



Key messages

- **Climate variability and change are already having severe impacts** on key sectors including agriculture and tourism.
- **These impacts are reversing economic growth**, exacerbating poverty and undermining the future prosperity of Caribbean countries.
- **CDKN research has provided locally appropriate climate change projections** that give fresh insight into the vulnerability of key sectors.
- **Adaptation investment in the agriculture sector is needed** to account for projected changes in rainfall and growing seasons, and occurrence of extreme events, especially drought.
- **Adaptation investment in the tourism sector is also needed** to build resilience to rising seas, bleached coral reefs, water scarcity and gradual temperature increase.
- **There are many potential adaptation measures** that can be applied by governments, businesses, individuals and development partners.
- **Financial support is needed** to support adaptation action as high up-front costs are a barrier to local adaptation efforts.
- **Effectively prioritising adaptation options** can maximise their value and lead to positive co-benefits for individuals, businesses and society.

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Climate impacts on agriculture and tourism: the case for climate resilient investment in the Caribbean

Introduction

For the Caribbean, climate change is not tomorrow's problem. The threats it poses are neither distant nor abstract – they are already apparent. In recent years, hurricanes have caused major damage in countries such as Jamaica, Grenada and Cuba; severe flooding has hit Belize and Guyana; and droughts affect much of the east of the region.¹ The small island state of Saint Lucia alone has faced 27 natural disasters between 1980 and 2008, with total economic damage reaching an estimated US\$2.5 billion.² The need for investment to build climate resilience in the Caribbean has never been greater.

These impacts are putting considerable strain on the finances of national governments, businesses and citizens, and threaten regional prosperity and development. The Commonwealth Expert Group on Climate Finance has said that climate change is already reversing some of the gains on poverty alleviation and economic growth that have been made in the Caribbean.³

Over the past decade, research funded by the Climate and Development Knowledge Network (CDKN) has provided fresh insight into the nature of the climate threat to the Caribbean. Researchers have developed regionally downscaled climate change projections and

climate visualisation tools providing information that can be used to make informed decisions at the subregional level.⁴ This information has been used in conjunction with a range of other tools, and has been applied to real-life situations in Caribbean nations including Saint Lucia, Jamaica, Barbados, Belize and Cuba.

Focusing on the agriculture and tourism sectors, this document identifies some of the most pressing issues and climate vulnerabilities facing Caribbean states. It makes the case that climate resilience investment by governments, businesses and development partners is urgently needed to

This document draws upon the following CDKN-funded projects:

- **Caribbean Weather Impacts Group:** The CARIWIG project has generated locally relevant climate data and information to help decision-makers evaluate climate change and its impacts across a range of timescales. The key resource is a data and information portal, supported by 11 case studies in which CARIWIG data sets have been applied to real-world scenarios such as projecting Caribbean crop yields.
- **The Global Islands' Vulnerability Research, Adaptation Policy and Development Project:** The GIVRAPD research project focused on community adaptation to climate change in Saint Lucia⁵ and Jamaica.⁶
- **The Caribbean Research Call:** The Research Call⁷ funded research proposals that aligned with research needs identified in CARICOM's implementation plan for the *Regional framework for achieving development resilient to climate change*.⁸ It supported five research projects in Belize, Jamaica, Saint Lucia, and Trinidad and Tobago.

sustain economic and social development, and points to some possible approaches to adaptation and resilience building.

Climate vulnerability in the Caribbean

The Caribbean is on the frontline of climate change. The Inter-American Development Bank estimated that between 2000 and 2009 the region incurred losses totalling around US\$33 billion due to natural disasters, including climate-related extreme events such as hurricanes, floods and coastal inundations.⁹ The high level of exposure to hazards such as hurricanes, sea level rise, storm surge, drought and flooding is compounded by underlying environmental, social and economic conditions in Caribbean nations.¹⁰

In this context, climate change can have devastating consequences for individual nations. This has been well demonstrated by past events. In 2005, for instance, Guyana was hit by a

flood that cost 62% of its GDP, sending the country into an economic recession from which it is still recovering.¹¹

Recovering from such disasters can take many years, and climate change is increasing both the severity and the frequency with which they occur.¹² Repeated shocks to economies and societies have the potential to hold back development over the long term, and cannot be considered as 'one-off' disruptions from which nations can expect to make a full recovery.

