' 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. An examination of the figure with regard to the Netherlands Antilles indicates that tourism income constituted between 19-31% of gross domestic income for the 1989 to 2007 period.

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



Source: Caribbean Tourism Organisation

This paper is structured as follows. In Section 2 stylized facts on tourism and climate change is examined. Section 3 reviews the literature on tourism demand and climate change. Section 4 outlines and defines the theoretical framework and Section 5 explores the variables used in this analysis and the statistical sources. Section 6 specifies the econometric model and methodology. The results of the model are presented in Section 7. 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 conclusion of the work done.

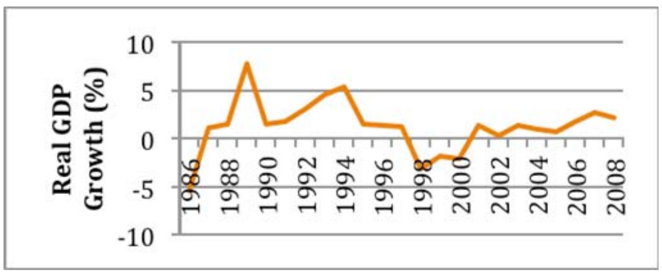
II. STYLIZED FACTS ON THE (FORMER) NETHERLANDS ANTILLES

A. TOURISM

The Netherlands Antilles is categorized as a high-income country by the World Bank and had a per capita income of US$19,566.9 in 2008. According to the International Monetary Fund (IMF) Country Report (No. 08/315, 2008) for the Netherlands Antilles, the economy has been expanding at a satisfactory pace since 2006, with the main drivers being increased tourism and investments. The report further stated that, while all of the islands contributed to economic growth, Curaçao had the highest growth performance.

As figure 2 shows, within the past few decades, the economic growth in the Netherlands Antilles has fluctuated and remained positive, except for the 2001-2002 period and more recently in 2008 when the economy experienced 0.44% negative growth, which was influenced in large part to the global economic slowdown.

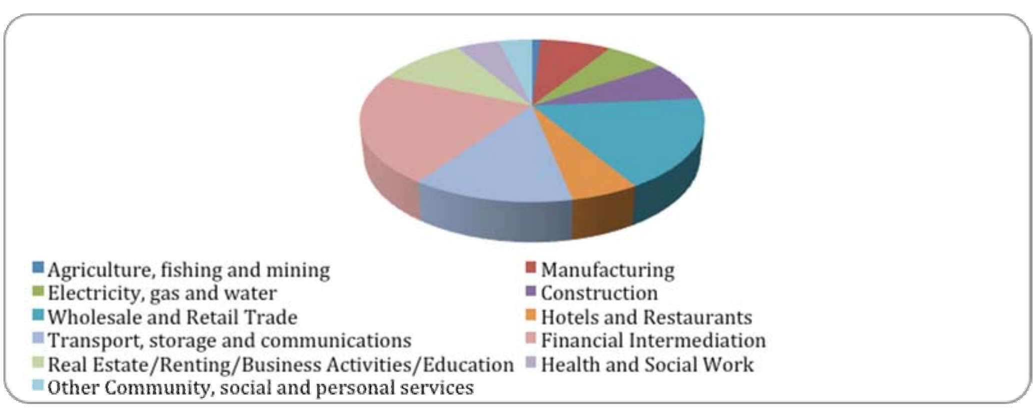
Figure 2
Real GDP Growth (%) in the Netherlands Antilles: 1986-2008



Source: World Bank Open Data (Author's Calculations)

The Netherlands Antilles' economy is propelled by activities related to oil, tourism and financial services. Figure 3 shows the sectoral composition of GDP in the Netherlands Antilles. It is clear that the major components of GDP are financial intermediation, transport, storage and communications and wholesale and retail trade.

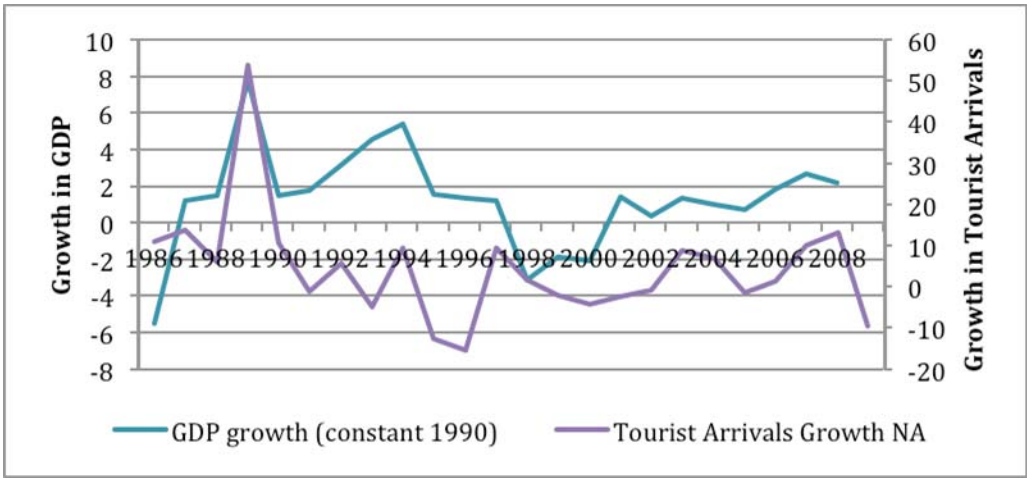
Figure 3
Sectoral Composition of GDP in Netherlands Antilles



Source: Central Bank of Netherlands Antilles

The Netherlands Antilles economy has a few main sectors that contribute to its GDP. It is apparent from figure 4 that while its economic growth is influenced by movements in the tourism sector, it is to a lesser extent than that of Aruba.

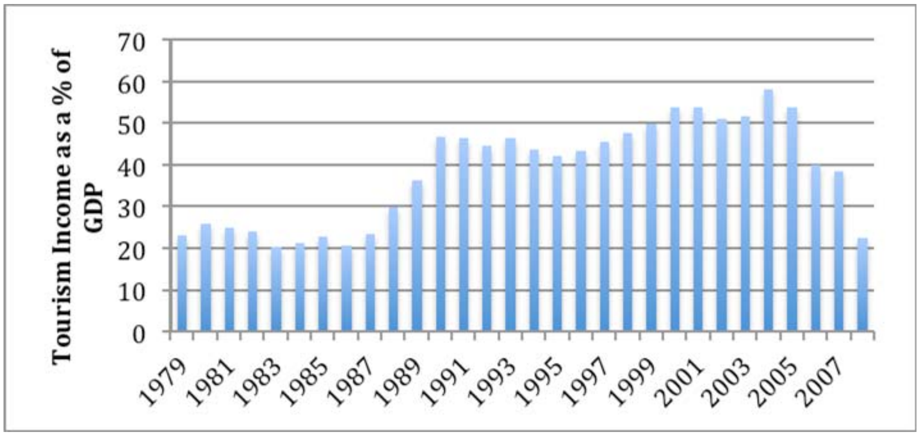
Figure 4
Netherlands Antilles – Real GDP Growth and Growth in Tourist Arrivals: 1986-2009



Source: Caribbean Tourism Organisation and Central Bank of Netherlands Antilles (Author's Calculations)

Figure 5 provides information on the share of tourism income as a % of GDP. The chart shows that for most of the 30-year period the income earned from tourism has been over or close to 40% of GDP, and this remained so until 2008 when the share dipped to 22%.

