ESTIMATING THE IMPACT OF A CLIMATIC SHOCK ON CREDIT SUPPLY AND THE PROBABILITY OF DEFAULT IN THE BAHAMAS

Sharon Branch, Lavashti Dames, Nathan Rolle, Lynsey Ward, and Allan Wright

Abstract

The Bahamas, as a small island developing state (SIDS), is largely susceptible to climate events such as hurricanes. In fact, over the last decade, the frequency and intensity of these catastrophic events have vastly increased. These exogenous shocks have negatively impacted the domestic economy and banking sector, which accounts for the second largest share of GDP. This paper used an Ordinary Least Squares (OLS) regression to estimate the impact of a climatic shock on the supply of credit in the banking sector, as well as the probability of default. The findings revealed that a climatic shock decreases the banking sector's credit supply, while increasing loan default rates, as measured by the non-performing loan rate (NPL). In addition, the paper forecasted the future impact of a climate shock on GDP over the next five years, using a heat index to identify which islands would be most impacted. The results showed significant GDP losses, though the magnitude would vary by island.

JEL Classification: C32, E51, G21
Keywords: climate risk, banking sector credit, default rate

The authors would like to thank Mr. Carlos Madeira, Visiting Economist at the Bank for International Settlements (BIS) for his contribution to this work.

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Introduction

Climate events, primarily natural disasters, are a negative externality for small island developing states (SIDs) like The Bahamas. Over the years, these occurrences have caused hundreds of millions of dollars in damages to critical infrastructure, and in some cases, loss of life. By extension, these shocks have driven losses in productivity, increased unemployment, and high budget deficits, which all ultimately slow growth in Gross Domestic Product (GDP). The frequency and intensity of these climatic shocks are projected to increase in the future, and their impact is expected to affect multiple sectors of the economy, including the country's second largest industry, financial services, which contributes approximately 15% - 20% of GDP.

In the banking sector, climate risk impacts loan portfolios, as clients can default on payments due to their inability to service their credit facilities in the aftermath of a natural disaster. This credit risk can cause disruptions in cash flow operations and bank liquidity (van Greuning and Bratanovic, 2020). Collectively, these can pose risks to financial stability. Hence, it is critical for regulators and financial institutions alike to adequately measure the implications of climate risk on their portfolios and design the appropriate policy responses to mitigate risks to financial stability and ultimately GDP.

The objective of this paper therefore is to evaluate the impact of a climatic shock on credit supply in the banking sector in The Bahamas, and the probability that consumers will default on their credit facilities; in particular, consumer loans, residential and commercial mortgages, and commercial loans. In addition, this paper also seeks to project the future impact of climatic shocks on GDP by applying a proposed heat index to map particular regions within the archipelago that would be most impacted by hurricanes in the next 40 years.

The remainder of this paper is organized as follows: section I provides an overview of climatic challenges faced by The Bahamas, and presents a regional comparison of the effects of climate change in The Bahamas vis-à-vis other parts of the world. Section II gives a snapshot of credit trends in the domestic banking sector in The Bahamas between 2012 and 2022, while section III presents a review of literature on the subject matter. Section IV outlines the methodology used for the study, while section V follows with a discussion of the results. Section VI then proposes some potential policy recommendations before concluding in section VII.

Section I: Overview of Climatic Challenges in The Bahamas

The Bahamas has one of the lowest carbon footprints in the world, contributing less than 0.01% towards global carbon emissions (United Nations Framework Convention on Climate Change, 2015). Yet, the country suffers significantly from climatic shocks, due to its location in the Atlantic Hurricane Belt, which increases its vulnerability to severe hydro meteorological conditions like hurricanes, storms, and cyclones. Also, the archipelago's low land to sea ratio makes it susceptible to flooding caused by storm surges. Currently, 80 percent of the country's landmass is within 5.0 feet (1.5 m) of the mean sea level (Wright et al, 2022). For this reason, climatologists project The Bahamas to be underwater by 2050 due to rising sea levels. This flooding presents a physical risk for Bahamian infrastructure, as it places exotic sea life, ecoculture, and properties in a vulnerable position.

The annual mean temperature of The Bahamas has been increasing since 1960, reaching as high as 0.5 degrees Celsius, with an average rate of 0.11 degrees Celsius per decade (The Bahamas Updated NDC, 2022). This increased temperature causes trapped heat energy in the ocean, thereby contributing to hurricanes. Between 1980 and 2018, The Bahamas was struck by 12 major hurricanes. These hurricanes caused an accumulated $3.7 billion in damages, which is equivalent to approximately 28.9% of the country's GDP. The most recent hurricane, Dorian, which passed over The Bahamas in September 2019, caused damages and losses of some US$3.4 billion, making it the strongest hurricane that the northern Bahamas has ever faced, and the second strongest hurricane ever recorded in the Atlantic Ocean.

Table 1: Hurricanes and The Bahamas 2012 – 2022

Hurricane	Year	Score	Damage (BSD)	Losses (BSD)	GDP (%)**
Sandy	2012	2	$702.8 million	-	0.9
Joaquin	2015	4	$104.8 million	$9.7 million	0.11
Matthew	2016	4	$373.9 million	$145.5 million	1.1
Irma	2017	4	$32.3 million	$86.9 million	0.4
Dorian	2019	5	$2.5 billion	$717.3 million	1.0

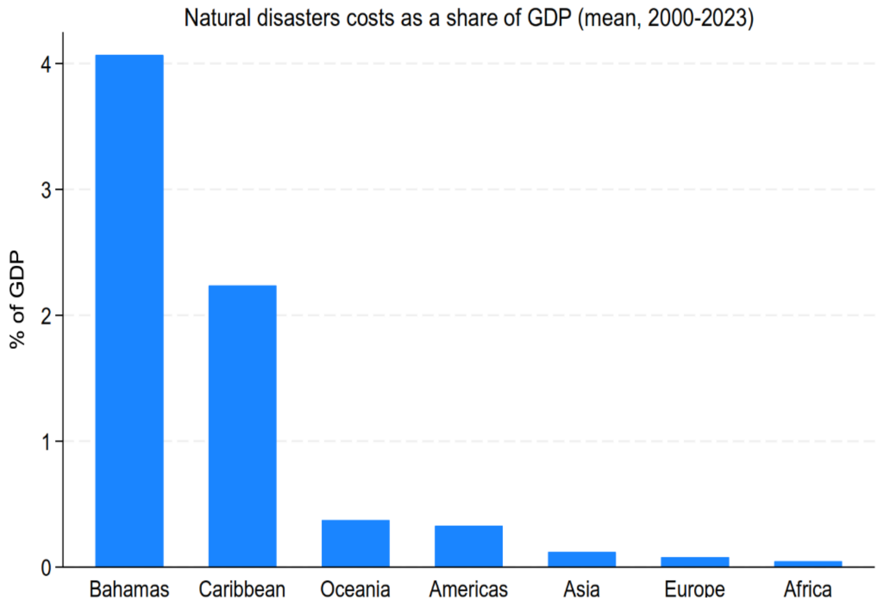
Adapted from Wright et al (2022), *Global Warming and The Bahamas*
* Values are projected to increase.
**Captures damages to public assets only.