This has been well demonstrated in Saint Lucia's agriculture sector, which has been hit by Hurricanes Ivan (2004), Dean (2007), Tomas (2010) and Matthew (2016).¹³ A full two years after Hurricane Tomas, government analysis of the country's banana industry showed that the number of farmers had reduced by 550 (approximately 36%).¹⁴

Using regionally downscaled climate change projections, CDKN-funded

research projects – including CARIWIG, GIVRAPD and the Caribbean Research Call – have identified some of the potential risks to key sectors, including agriculture and tourism. These sectors illustrate the scale of the challenge and the need for investment.

Caribbean agriculture

Agriculture is vital to the Caribbean both from an economic standpoint and for protecting food security, especially for the poorest and most vulnerable sections of society. Primary agriculture contributed 5% of regional GDP in 2012;¹⁵ however, there are considerable subregional variations ranging from over 20% in Guyana¹⁶ to just 0.5% in Trinidad and Tobago.¹⁷ The sector is also a significant employer, accounting for 19% of male and 9% of female employment between 2008 and 2011.¹⁸

Typically, Caribbean farms are small, often subsistence level, and use traditional farming methods that are rainfed and labour intensive.¹⁹ This leaves the sector vulnerable to climate change impacts on rainfall and temperature changes. CARIWIG research into the implications of future climate change on Caribbean agriculture focuses on slow-onset changes to rainfall and temperature, as well as more extreme droughts, and the resultant impact on key crops in the region.²⁰

Overall, the Caribbean can expect rainfall occurring in shorter, more intense spells, and warmer conditions.²¹ This is likely to have a significant impact on the growing season and the optimal location of many key crops. Researchers used

CARIWIG downscaled data and the Caribbean Assessment of Regional Drought (CARI-DRO) modelling tool to show that the region can expect more and longer drought events, with extreme droughts occurring one in every five years by the middle of the 21st century.²²

In Belize, for example, researchers predict that declining crop yields for dry beans will make the crop unsuitable for cultivation in the country, with potential yields falling by up to 60% by the 2050s. The country's corn crop is also expected to decrease dramatically, dropping by around 25% from 2010 levels by the 2030s.²³

In Saint Lucia, reduced rainfall volume is projected to have a negative effect on rainfed agriculture. Additionally, researchers project that river flow in the Font D'Or catchment will decrease by 10% between 2011 and 2040, and by as much as 40% by the end of the century. This in turn would put pressure on agricultural production which relies on pumped, irrigated water direct from the river and on groundwater – along with demand from other sectors including energy and tourism.²⁴

Investing in adaptation for increased agricultural resilience

The locally relevant climate data provided by CARIWIG have allowed researchers to identify adaptation options that are nationally and subnationally appropriate. With regard to agriculture, CDKN-supported research has identified potential measures that can be supported and applied by the state, businesses or individual growers.