Figure 5
Tourism Income as a % of GDP

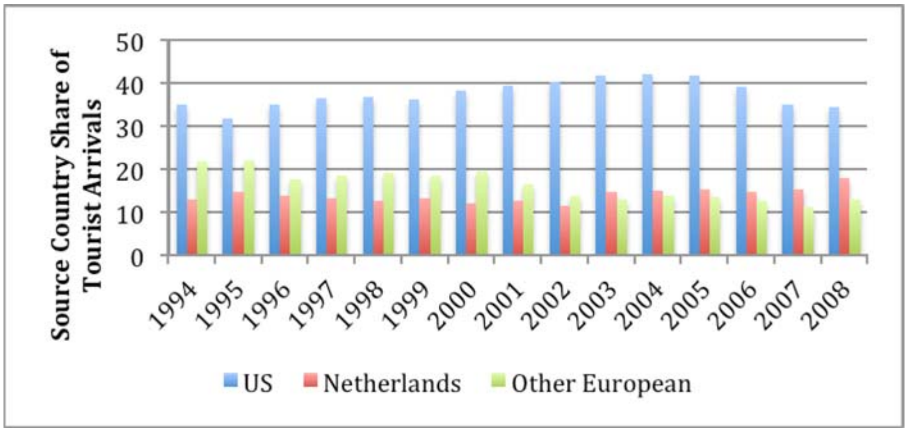


Source: Caribbean Tourism Organisation

The Netherlands Antilles' dependence on its tourism sector is made more tenuous by the fact that most of its tourists come from the United States. Figure 6 shows the high reliance that the Netherlands Antilles has on the tourists that come from the United States. The share of tourists coming from the

United States is substantial, and in the 2000s it has remained consistently over approximately 34%. Within the last four years, there has been an increasing number of tourists from the Kingdom of the Netherlands and other European countries.

Figure 6
Netherlands Antilles: Source Country Tourism Share



Source: Caribbean Tourism Organisation (Author's Calculations)

This dependence that the tourism sector of this country has on one source country renders it vulnerable to events that occur in the United States that impact tourism. Apart from the vulnerability posed by the high dependence on tourists, particularly from one source country, the tourism sector is in imminent danger from another threat – 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 the health and safety of tourists in relation to changes in temperature and precipitation and extreme events.

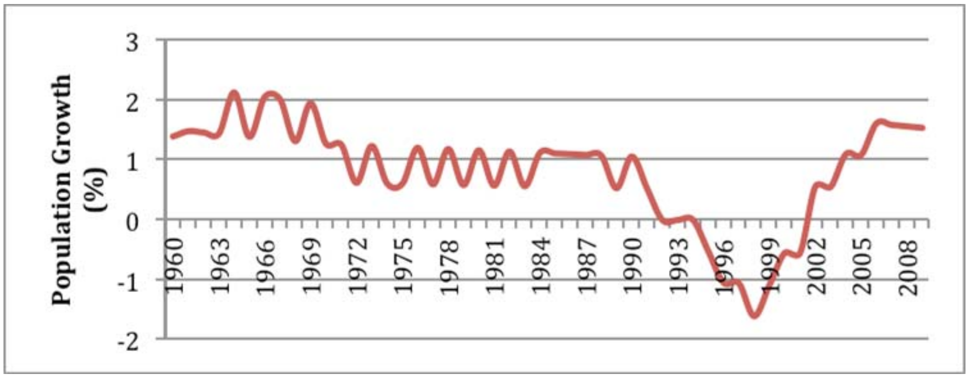
While the Netherlands Antilles is a component of the Kingdom of the Netherlands, it has the benefit of autonomy with regard to domestic matters. The Netherlands Antilles consists of five islands: Bonaire, Curaçao, Saba, St. Eustatius and St. Maarten[2]. These islands are geographically dispersed with Bonaire and Curaçao situated a little north of the Venezuelan coastline and the other three are approximately 800 miles north-east. In total the Netherlands Antilles has a land area of 783 square kilometres and a population of 198,000 (2009). Figure 7 indicates that there have been fluctuations in population growth in the Netherlands Antilles from 1960, and that, in particular, population growth experienced a steep increase in growth rates just before the turn of the century.

[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 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

[2] The Netherlands Antilles was dismantled on 10 October 2010.

Figure 7

Netherlands Antilles Population Growth for the period 1960-2009



Source: World Bank Open Data Source

B. CLIMATE AND CLIMATE CHANGE

Statistics on the various elements that constitute the climate are showing that the world's climate is changing: higher average temperatures (both air and ocean) are being experienced, as well as, rising sea levels and an increase in the intensity and frequency of storms and tropical cyclones (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 U.S. 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 industralization. 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 the islands that comprise the Netherlands Antilles are located along the coastline and are a key source of tourism activity – it is one of the natural resources that permits these islands 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.

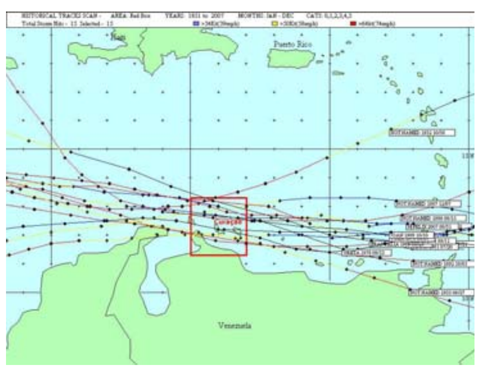
All five islands that comprise the Netherlands Antilles have tropical climate conditions where the annual average temperature ranged from 25.2 – 26.5°C for the past four decades and the average rainfall has ranged from 70 - 80 mm per month for the same period. The two islands closer to Venezuela (Curaçao and Bonaire) have a dry climate and, similar to Aruba, lie on the border of the general hurricane path. The other three islands lie closer to Puerto Rico and in the vicinity of the Leeward Islands and are situated in the track of violent tropical hurricanes which are likely to develop between July and October. These are also the months of the heaviest rainfall.

According to the Meteorological Service of Netherlands Antilles and Aruba (2010)[3] 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) were mainly due to flash floods and cost an estimated US$350,000. More recently, in October 2008, Hurricane Omar generated large waves which caused beach erosion and significant damage to the coastal facilities in Aruba, Bonaire and Curaçao.

The Windward Islands of Saba, St. Eustatius and St. Maarten are located within the hurricane belt. The Meteorological Service of the Netherlands Antilles and Aruba (2010) points out that roughly every year at least one tropical cyclone occurs within a range of 100 miles and on the average once every 4-5 years hurricane conditions are experienced. The most recent hurricanes to cause considerable damage to the islands were the Hurricanes Omar (2008), José (1999), Lenny (1999), Georges (1998), Luis (1995), Marilyn (1995), Hugo (1989), Donna (1960) and Dog (1950). Hurricane Luis caused extensive destruction and it is estimated that the total direct and indirect costs were approximately US$1 billion. As stated by the Meteorological Service of Netherlands Antilles and Aruba (2010) report, over 90% of all structures in St. Maarten was either damaged or completely destroyed. The island was without international communication for several days.

Figures 8 and 9 show the tropical cyclones that passed within 60 nautical miles of Curaçao and Bonaire (Fig. 8) and St. Maarten, Saba and St. Eustatius (figure 9) from as early as 1887 through to 2009.