As shown in Table 1, climate change has caused a number of exogenous shocks by way of hurricanes to the Bahamian economy in the past decade. Adapted from Wright et al (2022), the table shows the impacts of hurricanes on governmental fixed assets (i.e., banks, hospitals, schools) where the country reinvests into the losses. When shown as a percentage of GDP, the private sector was not included, as those damages have recoverable measures such as insurance payments or refinancing. Further, it should be noted that some 91.0% of the damages and losses from Hurricane Dorian were in the private sector, with the remaining 9.0% in the public sector. The passing of these hurricanes triggered increased government expenditure and revenue loss, which ultimately led to higher debt levels.

Furthermore, climate change also poses a risk to Bahamian welfare. Smaller developing countries, like The Bahamas, suffer the most from climate change due to the economic importance of climate-sensitive sectors (e.g. financial services, agriculture and fisheries), and the limited financial capacity to respond directly to the effects of climate change (OECD). Moreover, climatic shocks have caused significant Bahamian mortality. In 2019, many Grand Bahama and Abaco residents lost their lives, households, and vehicles, amid excessive flooding caused by Hurricane Dorian. In response to the increasing climate change risks, the government has prioritized a number of climate initiatives in recent years; however, it will take a holistic approach to mitigate the threat of climate change to The Bahamas.

When compared to the Caribbean region, the costs associated with natural disasters over the last two decades were nearly twice as high in The Bahamas at 4.0% of GDP, vis-à-vis just over 2.0% for the region. While the majority of Caribbean countries are located within the Hurricane Belt, The Bahamas' geographical location in the North Atlantic places it at the top of the belt, which increases the likelihood of a hurricane passing over its islands, as opposed to countries located in other parts of the belt. As depicted in Figure 1, the costs of natural disasters in the Caribbean were substantially higher than in other regions, including the Oceania region, which also includes a number of other SIDS. As a share of GDP, natural disasters have cost Oceania countries less than half of a percent, as compared to nearly four times that amount for the Caribbean. Further, the costs borne by the Americas, Asia, Europe and Africa were significantly less, at approximately a quarter of a percent, and in some cases, next to zero.

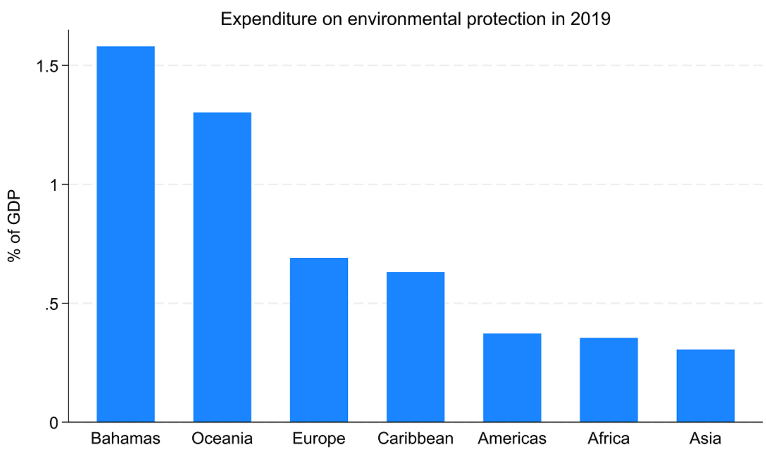
Figure 1



SOURCE: The International Disaster Database – EM-DAT

As a result of the surmounting costs of natural disasters, The Bahamas expends a greater proportion of its public resources on ensuring resilience. In particular, The Bahamas spent over 1.5% of GDP on environmental protection in 2019, followed by Oceania, which spent approximately 1.3% of their GDP to protect their environment (see Figure 2). The Caribbean however, spent just over half of a percent of GDP on environmental protection, which could speak to a number of factors. In some cases, it could be that governments lacked the fiscal space to direct resources to this cause. Interestingly, the European region spent less than The Bahamas, but marginally more than the Caribbean on environmental protection, despite the fact that they incur virtually no costs for natural disasters. Given that their countries are more developed, it is likely that they had the fiscal room to direct resources to resilience, even though their risk to climate change is perceivably lower. Moreover, the Americas, Africa and the Asian region all spent significantly less than the Caribbean, Oceania and The Bahamas on environmental protection.

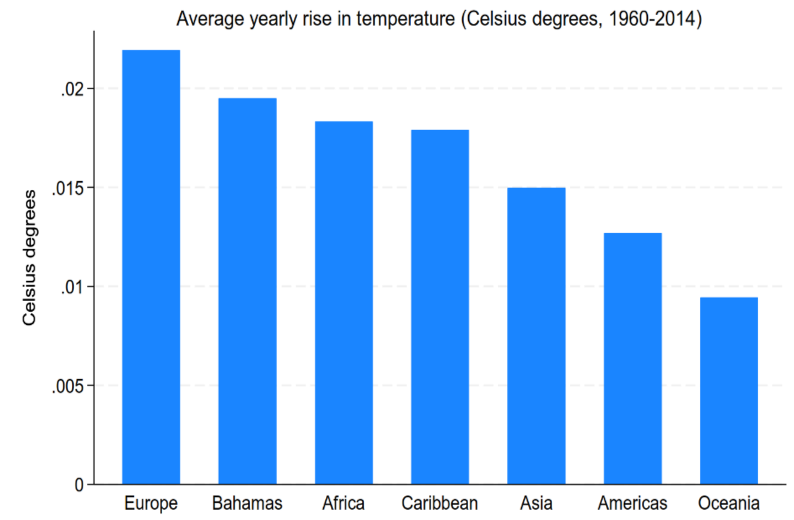
Figure 2



SOURCE: International Monetary Fund (IMF) Climate Change Indicators Dashboard

While there are a number of contributing factors to the increasing threat of climate change, the chief factor is rising temperature. Between 1960 – 2014, The Bahamas recorded an average annual rise in temperature of roughly 0.02 celsius degrees, slightly higher than Africa, which is known as the world's hottest continent (see Figure 3). However, the European region registered a higher annual rise in temperature, surpassing the growth of 0.02 celsius degrees marked by The Bahamas. The Oceania region recorded the lowest annual growth in annual temperature at less than 0.01 celsius degrees. As the level of greenhouse gas (GHG) emissions grow, global temperatures will continue to rise, thereby exacerbating the threat of climate change. With The Bahamas trailing only one region for the highest annual rise in temperature, the threat of climate change—and its associated risks—is heightened for this country when compared to its Caribbean counterparts.