- **Practise crop diversification or substitution:** CARIWIG research²⁵ in Jamaica found that crops such as sweet potato, cassava and yam are good diversification alternatives. Sweet potato is comparatively drought-resistant and requires little fertiliser or soil nutrients. It is also resistant to storms as it grows underground. Climate projections indicate that sweet potato crops in the country could increase in yield by up to 33% by 2041–70.²⁶
- **Invest in irrigation and mechanisation:** Researchers found that rainfed yields across many crop types were significantly lower than irrigated yields. Vegetable crops such as peppers can benefit greatly from irrigation, increasing yields by 50%.²⁷ As climate change is likely to reduce the amount of available surface water,²⁸ efficient irrigation methods such as drip-feed systems should be preferred. Some research suggests that improved mechanisation and efficiency of agricultural production have the potential to more than make up for reduced maximum potential yields driven by climate change.²⁹ While this may be true for commercial-level farming, for many smaller farms, capital investment is needed.
- **Monitor growing areas and plan for land-use change:** Changes to average temperatures and shifts in growing seasons should be monitored closely to ensure crops are being grown in the most suitable areas.³⁰ Research in Jamaica³¹ and in Trinidad and Tobago³² showed that planning is necessary to manage crop movements. For instance, while cocoa crops in Trinidad and Tobago are projected to have

improved yields 500 metres above sea level, currently 98% of higher-altitude areas are forested.³³ This suggests that climate change may increase the likelihood of deforestation if farmers move crops into higher altitudes in the future.

- **Improve education on sustainable farming practices:** Research in Belize³⁴ projects an increase in the number of forest fires as droughts intensify. The researchers note that a contributing factor to these fires is *milpa* farming practices, where land is cleared by fire before being replanted. Changing farming practices, to include alley cropping, minimum-tillage ploughing, and enrichment and mechanical clearing of brush land, will be beneficial to the soil and can increase farm productivity while avoiding fire incidents.³⁵
- **Adopt micro-insurance:** Developing micro-insurance products to protect farmers from climate-driven natural disasters and hurricanes could allow farmers to invest in more resilient infrastructure and crops after suffering a loss event.³⁶

Investment in climate change adaptation requires capital expenditure, which can be problematic for small farmers.³⁷ GIVRAPD research in Saint Lucia has found that while medium-scale farmers are able to invest in new technologies such as polytunnels and irrigation, for the island's 4,000 farmers who have plots less than 1 acre in size, the level of investment that is required remains out of reach.³⁸ Small-scale farmers will therefore need support in order to adapt to climate impacts. The value of investment in climate change

Box 1. Co-benefits of adaptation in the agriculture sector

Investing in climate adaptation can increase resilience to climate change and reduce future losses caused by extreme events.³⁹ However, these investments are amplified by other potential benefits that can accrue to the farmer, to the environment, or to wider society and the economy. These co-benefits might also lead to progress on climate change mitigation and carbon-cutting goals. Research has found, for example, that adaptation benefits that lead to increased agricultural yields can reduce the need for more land to be converted into cropland, a process that contributes to greenhouse gas emissions.⁴⁰

Many different adaptation measures can result in co-benefits. Identifying and highlighting them is a good way of making the case for adaptation investment. For example, CDKN research into micro-insurance⁴¹ showed that many people, including farmers, who have suffered damage as a result of climate impacts were forced to use their savings in order to repair their buildings, replace machinery or replace lost income; 25% of respondents reported that these savings were intended for educational purposes.⁴² This may in turn affect personal future earnings as well as damaging the wider economy. Insurance cover would allow individuals to rebuild after significant losses without suffering such damaging consequences.

adaptation measures can have benefits that extend beyond increasing climate change resilience (see Box 1), which may create a stronger incentive for external parties such as governments and development partners to provide this support.

Caribbean tourism

Tourism is a critically important economic sector in the Caribbean, contributing substantially to GDP and jobs. In 2014 tourism's total contribution, when supporting and dependent industries are considered, amounted to US\$51.9 billion, 14.6% of GDP; and 2,231,500 jobs, 13% of employment.⁴³

The tourism industry is very exposed to climate change and its impacts.⁴⁴ CDKN research in Belize shows that tourist infrastructure is particularly vulnerable to hurricanes and coastal

inundation, with 94% of tourist accommodation facilities and 79% of tourist attractions located at lower coastal elevations.⁴⁵