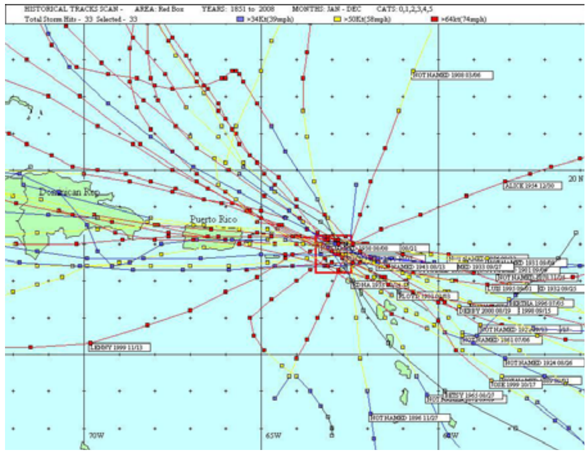
Figure 8
Tropical cyclones passing within 60 Nautical Miles of Curaçao and Bonaire (through December 31, 2008)



Source: Meteorological Service of Netherlands Antilles and Aruba

3 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

Figure 9
Tropical cyclones passing within 60 Nautical Miles of St. Maarten, Saba and St. Eustatius (through December 31, 2009)

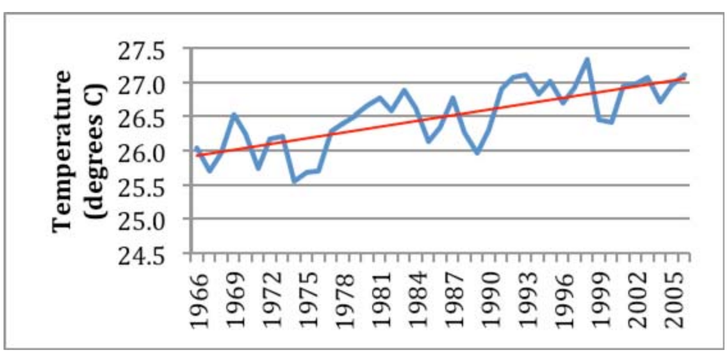


Source: Meteorological Service of
Netherlands Antilles and Aruba

Data on the temperature and precipitation in the Netherlands Antilles for the period 1966 to 2006 is shown in figure 10. 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).

International figures indicate that temperature worldwide is on the increase in most parts of the world, albeit at different levels. The data for the Netherlands Antilles shows that there has been a quite steep increase in average temperature during the past 40 years.

Figure 10
Average Temperature in Netherlands Antilles: 1966-2006

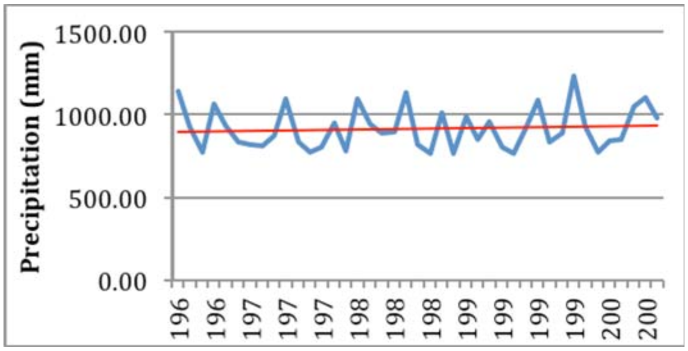


Source: Terrestrial Air Temperature and Precipitation:
1900-2006 Gridded Monthly Time Series, Version 1.01

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. The precipitation data for islands of the Netherlands Antilles indicate that rainfall has been basically steady during the entire period. (See figure 11).

Figure 11

Total Annual Rainfall for the Netherlands Antilles: 1966-2006



Source: Terrestrial Air Temperature and Precipitation: 1900-2006 Gridded Monthly Time Series, Version 1.01

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.

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
Netherlands 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

C. SRES A2 AND B2 SCENARIOS

In 2000 the Intergovernmental Panel on Climate Change (IPCC) published a set of climate scenarios in the Special Report on Emissions Scenarios (SRES). The 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 the Netherlands Antilles 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 2100 the population would have reached 15 billion, with generally slow economic and technological development. It predicts a little lower greenhouse gas (GHG) emissions 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 have 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.

Gössling 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[4]. 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 analysed 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[5], 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.

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[4]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.
[5]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.

The second strand of the literature concentrates on the tourist and his or her response to changing climatic variables and therefore includes the climate since they are significant influences on the tourism industry. It has been stated that the climatic factors that have the most 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 the results of other studies have found 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) 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. Berrittella et al. (2006) predicted that at the international level, changes in the climate would eventually lead to a loss in welfare and that 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 (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 questionnaire 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[6] 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^{0}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 in table 3 and ranges from the databases being used to estimate the models to forecasted levels of personal disposable income of travelers.

Table 3
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)

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

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 and 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 the Netherlands Antilles. 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.

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 storm 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 shall 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: Curry et al. (2009)

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.

This study employs the same methodology as that used by Toba (2009), and as reported by Haites (2002). In these studies, hurricanes in the Caribbean are expected to increase by 27% on an annual basis. Haites (2002) used the example of 1995 hurricanes (Luis and Marilyn) to determine the cost in terms of income loss from the tourism sector and found that tourism expenditures decreased by about 17%. Therefore, with a 27% increase in hurricanes due to climate change and an estimated 17% decrease in tourist expenditures when a hurricane strikes, it is estimated that tourist expenditures are expected to decrease by 21.6% due to increases in extreme events.

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. 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 2002). In addition, Haites (2002) further points that any rate of rise in the sea level is expected to have disastrous effects on most Caribbean countries. In many 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 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.

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 0.089 m to 0.238 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 to the Netherlands Antilles 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 the Netherlands Antilles due to sea level rise

Country	*A2 Scenario*	*B2 Scenario*
Curaçao		
Total Land Area (km^2)	444	444
Land Loss (km^2)	8.8	4.4
Value of Land Loss (US$ million)	616	308
Bonaire		
Total Land Area (km^2)	294	294
Land Loss (km^2)	5.8	2.9
Value of Land Loss (US$ million)	406	203
St. Maarten		
Total Land Area (km^2)	34	34
Land Loss (km^2)	0.68	0.34
Value of Land Loss (US$ million)	47.6	23.8
St. Eustatius		
Total Land Area (km^2)	21	21
Land Loss (km^2)	0.42	0.21
Value of Land Loss (US$ million)	29.4	14.7
Saba		
Total Land Area (km^2)	13	13
Land Loss (km^2)	0.26	0.13
Value of Land Loss (US$ million)	18.2	9.1

Source: Data compiled by author.

2. Loss of hotel infrastructure

Haites (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. The Netherlands Antilles has about 245 hotel/resorts/guest houses shared among the islands and most of these lie close to or very near to the coastline. An approximate estimation of hotel room replacement cost can be made for the Netherlands Antilles using the costing from the Haites (2002) study and employing the same sea level rise assumptions for the Caribbean. Figure 12 shows a map of Curaçao with just a fraction (13%) of the hotels and resorts highlighted. It is clear to see that the majority of structures are situated close to the coast.

Figure 12
Map of the Curaçao showing Hotels/Resorts

Similar to Toba (2009), if an assumption is made that 8% of hotel rooms[7] are destroyed due to sea level rise and the average cost per room is approximately US$80,000, then in the case of the Netherlands Antilles the annual hotel room replacement cost is approximately US$37.6 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 two to four weeks can cause coral bleaching. 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). 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 13 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.