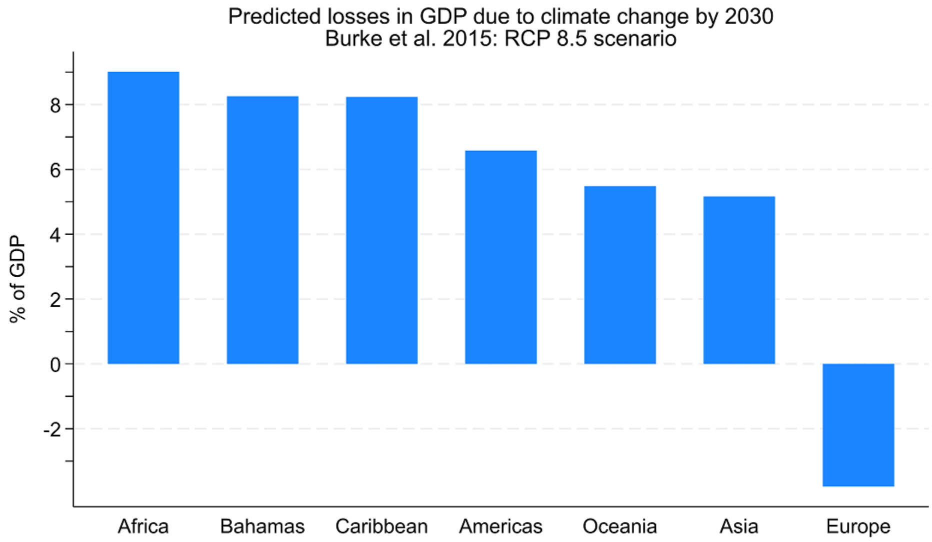
Figure 3



SOURCE: Khan, Mohaddes, Ng, Pesaran, Raissi, & Yang (2021)

Despite repeated calls for developed countries to reduce their GHG emissions in an effort to slow global warming, the threat of rising temperatures persists. As temperatures rise and the earth becomes hotter, the threat of climate change increases. Burke et al (2015) used a quadratic function to estimate the effects of temperature on the economy, and their findings showed that The Bahamas is predicted to experience losses in the range of 8.0% of GDP by 2030 due to climate change (see Figure 4). While this is on par with the Caribbean region, it is higher than the Americas (7.0%), Oceania (5.0%), and Asia (4.5%).

Figure 4



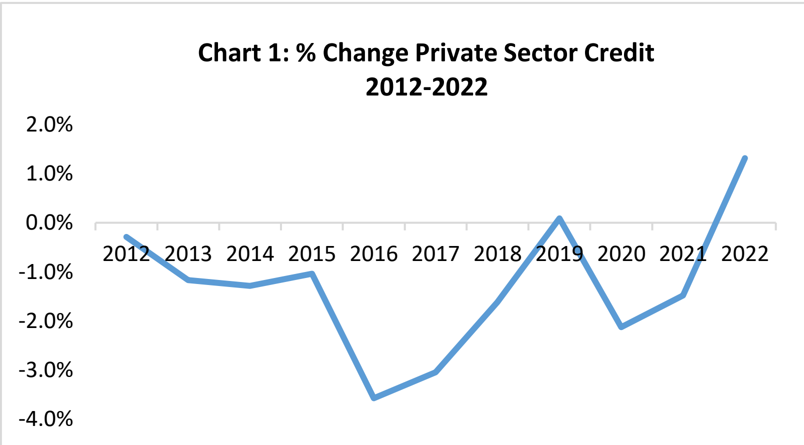
SOURCE: Burke, Hsiang, & Miguel (2015)

The European region on the other hand, is projected to experience a gain from the impact of climate change. As illustrated in Figure 2, the European region held the third highest level of spend on environment protection of the regions reviewed in 2019, at just under a half of a percent of their GDP. In value, this can equate to a significant spend, given the large size of their economies. Therefore, as they devote more resources in general to environment protection, their ability to withstand shocks caused by natural disasters is higher, thereby mitigating potential or incurred losses. In addition, the effects of climate change may drive an increase in migration from affected regions, such as the Caribbean or Oceania, some of which may opt to go to the European region, which can also explain the potential gain in GDP by 2030.

Therefore, based on this regional analysis, it can be deduced that The Bahamas is more prone to natural disasters, not only compared to its international counterparts, such as the European region or the Americas, but also to their colleagues in the Caribbean, due to its geographical location in the North Atlantic, which places it at the top of the hurricane belt. Over the review period, The Bahamas suffered more losses due to climate change than its regional and international counterparts, spent more on environmental protection, and experienced a higher average growth rate of temperature, thereby making it more vulnerable to the threat of climate change.

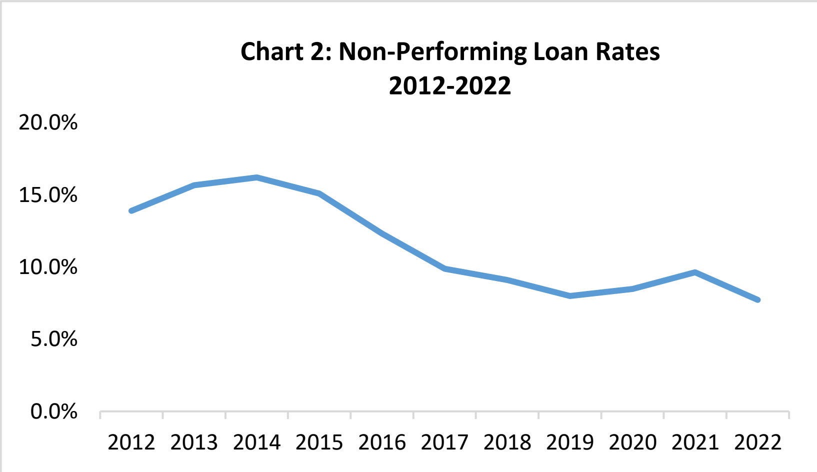
Section II: Overview of the Domestic Banking Sector Portfolio