Climate change is directly linked to damage to fragile natural habitats such as coral reefs, with increased sea temperatures, storm frequency and ocean acidification leading to coral bleaching and eventually death.⁴⁶ Degradation of natural assets such as coral reefs was also found to be a significant threat to the tourist industry, with more than 80% of tourists participating in reef-based activities such as snorkelling and diving.⁴⁷

In Saint Lucia, the tourism industry is already putting pressure on the country's water supply through high and growing demand. Changes in rainfall and increased drought incidence are projected to reduce available surface water further, and in turn to worsen existing regular water

outages.⁴⁸ This will have impacts for tourists, businesses and citizens.⁴⁹

Climate change also has the potential for more subtle effects on tourist behaviour that should be taken into consideration by the industry. Research from Barbados, Saint Lucia and Tobago⁵⁰ indicates that tourists from cooler climatic zones are less able to tolerate increased temperatures. This could lead to a shift in the origin countries of tourists, with implications for marketing strategies and tourist activities.

Tourist activities and preferences may also shift as temperatures increase.⁵¹ Research suggests that people may seek out parks in urban areas, or avoid cities when temperatures rise too high. Beachgoers may spend more time at or near the pool or within hotel complexes. These shifts may affect the amount of tourist money that benefits the destination country.⁵²

Investing in adaptation for increased tourism resilience

The nature of the tourism sector – which is reliant on multiple interconnected industries – requires adaptive co-management and multi-stakeholder approaches. CDKN-funded research points to many possible adaptation measures for the industry, most of which are highly dependent on the local context.

Research in Belize⁵³ identified 35 specific options for improving tourism sector resilience. Specific recommendations include planning

Box 2. The importance of prioritising adaptation options

The costs of adapting to climate change are high. World Bank estimates for the Caribbean suggest that the region faces costs of around US\$21 billion per year.⁵⁴ More recent estimates from the United Nations Environment Programme suggest that the costs could be as much as five times higher than that.⁵⁵ These costs represent a significant barrier for many Caribbean governments facing budgetary pressures, and can also dissuade companies and individuals from investing in climate resilience.

Prioritising 'no regret' and 'low regret' adaptation options is a good way of ensuring that adaptation measures represent good value and maximise co-benefits. The CDKN-funded Caribbean Climate Online Risk and Adaptation Tool (CCORAL)⁵⁶ is an online decision-support tool that can help decision-makers identify climate risks to their projects or investments. CCORAL also provides a suite of tools that can help to identify and prioritise adaptation options. An information brief accompanying the CCORAL tool illustrates how decision-makers can invest in no regret and low regret adaptation options.⁵⁷

impacts of climate variability and change on the key sectors of agriculture and tourism are, and will be, severe. Locally relevant climate change projections have given researchers a clearer picture of some of the potential changes at regional and subregional levels, with changing rainfall patterns, water scarcity and increased temperatures all expected in the region.

High capital investment costs for some adaptation measures mean that those who are less able to afford them will need support to adapt. This emphasises the importance of government in driving adaptation action. However, CDKN-funded research also shows how adaptation measures can be prioritised, focusing on low regret and no regret measures.⁶⁰ This helps to ensure that steps taken to adapt represent good value for money.

Effective identification and prioritisation of adaptation options can also lead to a range of co-benefits that can provide additional value in a variety of ways.

The scale of the adaptation challenge for key sectors such as agriculture and tourism clearly necessitates early action to build resilience by a wide range of stakeholders.⁶¹ The research also emphasises the importance of supporting the development at the local level of multi-stakeholder networks that can work together to build inclusive climate change resilience.

regulations that restrict building to areas at least 2.6 metres above mean sea level and 30 metres from the high-tide mark; and a range of disaster-preparedness measures to be undertaken at the beginning of the hurricane season, including water storage, first-aid training and supplies, and securing loose fittings.