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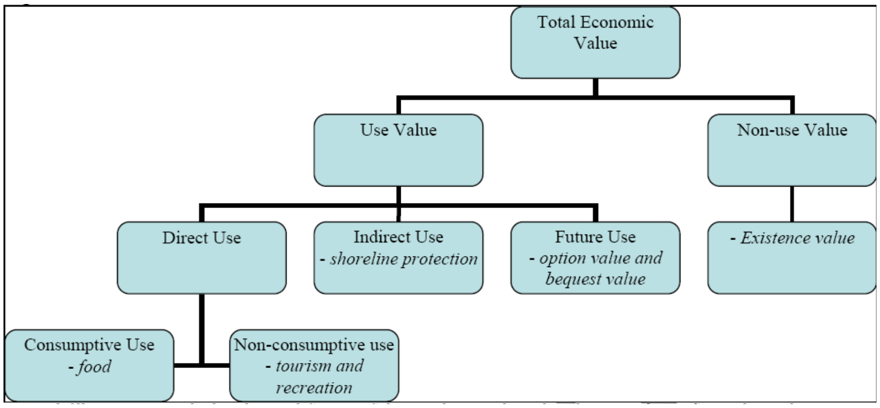
[7]A further assumption is that there is on average 147 hotels/resorts (each with approximately 40 rooms on average) near the coastline that have the potential to be affected by rises in the sea level.

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 13
Total Economic Value Framework



Source: World Resource Institute (2009)

Dixon et al. (1993) used the Contingent Valuation Method[8] 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 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 attempts 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 the Netherlands Antilles[9], this can be estimated to be approximately US$201 million per year.

[8] 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).

[9] The average annual tourism income for the 1979-2008 period is US$ 916 million.

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 continues 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[10]. 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 loses 4% of GDP by 2050 and 18% 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
Netherlands 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[11] 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 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[12], 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

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

[11] 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.

[12] 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.

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 Netherlands Antilles' 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 four layers of costing to estimate the total of climate change on the tourism sector for the Netherlands Antilles. The report will analyse and cost tourism demand using two climate variables: temperature and precipitation. The other three layers include approximating: (a) the cost of extreme events to the tourism industry by examining potential damage to tourism infrastructure; (b) the cost of sea level rise with respect to loss of beach and tourism infrastructure (exclusive of hurricane damage) along the shoreline; and (c) coral reef loss due to rising sea levels and temperatures.

For the purposes of this study, (b) and (c) 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) between 20-22% 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, snorkelling, boating and marine parks).

V. MODELLING TOURISM DEMAND IN THE NETHERLANDS ANTILLES

A. THE TOURISM DEMAND FUNCTION: A BRIEF 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), 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: per capita income in the destination country (in US$ millions), per capita income (GDP) in the source country (in US$ millions), temperature (°C) and precipitation (mm).

It is expected that a high per capita income[13] is desirable by tourists visiting a country, since it translates to a higher standard of accommodation and facilities for tourists to enjoy. Tourists also prefer visiting countries where there is a low level of poverty[14].

In tourism demand functions, income 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 travelers.

A priori, it is expected that both income variables (*napcy* in the destination country and *uspcy* in the source country) would be positively associated with tourism demand. It is anticipated that the two climate variables will have a negative relationship with tourism demand.

VI. DATA

Several sources were used to collect the data used in the study. Information on tourist expenditure was obtained from the Caribbean Tourism Organisation. 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/) 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[15]. There is support in the literature for the use of annual data in the 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. 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 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 the Netherlands Antilles is estimated by applying a co-integration

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[13] As classified by the World Bank, low-income countries have per capita incomes of US$975 or less, middle income countries over US$976 and high-income countries over US$11,906.

[14] Generally, countries with high incomes generally have low levels of poverty and vice versa.

[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 per capita income and precipitation.

analysis according to the procedure proposed by Engle and Granger (1987) and expanded by Johansen (1988) and Johansen and Juselius (1990). In broad terms, co-integration 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 this case, are Netherlands Antilles per capita income, per capita income in the source country, temperature and precipitation. Co-integration 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 co-integrated. This technique has been employed in other studies examining tourism demand; see for example Dritsakis (2004) and Querfelli (2008). Co-integration 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 behaviour of the endogenous variables to converge to their co-integrating relationships.

Johansen's (1988, 1995) unified maximum likelihood framework is employed to test for the existence of co-integration by estimating a VAR (2) model[16]. The results of the co-integration analysis based on both the trace and maximum eigenvalue of the stochastic matrix indicates that there are at most two co-integrating relationships. Table 7 presents the results of the co-integration test based on a trace of the stochastic matrix.

Table 7
A co-integration analysis of tourism expenditure

Null	*Alternative*	*Trace statistics*	*95% quantile*
r=0	*r>=1*	84.74	68.52
r<=1	*r>=2*	50.63*	47.21
r<=2	*r>=3*	23.14	29.68

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 Netherlands Antilles.

$$te = f(pcy, spcy, t, p)$$

Where, *te* is the total tourist expenditures
pcy is the per capita income in the destination country
spcy is the Gross Domestic Product in the source country
t is the temperature
p is the precipitation

Annual time series data for the 1977 – 2008 period was collected for the Netherlands Antilles and the empirical methodology employed is based on Johansen's (1995 and 1998) system of co-integration

[16]All of the variables are treated as endogenous in the VAR system. - there are 32 observations and each equation is fitted with five parameters, leaving 27 degrees of freedoms for the variance.

analysis. To undertake the estimation, the above equation will be analysed by employing a double-logarithmic specification. The double log model, as reported by Lim (1999), is one of the more popular model specifications. The results of the model are outlined and analysed in the following section.

VIII. RESULTS

The results for the error correction model are provided in Table 8. All of the variables proved to be significant. The R^2 shows a reasonable fit of the model and it is observed that the model can predict approximately 58% of the variation of tourist expenditures in the Netherlands Antilles. The model will eventually be used to generate forecasts of the dependent variable (tourism expenditure) and the independent variables (Netherlands Antilles per capita income, United States per capita income) and temperature and precipitation (to examine the 'Business as Usual' scenario). 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. 2000-2008. 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.

Table 8
Long-run coefficients for VEC model

Variable	*Coefficient Estimates*
ln(NA per capita income)	-0.000439*** (0.0000503)
ln(US per capita income)	4.222*** (0.6096)
ln(temperature)	-8.126*** (1.603)
ln(precipitation)	-4.381*** (0.690)
Observations	33
R^2	0.585
Theil U statistic	0.016
MAPE	31.23%

Notes: (1) Standard Errors in parentheses(2) *** p < .001, ** p < .01, * p < .05

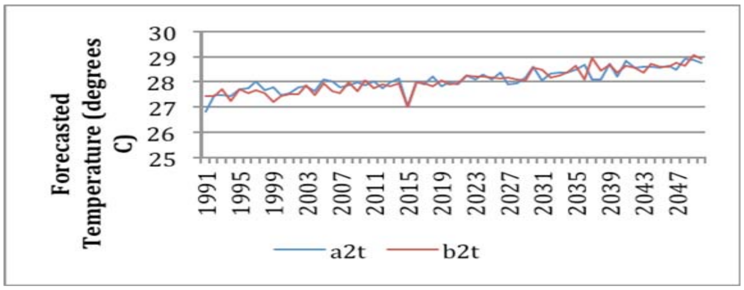
An examination of the results indicates that the coefficient estimates were generally in agreement with expectations and, of importance, the results obtained for the climate variables were highly significant. In particular, United States per capita income has a positive relationship with tourism expenditure and Netherlands Antilles per capita income, temperature and precipitation have a negative relationship with tourism expenditure.