Despite a robust level of liquidity, banks in the region maintain a conservative lending stance, driven mostly by the impact of the 2008/09 global financial crisis and its associated heightened risk. The crisis represented a supply shock, as financial institutions imposed more stringent lending criteria, thus reducing the availability of credit. An examination of credit trends in The Bahamas over the 2012-2022 period showed that the demand for private sector credit was lackluster. This demand-side weakness was evident as non-performing loans (NPLs) remained elevated, signaling borrowers' continued difficulties in repaying existing loans. Specifically, private sector credit contracted by 0.3% in 2012, and remained in the negative, peaking in 2016 with a 3.6% decline, before registering a slight increase of 0.1% in 2019. However, as consumers continued to deleverage and the outbreak of the Novel Coronavirus (COVID-19) pandemic began, lethargic private sector credit demand persisted over the review years. Specifically, in 2020, private sector credit fell by 2.1%, with the decline slowing to 1.5% in 2021, before recording a modest growth of 1.3% in 2022 (see Chart 1). This sustained weak demand highlights the enduring impacts of both the financial crisis and the pandemic on consumer borrowing behavior.



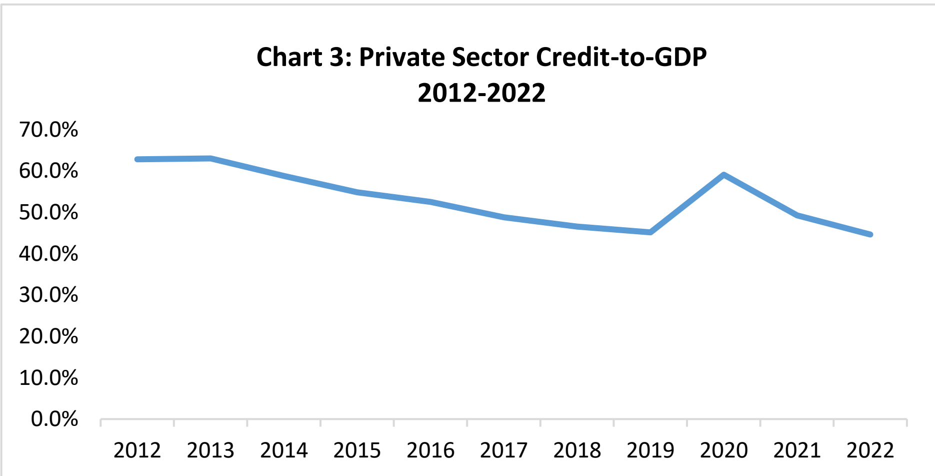
SOURCE: Central Bank of The Bahamas

In terms of the NPLs, rates had trended upward since 2012, remaining in the double digit range until 2016. The NPL rate moved from 13.9% in 2012, peaking at 16.2% in 2014, before narrowing to 15.1% in 2015 and 12.3% in 2016. NPL rates continued to tend downwards, entering into the single digit range at 9.9% in 2017. The rates declined further in 2018, to 9.1% and in 2019, to 8.0%, before increasing in 2020, to 8.5% and in 2021, to 9.6%, reflective of the negative impact of the COVID-19 pandemic. However, given the commercial banks forbearance measures introduced to assist customers whose debt servicing capacity was adversely impacted as a result of the pandemic, the NPL rate fell to 7.7% in 2022, marking the lowest level since 2012 (see Chart 2).



SOURCE: Central Bank of The Bahamas

Commercial bank credit is a main source of finance for the private sector and contributes to economic growth. Therefore, the ratio of private sector credit flows to GDP at current market prices is an important indicator for determining the credit contribution to economic growth. In The Bahamas, credit granted to the private sector by the commercial banks as a share of GDP has been on a downward trajectory since 2012. The credit to GDP ratio averaged 53.2% per annum over the 2012-2022 period. Specifically, the ratio stood at 62.8% in 2012—its highest level—but started to trend downward, although remaining above 50.0% up to 2016 (52.5%). The ratio fluctuated within the 45.0% range through to 2019, but increased to 59.1% in 2020, reflective of the steep contraction in GDP as a result of the COVID-19. However, in 2021, private sector credit as a share of GDP narrowed to 49.3%, and fell further to 44.6% in 2022 (see Chart 3).



SOURCE: Central Bank of The Bahamas

Section III: Literature Review

This study benefitted from several scholarly works that have measured the impact of a climatic shock on credit supply, credit default, and the banking sector's loan portfolio. Each scholar credited climate risks as a negative externality to the credit supply.

Li, Li, and Lu (2022) were among few researchers to provide a macro view analysis of climate risk on credit supply. They hypothesized that climate risk will have negative impacts on private sector credit supply, but positive impacts on public sector credit supply. In this regard, they undertook a heterogeneous study of climatic shocks on private and public sector bank credit for 174 countries from 2000-2019. The authors used an Ordinary Least Squares (OLS) regression, using the University of Notre Dame's Climate Adaptation Index as a proxy for climate risk, to test the impact of climate shocks on the supply of private and public sector credit. Their findings showed that climate risk has a significant negative effect on credit supply to the private sector, and a positive effect on public sector credit. They also provided new evidence that the climate risk effect is more significant in high-income countries than in low income countries, which suggests quick contagion in high-income countries.

However, a potential limitation in this study is their lack of micro level perspective on credit supply. Li, Li, and Lu (2022) focused more on the international scope of bank credit supply across country-level perspectives but neglected to consider climatic shock's effect on consumer credit.

Calabrese et al (2022) provided a case-specific examination of Floridian mortgage defaults triggered by climatic shock. They observed data on Floridian mortgage portfolios according to loan frequencies and default rates after extreme weather conditions. The authors determined that hurricanes and heavy rainfall in high risk areas tend to discourage mortgage repayments in Florida. An Additive Cox Proportional Hazard Model was developed to incorporate impacts from catastrophic weather conditions, and applied in the analysis of credit risks. Their study is unique because three approaches were incorporated in their model—spatial effects for improving model performance, survival approach which is used in credit scoring to predict loan defaults, and capturing non-linear underlying covariate-response relationships (Calabrese et al, 2022). Their results showed that an extreme weather shock can negatively impact mortgage defaults.