Researchers found that, crucially for effective adaptation in the tourism sector, adaptation plans "need to be presented and supported at the national level through national policy frameworks".⁵⁸ Implementation must involve a wide range of stakeholders, including from private sector operators. Such multi-stakeholder processes were found to be vital for successful adaptation of tourism at the local level because the sector is highly intermeshed with other

sectors, including water and energy, and relies on natural ecosystems such as coral reefs. CDKN research showed how governments can foster local networks that include public and private sector institutions as well as local communities through a case study⁵⁹ focusing on the Soufriere Marine Management Area. This longstanding protected marine reserve on Saint Lucia's west coast has successfully managed marine conservation in the face of competing interests from a wide range of stakeholders including the tourism industry, fishermen and conservation groups.

Conclusion

CDKN-funded research in the Caribbean has shown that the

Resources for policy-makers

Table 1 provides a directory of the useful reports and tools on which this publication is based. This may be used as a toolkit for decision-makers to build a clearer picture of some of the potential impacts of climate change for key sectors in the Caribbean, identify adaptation options, prioritise them, and integrate them into existing decision-making processes.

Table 1. Summary of research from the Caribbean

Resource	Type	Country	Project	Details	Source
Climate impacts and vulnerability – agriculture					
CARIWIG case study report 5: Assessment of climate change impacts on agriculture on Cayo District, Belize	Report	Belize	CARIWIG	Uses CARIWIG tools to study the impact of climate change on crop production in Belize	http://cdkn.org/resource/assessment-climate-change-impacts-agriculture-cayo-district-belize
CARIWIG Case Study Report 11: Effect of climate change on water availability in the Font D'Or catchment, Saint Lucia	Report	Saint Lucia	CARIWIG	Assesses projected impacts of climate change on river flows in the Font D'Or catchment under two scenarios	http://cdkn.org/resource/effect-climate-change-water-availability-font-dor-catchment-saint-lucia/
CARIWIG Case Study Report 6: The impact of future climate change on sweet potato production	Report	Jamaica	CARIWIG	Aims to assess the impact of future climate change on sweet potato production in Jamaica	http://cdkn.org/resource/case-study-impact-future-climate-change-sweet-potato-production/
CARIWIG Case Study Report 2: Drought and agricultural-related forest fires in Belize	Report	Belize	CARIWIG	Uses CARIIDRO to assess the relationship between agricultural forest fires and climate change via drought indices	http://cdkn.org/resource/case-study-drought-agricultural-related-forest-fires-belize/
CARIWIG Case Study Report 4: An example of local assessment of future drought. Las Tunas province, Cuba	Report	Cuba	CARIWIG	Uses CARIIDRO to assess likelihood of drought events in Las Tunas, Cuba	http://cdkn.org/resource/case-study-example-local-assessment-future-drought-las-tunas-province-cuba/
'Climate Impacts and Resilience in Caribbean Agriculture: assessing the consequences of climate change on cocoa and tomato production in Trinidad & Tobago and Jamaica (CIRCA) – Crop-Climate Suitability Modeling'	Presentation	Trinidad and Tobago, Jamaica	Research call: Climate impacts and resilience in Caribbean agriculture	Presents climate impacts on two specific crop types (cocoa and tomato production) in Trinidad and Tobago, and Jamaica	http://cdkn.org/wp-content/uploads/2014/04/CIRCA_WP21.pdf
Community-based vulnerability assessment of agriculture, fisheries and tourism in Soufriere, Saint Lucia	Working paper	Saint Lucia	GIVRAPD	Summarises the results of a community-based vulnerability assessment of the tourism, fishery and agriculture sectors in Soufriere Quarter, Saint Lucia	http://cdkn.org/resource/working-paper-community-based-vulnerability-assessment-agriculture-fisheries-tourism-soufriere-st-lucia