It was found that decreases in per capita income translate to increases in tourist expenditures. This was not an expected result, however, while tourists visiting a country relate higher standards of living with more superior facilities and infrastructure for their use, each country is unique and it is possible that tourists visiting the five islands of the Netherlands Antilles are more interested in the unique tourist products offered by the islands and are less concerned with the infrastructure in place on these islands.

As expected, a positive coefficient was obtained for United States per capita income. Specifically, the coefficient obtained is highly significant and positive, indicating that when per capita income in the United States increases so do tourist expenditures in the Netherlands Antilles. With respect to the sensitivity of tourist expenditure to United States per capita income, the magnitude of the GDP coefficient is higher than that for per capita income for the Netherlands Antilles, indicating that tourist expenditures in Netherlands Antilles is very sensitive to changes in United States per capita income.

An anticipated result was obtained for the temperature variable, essentially, as temperature increases, tourist arrivals decrease. This has serious implications for tourism, and by extension, the economic well-being of the Netherlands Antilles, given the predicted increases in temperature under the various climate scenarios put forward by IPCC in its SRES. As figure 14 indicates, under both the A2 and B2 climate scenarios temperatures are expected to increase in the future.

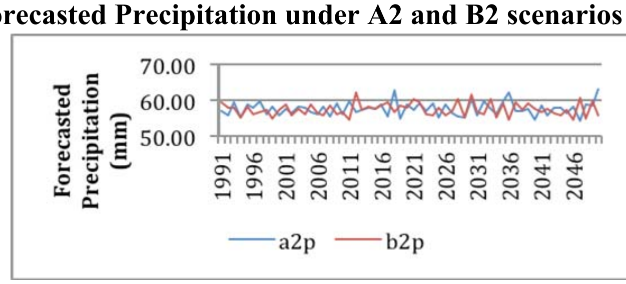
Figure 14
Forecasted Temperature under A2 and B2 scenarios (1991-2050)



Source: INSMET

The results of the model indicate that precipitation has a negative effect on tourist expenditures and changes in tourist expenditure are less sensitive to precipitation than temperature (the model yielded a temperature coefficient of -8.126, whereas the precipitation coefficient was -4.381). The literature on tourism demand has pointed to the fact that tourists prefer dry holiday destinations rather than wet ones (Lise and Tole, 2002), therefore, according to the results of the model, as the climate changes in some countries and less precipitation is observed it would have a positive impact on tourism. However according to IPCC predictions, precipitation is expected to decline in certain Caribbean countries. 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 15 shows the forecasted values of precipitation under both A2 and B2 scenarios. The literature shows that hotels and their guests consume vast quantities of water.

Figure 15
Forecasted Precipitation under A2 and B2 scenarios (1991-2050)



Source: INSMET

IX. FORECASTING THE COST OF CLIMATE CHANGE FOR THE NETHERLANDS ANTILLES

A tourism demand model was estimated to determine the factors that impact tourism demand in the Netherlands Antilles. 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 the Netherlands Antilles until 2050. The forecasted tourist expenditure data is used to obtain the cost to the tourism sector under two climate scenarios: A2 and B2.

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: per capita income, per capita income of the United States. Analogous 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.

With respect to the climate variables for the A2 and B2 scenarios[17], forecasts for both variables were received from the Institute of Meteorology in Cuba (INSMET). The predictions from INSMET were obtained from the European Centre Hamburg Model (ECHAM), 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 United States dollars 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.

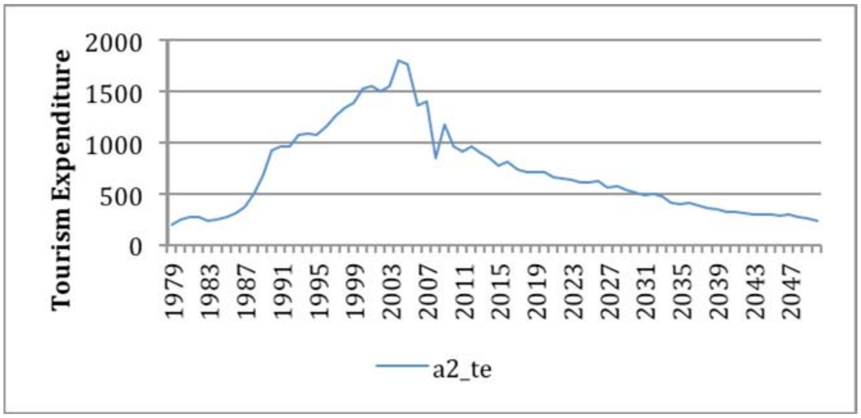
As mentioned in the literature review, apart from temperature and precipitation and its effects on the tourism sector, there are other climate variables that have the potential to negatively affect the tourism sector in the Netherlands Antilles, in particular, extreme event, sea level rise and destruction of ecosystems due to ocean acidification. Due to lack of data, the methodology used for this part of the study was adopted from Toba (2009). It must be noted that most of the results obtained from existing research on economic effects of climate change in the Caribbean, and indeed even on an international basis, is not directly comparable to each other and to this study since many variations exist with respect to the number of countries used in the studies, the sectors examined, the data and methodologies employed.

X. FORECASTING RESULTS

To obtain the annual level of tourism expenditure in the Netherlands Antilles based on forecasted changes in temperature and precipitation, the tourism demand model was estimated under A2 and B2 conditions until 2050. Figure 16 provides the forecasted tourism expenditures in the Netherlands Antilles until 2050 under the A2 climate scenario.

[17] As mentioned before, there are five islands that make up the Netherlands Antilles and they are located in two different regions in the Caribbean. Region specific models were employed at first, but no significant results were obtained. A decision was then taken to find the average temperature and average precipitation in the two regions for the forecast period i.e. 2009 – 2050 (See Annex II for the charts which show the average for the period).

Figure 16
Forecasted Tourism Expenditures under the A2Climate Scenario

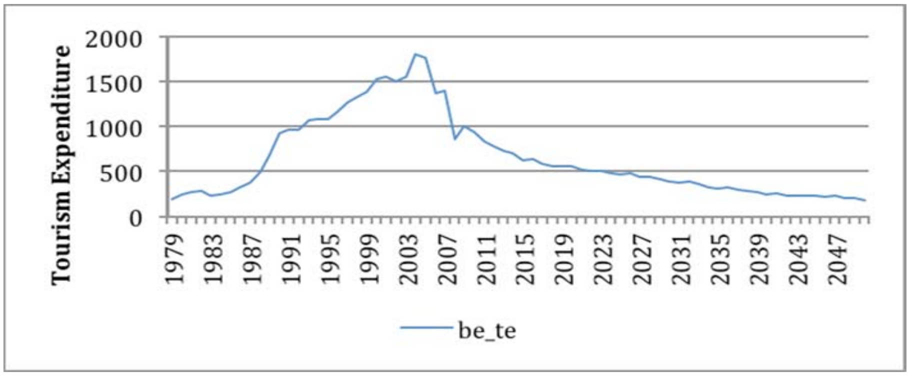


Source: Data compiled by author.

Figure 16 indicates that the Netherlands Antilles would see an increase in fortunes of its tourism sector from about 2012, but the income from this sector starts to gradually decrease as 2050 approaches.