Meisenzahl (2023) undertook an analysis of bank lending in response to climate risks by referencing U.S. bank loan portfolios from 2012. The author used bank loan portfolio data from the Federal Reserve to stress test U.S. banks. The findings showed that banks significantly reduced lending to areas more impacted by climate change beginning in 2015 and between 2014 and 2020. In particular, a one standard deviation increase in climate risk reduced country level bank portfolio balances by up to 4.7%.

According to Li and Wu (2022), papers that examine mortgage lending risks on credit supply are too U.S. centric. They emphasized that climate risk also impacts bank loan supply in China. Furthermore, the empirical study adopted a Climate Risk Index indicator that took corporate loans into consideration. The CRI measures regional vulnerabilities to severe weather conditions while evaluating the direct impact caused by those weather conditions (Li and Wu, 2022). In their analysis, Li and Wu (2022) acknowledged that climate risks decline corporate profits, thereby decreasing funds for debt repayment. Also, climate risks tended to devalue collateral, thereby reducing a borrower’s solvency and increasing their credit risk. In addition, climate risk will affect borrower loan demand, causing difficulties for people to measure their return on investments, and reduces corporate deposits as companies increase cash reserves as a preventative measure. Several recommendations were proposed to solve effects of climate risk: (1) commercial banks should adjust credit infrastructure, (2) government intervention in climate protection, and (3) central banks must develop monetary policy tools that will help commercial banks navigate these risks.

Hass et al. (2016) used a heat index to estimate the variability and effects of temperature and humidity in the South-eastern United States. The scholars calculated the heat index using hourly temperature distributions and relative humidity data from various weather stations across Knoxville, Tennessee, showing how humidity can influence high temperatures in different neighborhoods. Both temperature and relative humidity were tested in five-minute intervals at each weather station. Their results revealed that areas with more trees had a higher heat index than those with less vegetation. Unlike other studies where temperature is a variable for heat exposure, Hass et al. (2016) also included humidity as an accurate measure. However, their study was limited by its narrowed analysis.

Zahid and Rasul (2010) also adopted a heat index to identify regions of Pakistan that were most vulnerable to heat waves, sun burns, and heat strokes. During the summer seasons, changes in the heat index were calculated using monthly maximum temperature and relative humidity data from 1961 to 2007. Using the heat index data and health effects table from Steadman (1979, 1984), the scholars used a multiple linear regression test to form their own heat index equation:

$$\text{HI} = -42.379 + 2.04901523T + 10.14333127R - 0.22475541TR - (6.83783 \times 10^{-3})T^2 - (5.481717 \times 10^{-2})R^2 + (1.22874 \times 10^{-3})T^2R + (8.5282 \times 10^{-4})TR^2 - (1.99 \times 10^{-6})T^2R^2 \quad (\text{ Eq. 1})$$

This equation accounts for both ambient dry bulb temperature and relative humidity. They found that the heat index was directly proportional to increased atmospheric temperature and relative humidity. Further, their results showed that the majority of Pakistan was effected by a high heat index, as the average air temperature increased by 3°C. (276.15K).

This paper's contribution to climate finance are follows: firstly, we introduced literature on climate risk and probability of credit default in the Bahamian context. Not many regional studies have been pursued in this field, therefore providing a foundation for other scholars to pursue future research. Moreover, this work revealed the impact that climatic shocks can have on the credit supply of Bahamian banks in the event of a hurricane. Secondly, we projected the future impact of climate shocks on the Bahamian economy using a heat index; which is another area where there is limited literature for the region.

Section IV: Methodology

This paper set out to answer three questions: to what degree would a climatic shock impact the supply of credit from the banking sector; to what extent would a climatic shock impact the probability of credit default by borrowers; and what would be the future impact of climatic shocks on overall GDP. To answer these questions, we approached the study in three ways.

Firstly, to collect the data, we used data reports from the Central Bank of The Bahamas. Specifically, the Quarterly Statistical Digest reports in aggregate form various statistics on commercial banks, as well as other financial institutions. We used panel data for all of the variables, with an annual frequency over the period 2000 to 2019. The estimates for GDP were derived from the Bahamas National Statistical Institute (BNSI).

Further, we used the University of Notre Dame Global Adaptation Index (ND-Gains)—a useful indicator for forecasting climate change issues and the adaptive capacity of countries to respond to climate shocks—as a proxy for estimating the frequency of hurricanes, or the likelihood that one will occur. The index covered the period 1995 to 2021. Then, to estimate the intensity of a shock posed by a hurricane, we constructed a category index by weighting the intensity of hurricanes vis-à-vis their occurrence over the period 2000 to 2021, using 2004 as the base year, as it represented the average frequency and intensity of hurricanes in The Bahamas over the period.

To estimate the impact of a climatic shock on the supply of credit in the banking sector, based on the study by Li et al (2022), we then regressed the ND-Gains index and the category index against private sector credit from the banking sector using an OLS regression. Two regressions were ran using datasets for the period 2000 – 2019, one with the data denoted as ratios and the other using dollars. The regression followed equation (1), with eight (8) variables in total: private sector credit from banks only, inflation (CPI), real GDP, trade openness, return on equity (ROE), bank deposits, the ND-Gains index, and the category index.

$$(1)\quad \text{Credit} = \beta_0 + \beta_1 NDGains_{it} + \beta_2\, CatInd_{it} + \beta_3 CPI_{it} + \beta_4 GDP_{it} + \beta_5 Return_{it} + \beta_6 Trade_{it} + \beta_7 Dep_{it}$$

We also ran a series of robustness checks, specifically to correct for endogeneity, multicollinearity and heterogeneity. A Johansen Cointegration test was conducted to evaluate whether or not the variables are stationary, while an Augmented Dickey-Fuller Test was ran to test for autocorrelation. The results of both tests showed that the variables were stationary and that there was no autocorrelation among the variables. Moreover, there was a long-term relationship between the variables, as suggested by the cointegration test. We also introduced a lagged variable, to account for the impact two periods later.

For the second part of the study, we used a similar approach to Serwa (2016) to estimate the probability of default, modelling loan quality using the NPL rate. In this case, NPLs are considered loans that were more than 90 days past due. We calculated the NPL rate for each loan category, including the overall or total default rate for all loan types, the rate for residential mortgages, commercial mortgages, and personal loans. The individual default rates were then regressed against real GDP to ascertain the impact a shock in GDP due to a climate event would have on the default rate. Equation (2) captured the approach, using real GDP, the default rate, inflation (CPI), and growth in the subsequent period (or quarter) as variables.

After a robustness check, we found that there was considerable multicollinearity between inflation and real GDP; therefore, inflation was omitted as a variable.

(2) Real GDP = $\beta_0 + \beta_1 default\ rate_{it} + \beta_2\ rGDP2_{it}$

We also ran a second regression with an additional variable that captured the default rate two quarters later, to take account for the lagged effect a climate shock may have on a borrower's capacity to service their debt, as depicted in equation (3).

(3) Real GDP = $\beta_0 + \beta_1 default\ rate_{it} + \beta_2\ default\ rate2_{it}$

The first two parts of the study looked at the impact of a climate shock on the supply of, and demand for credit from a historical perspective. However, given the increasing intensity of climate threats, we made consideration for the future impact of climate shocks on GDP over the next five years. Therefore, for the third part of the study, a proposed heat model is adopted to identify islands in the archipelago that would be most impacted by high heat density. The thinking here was grounded in the link between global warming and climate events, in that the higher the temperature is, the higher the probability of a climate shock occurring by way of a natural disaster. The heat model estimated the probability of heatwaves, using normal distribution to model temperature and precipitation data. It was assumed that specific islands, along with their main sectors, will experience climatic shocks within the next 40 years.

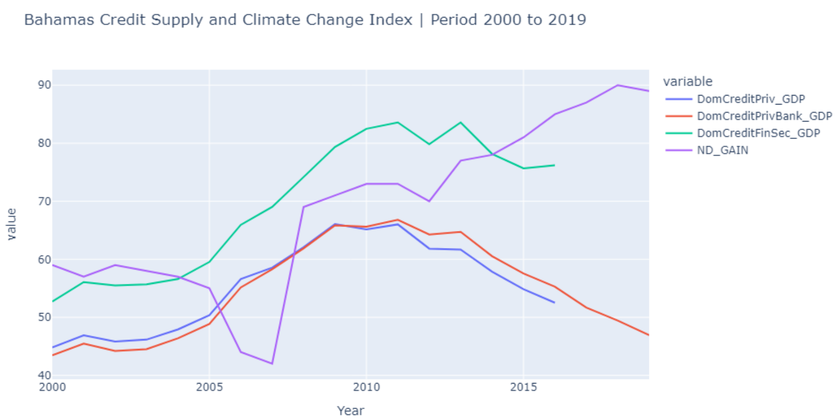
Subsequently, we projected GDP for the identified islands over the next five years, to calculate the total loss to overall GDP for The Bahamas. To do this, we averaged the nominal GDP by island over the period 2015 – 2018, and applied that as a proportion of total nominal GDP as projected by the IMF for the period 2024 – 2028. We then used a weighted average to ascertain the total GDP impact for the entire Bahamas.

Section V: Discussion

The results of the models revealed that climatic shocks do in fact impact the supply of credit in the banking sector in The Bahamas, as well as borrowers' capacity to repay, which was measured by the probability of default.

The first regression showed that the supply of domestic credit from banks shares a negative relationship with climatic shocks (see Figure 5). In particular, a 1 unit shock to the ND Gains will decrease domestic credit in the banking system by 0.16%. This means that the occurrence of one additional hurricane will cause a 0.16% decline in domestic credit from banks. Similarly, the results of the model showed that a 1 unit shock in the category index will decrease domestic credit by 0.01%, indicating then that the stronger a hurricane is, the larger the decrease in the supply of domestic credit from banks. When we introduced lagged variables to the model, the coefficients for the ND Gains and Cat Index both decreased. At one successive period, the ND Gains fell to 0.21%, while the Cat Index remained at 0.01%. Similarly, at two periods, ND Gains reflected a 0.4% decline, while the Cat Index showed a decline of 0.02%. The second regression, which used data denoted in dollars, showed that a 1 unit shock to the ND Gains would cause a decrease in domestic credit of $0.29 million, while a 1 unit shock to the Cat Index will cause a $0.02 million decline in domestic credit. Considering the lag, the ND Gains at one period forward reduced domestic credit by $0.38 million, and by $0.73 million at two periods forward.

Figure 5



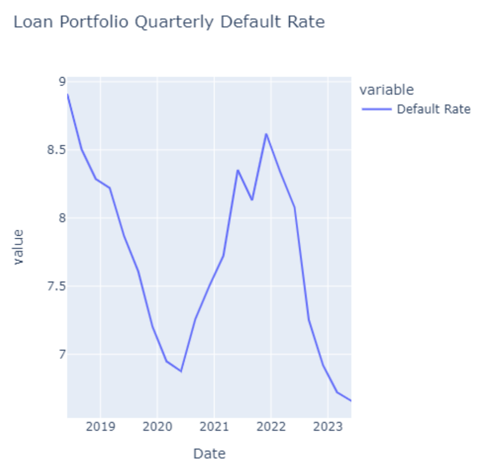
For comparison, we also ran the regression using data for all credit issuing institutions in the financial services sector in The Bahamas—which would include insurance companies and credit unions in addition to banks—to ascertain whether the impact of a climate shock on domestic credit would be larger or smaller. Due to data availability, the time series only covered the period 2000 – 2016. The results showed that a 1 unit change in the ND Gains would decrease domestic credit in the financial services sector by $0.12 million, which was smaller than the $0.29 million estimated when looking solely at banks. However, when using credit as a percentage of GDP, the results showed that a 1 unit change in the ND Gains would cause a decrease of 0.19% in domestic credit from the financial services sector, which was larger than the 0.16% decline it would cause when limited to banks.

Further, when including all credit institutions, a 1 unit change in the category index would cause a decline in domestic credit of $0.01 million, which was slightly lower than the $0.02 million decline estimated to occur when solely accounting for banks; while a 1 unit change in the category index would cause a decline of 0.01% when using ratios, which was aligned with the estimated change when solely looking at banks.

As for the second part of the study, which examined the impact of a climate shock on the demand side by looking at borrowers' capacity to repay, the results of the model showed that in general, a climatic shock would cause an increase in the default rate (see Figure 6). Specifically, the results revealed that a 1.0% decline in GDP as a result of a climatic shock would increase the overall loan portfolio default rate (as measured by NPLs) by 0.012% on average in the same quarter, which was equivalent to some $0.71 million.

We then lag the regression by two quarters to ascertain whether the impact would be larger or smaller, and the results revealed that a climatic shock would cause an increase in the default rate by 0.016%, or some $0.98 million; thereby indicating that the impact of the climate shock becomes more pronounced as time goes on. This is intuitive in that often times the effects of a natural disaster only materialize on indicators like GDP in the periods after the initial shock.