Figure 17 gives an indication of what the level of tourism expenditures in the Netherlands Antilles would look like until year 2050 under the B2 climate scenario.

Figure 17
Forecasted Tourism Expenditures under the B2 and BAU Climate Scenarios



Source: Data compiled by author.

From the information in the chart, it appears that after 2011 tourism expenditure is expected to keep decreasing at a fairly even pace until 2050.

Table 9 shows the forecasted tourism expenditure under the A2, B2 and BAU climate scenarios until the mid-century mark. As expected, the least amount of income is earned under the A2 sector and the most under the BAU (no climate change) scenario.   This is due to the assumption that under the BAU scenario, tourists continue to visit the Netherlands Antilles without being hampered or distressed by the effects of the changing climate, such as increased temperatures, rising sea level with the accompanying coastal damage and coral reef loss.

Table 9
Aggregated Forecasted Tourism Expenditure until 2050 under The A2, B2 and BAU scenarios *(Expenditure in US$ - 2008 dollars)*

Year	*A2*	*B2*	*BAU*
2020	8683.37	10241.52	17351.79
2030	13336.84	16239.37	29411.03
2040	16499.58	20365.16	38805.84
2050	18707.75	23261.93	46303.96

Source: Data compiled by author.

Using these tourism expenditure figures, a costing was undertaken for the Netherlands Antilles' tourism sector until 2050 with the BAU expenditures as a comparator. The results are outlined in table 10. The table shows the costs under the A2 and B2 climate scenarios for four different points in the half-century period: 2020, 2030, 2040 and 2050.

Table 10
Costing For A2 and B2 Scenarios: Temperature and Precipitation
(Costs in US$ - 2008 dollars)

Year	*A2*	*B2*
2020	9,066.86	8,435.53
2030	15,064.71	15,841.31
2040	19,190.50	22,073.37
2050	22,087.27	27,363.33

Source: Data compiled by author.

The results in table 10 show that under the A2 climate scenario, changes in temperature and precipitation costs the tourism industry approximately US$22 million by 2050. Under the B2 climate scenario, the Netherlands Antilles' tourism sector has much more to lose due to the higher income earned under this climate scenario.

Table 11 provides the costing for extreme events under the A2 and B2 scenarios. Included in these figures are the costs to be borne due to the losses that are estimated to occur due to increases in the frequency and intensity of hurricanes and the accompanying windstorms, floods and landslides. The cost to the Netherlands Antilles with regard to extreme events is shown in table 11.

Table 11
Costing For A2 andB2 Scenarios: Extreme Events
(Costs in US$ millions - 2008 dollars)

Year	*A2*	*B2*
2020	1,622.96	1,958.44
2030	2,628.11	3,253.98
2040	3,311.26	4,145.15
2050	3,788.23	4,770.85

Source: Data compiled by author.

The total costs under the scenarios for extreme events are as follows: A2: US$3.78 billion and under the B2: US$ 4.77 billion – Again, the B2 costs are higher due to the superior earnings under this sector[18].

Table 12 presents the loss to the tourism sector in the Netherlands Antilles due to the predicted rise in sea level and the destruction of ecosystems due to occurrences such as ocean acidification. Again, the methodology employed by Toba (2009) is employed i.e. 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[19] and ecosystem destruction, it is projected that this amount would be lost due to non-participation in these activities. The costs calculated in table 10 represents the loss that would occur when tourist refrain from sea-related activities.

Table 12
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	2,254.12	2,720.06	95.43
2030	3,650.16	4,519.41	161.76
2040	4,598.98	5,757.15	213.43
2050	5,261.43	6,626.18	254.67

Source: Data compiled by author.

Table 12 shows that under the A2 climate scenario the Netherlands Antilles' tourism sector loses US$5.26 billion due to rises in the sea level and the destruction of the ecosystem, while under the B2 climate scenario the loss is a bit more at US$6.62 billion. However, when it comes to the BAU scenario, the cost is quite lower and is only due to the negative impact of human activity on the coral reefs, and not changes in the climate.

Table 13 illustrates the total costs that the Netherlands Antilles will incur under the three climate scenarios. The total costs include figures from losses due to changes in temperature and precipitation, the increase in intensity and/or frequency of extreme events and those occurring due to sea level rise and destruction of ecosystems. In the case of the BAU scenario, only the cost from coral reef loss due to human activity is included.

Table 13
Total costs incurred for the Netherlands Antilles under the A2, B2 and BAU Scenarios
(Costs in US$ millions - 2008 dollars)

Year	*A2*	*B2*	*BAU*
2020	3,967.75	4,762.85	95.43
2030	6,428.91	7,931.80	161.76
2040	8,102.15	10,123.03	213.43
2050	9,270.53	11,670.66	254.67

Source: Data compiled by author.

[18] As expected, under the A2 scenario the cost to the Netherlands Antilles is less than the B2 scenario since tourism income was less in this scenario.
[19] According to Haites et al. (2002) by 2050 the sea level is expected to rise as follows: 0.08 meters (low case scenario); 0.44 meters (high case scenario).

The total figures (table 13) indicate that the Netherlands Antilles has to take some decisive and positive actions with regard to mitigation and adaptation within the tourism industry to help in the reductions of these future costs, which are amounting to a considerable amount, specifically US$9.2 billion (A2 scenario) or US$11.7 billion (B2 scenario). The fallout from the BAU scenario for the tourism sector is US$254.6 million. These figures amount to between 1% - 1.5% of GDP for the Netherlands Antilles GDP.

Finally, table 14 presents the discounted future aggregate costs of climate change to the Netherlands Antilles' tourism industry for 2020, 2030, 2040 and 2050.

Table 14

Net Present Value of Aggregate Costs in the Tourism Sector
Under Scenarios A2, B2 and BAU - Discount Rate: 0.5% and 4%[20]

(Costs in $US millions - 2008 dollars)

	A2			B2			BAU		
Year	**0.001**	**0.02**	**0.04**	**0.001**	**0.02**	**0.04**	**0.001**	**0.02**	**0.04**
2020	3946.09	3566.71	3225.08	4736.01	4266.17	3843.81	94.09	78.36	74.77
2030	6163.45	5215.30	4441.94	7853.80	6565.14	5527.24	158.13	126.39	107.97
2040	7997.70	6352.01	5137.94	9988.56	7873.37	6318.58	207.12	126.39	125.38
2050	9124.49	6922.66	5421.43	11481.09	8629.13	6693.97	242.57	177.28	134.08

Source: Data compiled by author.

The next section of the study examines adaptation and mitigation in the tourism sector.

XI. APPROACHES TO MITIGATION AND ADAPTATION IN THE TOURISM SECTOR

Rogner et al. (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 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 GHG 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).

The World Tourism Organization-United Nations Environment Programme-World Meteorological Organization (UNWTO-UNEP-WMO) (2008) has outlined four key mitigation measures that can be used to deal with GHG emissions from tourism:

(a) 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

[20] These discount figures were suggested by ECLAC for use in the study.

car and aircraft, choosing less distant destinations), as well as changing management practices (e.g. videoconferencing for business tourism).

(b) 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).

(c) 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.

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 Small Island Developing States (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 harm 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 recognised 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 adopt and the ones that countries like the Netherlands Antilles adopt 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 the Netherlands Antilles can utilize to tackle 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 15).