Figure 6



By type of loan, the model showed that a 1 percent decline in GDP as a result of a climate shock would cause an increase in the default rate for residential mortgages of 0.014%, or some $34 million. For personal loans, the default rate would rise by 0.021%, or some $0.4 million.

For the third and final part of the study, findings from the Michael Minn heat model revealed that three islands would be most impacted by climatic shocks in the future: Western Grand Bahama (the country's second capital and a region where manufacturing, oil, and maritime are widespread), Andros (the largest island in the archipelago known for its rich ecocultural and tourism, yet there is less commercial activity), and Abaco (known for tourism and fishing). Each island has diverse sectoral contributions to the overall GDP; however, a natural disaster would cause major losses to the economy.

Figure 7

Michael Minn Heat Model

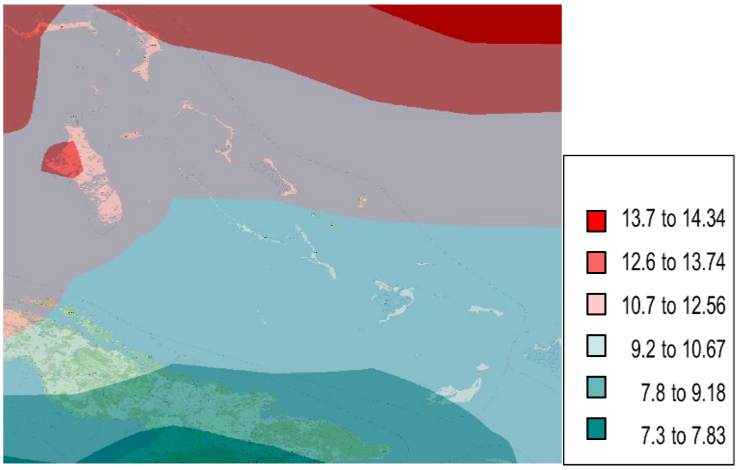


Table 2: Projected GDP Contributions By Island

Years	New Providence	Grand Bahama	Andros	Abaco
2024	44.0%	13.5%	0.7%	3.7%
2025	42.9%	13.0%	0.7%	3.6%
2026	41.5%	12.6%	0.6%	3.4%
2027	40.2%	12.2%	0.6%	3.3%
2028	38.8%	11.8%	0.6%	3.2%

SOURCE: Based on Authors' calculations

Based on the findings of the heat model, we projected the GDP contribution of each of the islands identified as having the highest heat density; Grand Bahama, Andros, and Abaco. While New Providence was not identified as having an extreme heat density, we included it, given that it houses the bulk of commercial activity in the country. As shown in table 2, in the event of a climate shock, the GDP contribution of each of the impacted islands is projected to decrease over time. In 2024, Grand Bahama, Andros and Abaco are expected to contribute to overall GDP at 13.5%, 0.7% and 3.7%, respectively. However, these contributions are forecasted to decline to 11.8%, 0.6% and 3.2%, by the year 2028. Similarly, New Providence's contribution to overall GDP is expected to decrease from 44.0% in 2024 to 38.8% in 2028.

Table 3: Projected GDP Loss

Years	ALL BAHAMAS
2024	11.1%
2025	10.7%
2026	10.4%
2027	10.0%
2028	9.7%

SOURCE: Based on Authors' calculations

To calculate the total GDP loss associated with a climate shock, we used a weighted average of the capital, and the islands identified as having the highest heat index based on their contributions to GDP. The results (see Table 3) showed that a climatic shock to The Bahamas would cause an estimated GDP loss of 11.1% in 2024, with the impact expected to abate to some 9.7% by 2028, as the country becomes more resilient, thereby being able to better withstand external shocks associated with climate. This is in line with the projections made by Burke et al. (2015) in section 1.

Section VI: Policy Recommendations

The impact of climate change on small island developing states (SIDS) like The Bahamas will intensifying as global temperatures continue to rise. The effects of this can be seen through the loss of life in some cases, and extensive damage to key infrastructure and homes; and these have implications for the macro-economy by way of job losses, and ultimately GDP. Further, climate change can impact the financial services sector through a number of channels, including the transmission of monetary policy, damage to critical infrastructure, or from their direct credit exposure to households.

The results of the study showed that a climatic shock drives a decrease in the supply of credit from banks in The Bahamas, and increases the probability that borrowers will default on their loan obligations. This in turn has implications for financial stability, which can also impact the wider economy. Therefore, it is imperative that governments, the regulator and the private sector take the necessary steps to address the risk of climate change.

The damages and losses of a hurricane in The Bahamas can cost hundreds of millions of dollars. For example, Hurricane Dorian—the most recent hurricane to hit The Bahamas—caused damages and losses amounting to US$3.4 billion. To offset the reduction in the supply of credit that can occur as a result of a climatic shock, consumers will need to take other measures to equip themselves with the necessary resources for rebuilding in the aftermath of a hurricane. This can include ensuring that hurricane coverage is added to their home insurance policy—particularly for those who no longer have a mortgage facility with a financing institution and are therefore required to have insurance coverage. It can also include ensuring all automobiles are fully covered so that car owners can rely on the pay-outs from their insurance policies for their recovery phase.

Currently, the insurance penetration rate in The Bahamas is low for both residential and commercial properties. In fact, it was revealed that only 40%-50% of the residential and commercial properties on Abaco and Grand Bahama—the two most affected islands by Hurricane Dorian—were insured, leaving the balance to have to rebuild with either Government assistance, or out of pocket. For those that do not have insurance, the reasons are predominantly rooted in the high cost of coverage.

It is therefore recommended that regulators and private players alike work together to innovate ways in which they can lower the cost of existing policies, or create new products that are less expensive but still adequately comprehensive to meet the needs of consumers in the aftermath of a natural disaster. Micro insurance products might be well tailored for this cause, as they are typically targeted toward poor and vulnerable groups, who are a part of the groups most impacted by natural disasters. In addition, the government may consider making insurance coverage for all home-owners, regardless of whether they hold a mortgage or not, mandatory. This will in turn relieve the associated pressure on the public purse to rebuild in the aftermath of a natural disaster.

Moreover, the less damages in the aftermath of a natural disaster, the less dependent consumers will be on credit for rebuilding in the recovery phase. Therefore, one policy response to the reduction in the supply of credit due to a climatic shock could be for the government to improve the building code to include more sustainable approaches to construction. According to the United Nations Environment Program (UNEP), investing in more resilient infrastructure can save up to US$4.2 trillion in damages related to climate change. One example of ways the government can encourage the construction of more climate resilient buildings is by supplementing through fiscal subsidies the use of green water management systems such as rainwater harvesting, which can help make homes resistant to flooding and droughts.

In addition, the government supports the use of renewable energy sources—which make homes and buildings less susceptible to energy disruptions—by allowing the free importation of these materials. However, to further this support, they can provide subsidies for the installation, and work with the existing electricity supplier to sell power back to the grid. Lastly, as is done in Bangladesh, the Government can seek to build multi-purpose buildings that rest on pillars with buoyant tanks that raise during floods, in an effort to curb the level of damage extended to homes that are built in coastal areas.

Furthermore, while The Bahamas is considered a low emitter of GHGs when considering the total metric tons by countries. However, when observed on a per capita basis, the level of emissions can be seen as high, given its small population. To this end, The Bahamas can also consider ways in which it can decrease its carbon footprint through a number of policy changes. For example, currently, the government incentivizes the use of electric vehicles by attaching a lower customs duty rate on their import when compared to non-electric vehicles. However, they may consider making the import of electric vehicles duty-free to encourage a more persons to buy electric, thereby reducing the number of fuelled vehicles, and thereby the level of carbon emissions.

Additionally, the government may also consider restructuring its current agreement with the cruise and airline industries, which also contribute to high emissions, to encourage green alternatives in their operations, as well as paid subsidies to the government of The Bahamas, so that they can reinvest those funds in resilience building for the country. The government recently introduced a $5 tourism environmental tax per passenger on cruises; however, there are no stipulations for how the additional revenue is to be spent. Consideration can be made to earmarking the revenue attained from this tax for resilience building, so as to mitigate the devastating impact of climate shocks in The Bahamas. Applying the tax to the airline industry may also be considered. Through this taxation, both airlines and cruise companies may be encouraged to green their operations, which ultimately reduce emissions for each visited port.

Turning now to the impact climate has on borrowers' capacity to repay, it is critically important for financial institutions that extend credit to ensure they are adequately incorporating the risk of climate change in their financial frameworks. While commercial banks in the domestic banking sector in The Bahamas are well capitalized, an increase in borrowers' probability of default poses a risk to their credit exposure, as it can result in losses, and these losses can translate into risks to financial stability. What is more, depending on the level of interconnectedness in the domestic banking sector, contagion risks can exacerbate this impact on financial stability. Therefore, credit lending institutions should ensure they are adequately accounting for the risk of climate change in their modelling, so that they manage their exposure accordingly.

Additionally, it is equally important for the Central Bank and other regulators to acknowledge the risk that climate change poses to financial stability in their prudential and supervisory policies. One way to do this would be to require financial institutions to account for climate risks in their stress tests, an initiative that is being done in the United Kingdom for insurance firms in particular for both physical and transition risks. Relatedly, the Central Bank should also incorporate climate risk in their frameworks for refinancing operations as well as in their investment decisions, particularly for international reserves.

On a broader level, the fight against climate change will take a holistic approach, not just on a national level, but it will also call for international cooperation and coordination. SIDS, like The Bahamas, are some of the lowest emitters of greenhouse gases, but bear the brunt of their impact on the environment, given their geographical location. Further exacerbating the impact is the fact that they are typically unable to respond adequately given their limited resources and small size. To this end, a number of SIDS and other developing countries have repeatedly called on developed countries—who are also the largest emitters—to action their commitments under the Paris Agreement[1] not only to reduce their emissions but to contribute monetarily to their developing counterparts to aid in their efforts to build resilience. The Loss & Damage Fund established for vulnerable countries at COP28 is a significant step forward. Countries collectively pledged some US$700 million; however, this is pointedly smaller than the US$400 billion needed to fight climate change. Therefore, it will

[1] The Paris Agreement is a legally binding international treaty on climate change, which was adopted by 196 parties at the United Nations Climate Change Conference (COP21).

be important for the signed parties to honour their commitments and follow through with the financing.

In parallel, it will be equally important for continued and deepened support from the multilateral community to support resilience building efforts in SIDS and other developing countries. This support can include increased concessional financing toward green initiatives in particular, technical assistance and heightened advocacy to G7 countries on the climate needs of SIDS. The multilateral community can also assist by innovating new financing instruments to fund climate initiatives such as green and blue bonds, debt-for-nature swaps, among other instruments.

Section VII: Conclusion

In conclusion, the issue of climate change continues to impact The Bahamas. We examined the extent to which a climate shock impacts the supply of credit in the banking sector using the Notre Dame Global Adaptation Index as a proxy for climate risk and a category index we developed as a proxy for climate intensity. The results showed that a climatic shock does in fact cause a decrease in the supply of credit in the banking sector in The Bahamas. We also sought to ascertain the impact of a climatic shock on the probability that borrowers will default on their existing credit facilities. The results showed that a decline in GDP caused by a climate shock will increase the probability of default in the overall loan portfolio. Further, the proposed heat index revealed that the north-western Bahamas is expected to experience exogenous shocks from future climatic events; particularly Western Grand Bahama, Andros, and Abaco. Projections indicated that there will be falloffs in each island's GDP contribution due to sectoral losses caused by climatic shocks, and an overall loss in GDP of some 9.7% by 2028.

Given these results, we proposed a number of policy recommendations for regulators, the government, as well as the private sector and the multilateral community that will not only help to offset the decline in the supply of credit and increase in the probability of default associated with a climate shock, but also help to build resilience over the long-term. Ultimately, it will take a holistic approach to address the issue of climate change in The Bahamas, as well as other SIDS, with time being the most pertinent factor.

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Appendix

Johansen Cointegration Test

Trace Statistic				
		Critical Values		
Hypothesized No. of CE(s)	**Trace Statistic**	**10%**	**5%**	**1%**
None*	89.215563	65.8202	69.8189	77.8202
At most 1	44.951672	44.4929	47.8545	54.6815
At most 2	14.343342	27.0669	29.7961	35.4628
At most 3	1.377451	13.4294	15.4943	19.9349
At most 4	0.046649	2.7055	3.8415	6.6349

Maximum Eigenvalues Statistic				
		Critical Values		
	Max-Eigen Statistic	**10%**	**5%**	**1%**
None*	44.263890	31.2379	33.8777	39.3693
At most 1*	30.608331	25.1236	27.5858	32.7172
At most 2	12.965890	18.8928	21.1314	25.865
At most 3	1.330802	12.2971	14.2639	18.52
At most 4	0.046649	2.7055	3.8415	6.6349

*Rejection of the Null Hypothesis at the 0.05 level