Table 15
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	Need to motivate and	Lack of education and	Undertake

Adaptation measures	*Relevance to tourism*	*Barriers to implementation*	*Measures to remove barriers*
raising	mobilise tourism staff and also tourists	resources that support behavioural change	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 Chang*e*

The Stern Review (2006) has emphasised 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 policymakers, 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 the countries that comprise the Netherlands Antilles. The IPCC (2001) drawing from Smit et al. (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.

The Government of the Netherlands Antilles is located in Curaçao, and the country is engaged in creating legislation that would meet the terms of the Kyoto Protocol (ECLAC, 2010). The Netherlands Antilles has in place at present nature conservation legislation, which indicates that only the framework for a nature policy plan is in place. The Nature and Environment Policy Plan includes policy for the environment, but it is not based on legislation but on a departmentally recognized need to address these issues. The environmental legislation has not been passed by any of the new entities resulting from the break-up of the former Netherlands Antilles. Other policies and legislation, which address the environment and targets facets directly related to the tourism industry include: tourism legislation, a Reef Management Ordinance (1976) (Curaçao only). An Island Nature Ordinance has been around in various draft forms for over 10 years but has not been passed.

Table 16 presents some of the potential adaptation measures and their corresponding evaluation criteria for the tourism sector in the Netherlands Antilles.

Table 16

Potential adaptation measures and evaluation criteria for the tourism sector in the Netherlands Antilles

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	X		X	X	
		Offer incentives to retrofit tourism facilities to limit the impact of increased wind speeds		X			X	X		X		
		Retrofit ports to accommodate the expected rise in wind speeds	X		X		X	X		X		
		Catastrophe insurance for those governments buildings that are used by tourists	X		X			X		X	X	
		Insurance for adaptive re-buildings		X					X	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	
		Retrofit hotels to conserve water	X	X				X	X	X	X	X
		Build desalination plants										
		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 swamp	X	X	X		X	X	X	X	X	x
		Raise the land level of low lying areas	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	

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*
		Introduce new legislation to change planning policies, zoning and land use priorities as needed		X	X			X		X	X	
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 sources such as vessel operations and offshore sewage		X			X				X	
		Artificial reefs or fish-aggregating devices	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	
		Implement pro-active plans to respond to non-native invasive species					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*
Extreme climate events	Climate change	Provide greater information about current climate events		X	X				X	X	X	X
		Develop national guidelines		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		
		Accelerated depreciation of properties in vulnerable coastal zones			X					X		
		Supporting infrastructure investment for new tourism properties					X		X		X	
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		
		Fund discount programmes run by hotels	X	X		X				X		
		Introduce "green certification" programmes for hotels		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	X		X		X		X	X		
		Recognition of the vulnerability of some eco-systems and adopt measures to protect them		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*
		Introduction of alternative attractions		X	X							
		Provide retraining for displaced tourism workers					X		X	X		
		Revise policies related to financing national tourism office to accommodate the new climatic realities					X		X	X		

Adapted from: Moore (2010) National Tourism Sector Assessment: Montserrat and St. Lucia

A. SHORT-LISTED OPTIONS FOR BENEFIT-COST ANALYSIS

Using the evaluation criteria scheme in table 16 and the assistance of country experts, two options for mitigation and nine options for mitigation and adaptation to climate change in the Netherlands Antilles, have been short-listed, bearing in mind the location of the five islands that constitute the former Netherlands Antilles. These suggested options are listed under the headings of Mitigation (2 options) and Adaptation (9 options).

Mitigation Strategies

Option 1 – Restrict GHG emissions of refinery, desalination water and power plants, sewage treatment facility and solid waste management facility to international set requirements.
Option 2 – Encourage participation on the voluntary carbon market.

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 –Construction of water storage tanks – at present only Saba does not have a desalination plant.
Option 4 – Build tourism infrastructure further back from coast
Option 5 – Beach re-nourishment
Option 6 – Coral nurseries to help restore areas of the reef that have been damaged due to the effects of climate change
Option 7 – Enhanced reef-monitoring systems to provide early warning alerts of bleaching events.
Option 8 – Develop national guidelines
Option 9 – Flood drainage protection for hotels

The cost-benefit analysis of the above options is presented in table 17. The results of the cost-benefit analysis indicate that the mitigation options had benefit cost ratios under 1. In the case of the adaptation options, at least three of the adaptations options had cost benefit ratios over 1 through the 20-year horizon: Options 1, 2 and 9.

Table 17
Cost-benefit analysis of proposed options for Netherlands Antilles (US$)

Options	*Risk mitigation or transfer options*	*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 plants, sewage treatment facility and solid waste management facility to international set requirements.	$1,051,080.851	$14,509,323.06	0.07	($13,458,242.21)
M2	Encourage participation on the voluntary carbon market.	$145,093,230.6	$217,285,016.5	0.67	$21,728,5015.8

		Adaptation Options			
A1	Offer incentives to retrofit tourism facilities to limit the impact of increased wind speeds	$1489,059.48	$844,208.83	1.8	$644,850.66
A2	Catastrophe insurance for those government buildings that are used by tourists.	$25405,875.50	$7432,508.95	3.4	$17973,366.55
A3	Construction of Water Storage Tanks	$38260,500.53	$66739,510.57	0.6	($28479,010.03)
A4	Build tourism infrastructure further back from coast	$9503,923.40	$9620,345.44	1.0	($116,422.04)
A5	Beach Re-nourishment	$2167,815.11	$36703,747.90	0.1	($34535,932.79)
A6	Coral Nurseries to help restore areas of the reef that have been damaged to the effects of climate change	$47519,617.02	$45765,558.90	1.0	$1754,058.12
A7	Enhanced reef monitoring systems to provide early warning alerts of bleaching events	$2580,732.27	$7696,276.35	0.3	($5115,544.08)
A8	Develop National Guidelines	$1306,789.47	$13955,375.95	0.1	($12648,586.49)
A9	Flood drainage protection for hotels	$15443,875.53	$8888,065.34	1.7	$6555,810.20

Source: Data compiled by author.

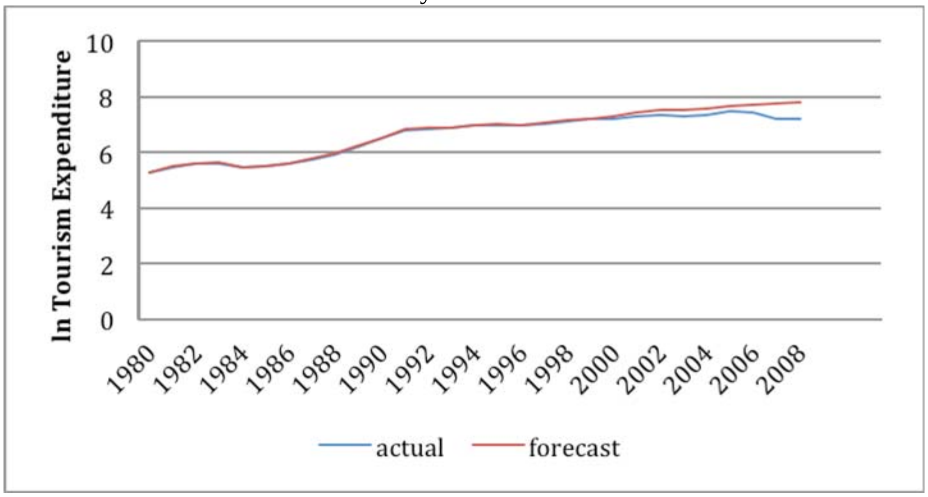
XII. CONCLUSION AND RECOMMENDATIONS

In this study the impact of climate change on the tourism sector in the islands that make up the Netherlands Antilles was examined taking into consideration both demand and supply factors. Four 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 modelled for the Netherlands Antilles using an error correction model within a co-integration framework employing economic and climatic variables. The model was then used to predict the impact of climate change under two climate scenarios (A2 and B2) until the mid-century mark (2050). Supply issues were addressed in the other layers and these were related to extreme events, sea level rise and the destruction of coral reefs. The results specify that the Netherlands Antilles can lose over US$9.27 billion under the A2 scenario and US$11.67 billion under the B2 scenario. It is clear that the Netherlands Antilles must take decisive action and put measures in place to adapt and mitigate against impending climate change, if growth is to be sustained in the tourism sector. With respect to mitigation and adaptation strategies, there are certain options that would be more viable for the Netherlands Antilles to propel its drive towards achieving sustainability and growth in the tourism sector. Eleven options were chosen for the cost benefit analysis was undertaken on the selected options. These initial estimations indicate that at least three of the options had cost-benefits ratios over 1.

It is clear that further and more in-depth work has to be undertaken on climate change and its impact on the tourism sector. The Netherlands Antilles has enacted legislation and initiated projects to tackle climate change and it is especially important that further strategies be examined which are specific to the tourism sector, since this is one of the main sectors that drives the economy.

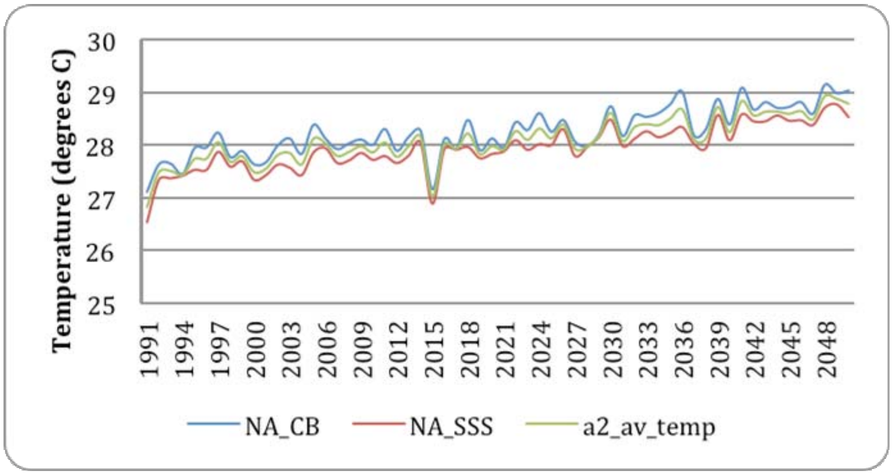
Annex I

Predictability of the VEC Model

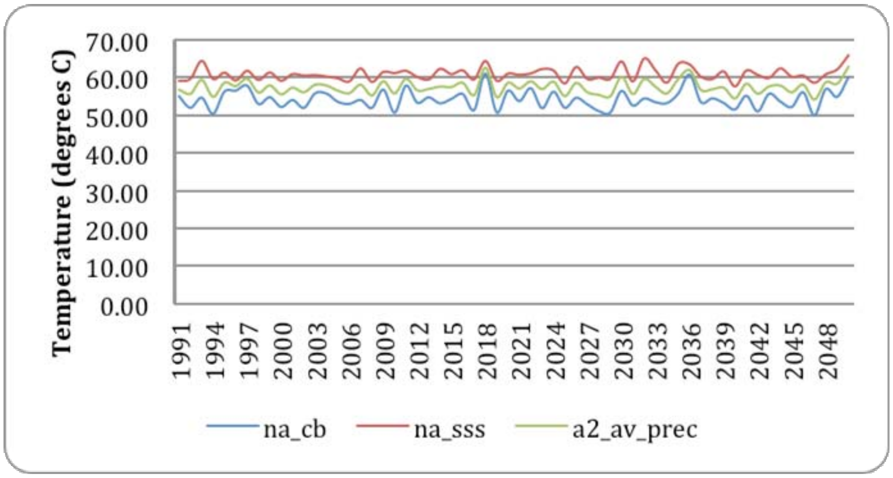


Annex II

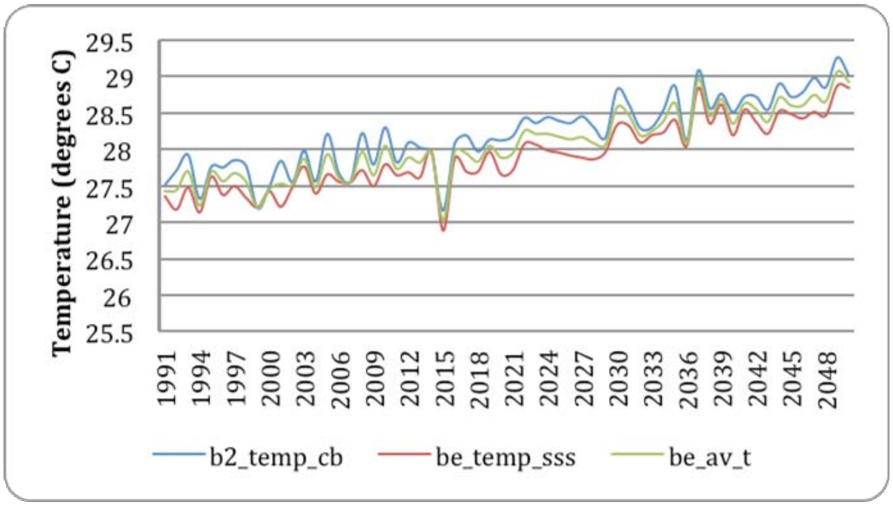
Average forecasted temperature for A2 climatic scenario



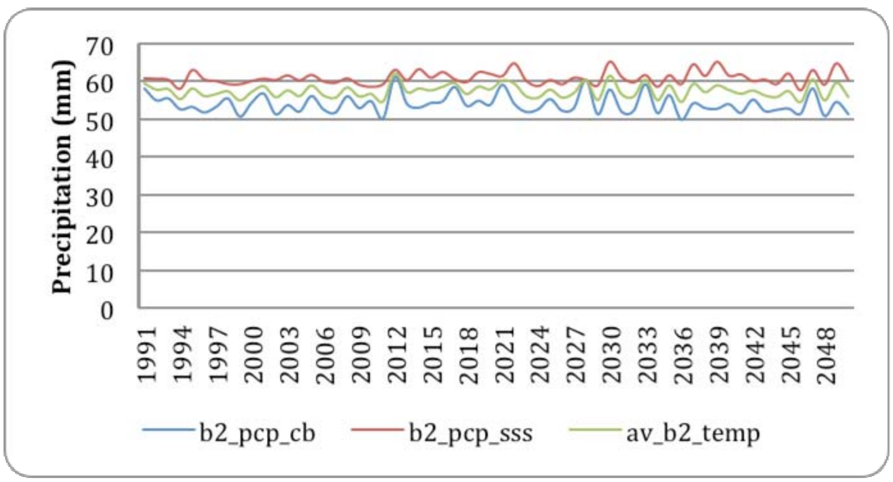
Average forecasted precipitation for A2 climatic scenario



Average forecasted temperature for B2 climatic scenario



Average forecasted precipitation for B2 climatic scenario



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