Resource	Type	Country	Project	Details	Source
'Climate Impacts and Resilience in Caribbean Agriculture: Assessing the consequences of climate change on cocoa and tomato production in Trinidad & Tobago and Jamaica (CIRCA) – Climate Proof Screen'	Presentation	Trinidad and Tobago	Research call: Climate impacts and resilience in Caribbean agriculture	Presents drought and heat stress responses of cocoa	http://cdkn.org/wp-content/uploads/2014/04/CIRCA-talk-WP1.pdf
'Climate Impacts and Resilience in Caribbean Agriculture: Assessing the consequences of climate change on cocoa and tomato production in Trinidad & Tobago and Jamaica (CIRCA) – Farm Level Assessments'	Presentation	Trinidad and Tobago, Jamaica	Research call: Climate impacts and resilience in Caribbean agriculture	Presents a community-based assessment of local farmers' knowledge, risk perceptions and vulnerability to climate variability and change in established farming communities in Jamaica and Trinidad	http://cdkn.org/wp-content/uploads/2014/04/CIRCA-Presentation-WP3-compressed.pdf
Jamaica: Assessing the impact of climate change on cocoa and tomato	Policy brief	Jamaica	Research call: Climate impacts and resilience in Caribbean agriculture	Highlights the impacts of climate change on Jamaica's cocoa and tomato crops	http://cdkn.org/resource/policy-brief-jamaica-assessing-impact-climate-change-cocoa-tomato
Trinidad & Tobago: Assessing the impact of climate change on cocoa and tomato	Policy brief	Trinidad and Tobago	Research call: Climate impacts and resilience in Caribbean agriculture	Highlights the impacts of climate change on Trinidad's cocoa and tomato crops	http://cdkn.org/resource/trinidad-tobago-assessing-impact-climate-change-cocoa-tomato
Adaptation options – agriculture					
Developing micro-insurance as a climate adaptation strategy for small island coastal communities: comparing the needs, viability, and feasibility for micro-insurance in Mauritius, Seychelles, Saint Lucia and Jamaica	Working paper	Jamaica, Saint Lucia, Mauritius, Seychelles	GIVRAPD	Analyses the viability of micro-insurance in Mauritius, Seychelles, Saint Lucia and Jamaica	http://cdkn.org/resource/working-paper-developing-micro-insurance-climate-adaptation-strategy-small-coastal-communities-comparing-needsviability-feasibility-micro-insurance-mauritius-seychelles-sa
The adaptive capacity of Whitehouse, Jamaica to climate change	Working Paper	Jamaica	GIVRAPD	Describes a case study on the capacity of Whitehouse (Jamaica) to adapt to climate change using the Local Adaptive Capacity framework that characterises adaptive capacity based on five elements – asset base, institutions, knowledge, innovation, and flexibility in decision-making and governance – corresponding with an evolutionary perspective on adaptive capacity	http://cdkn.org/resource/working-paper-adaptive-capacity-whitehouse-jamaica-climate-change



Resource	Type	Country	Project	Details	Source
Climate impacts – tourism					
CARIWIG Case Study Report 11: Effect of climate change on water availability in the Font D'Or catchment, Saint Lucia	Report	Saint Lucia	CARIWIG	Assesses projected impacts of climate change on river flows in the Font D'Or catchment under two scenarios	http://cdkn.org/resource/effect-climate-change-water-availability-font-dor-catchment-saint-lucia/
CARIWIG Case Study Report No 9: Flood risk and urban development in Belize City, Belize	Report	Belize	CARIWIG	Investigates the effects of climate change on rainfall, temperature and extreme events in Belize City	http://cdkn.org/resource/case-study-flood-risk-urban-development-belize-city-belize/
'Differential climate preferences of international beach tourists'	Journal article	Barbados, Saint Lucia and Tobago	GIVRAPD	Describes a survey of 472 beach tourists comparing the climatic preferences of diverse tourism market segments on Barbados, Saint Lucia and Tobago	<i>Climate Research</i> 57: 259–269.
'Bioclimatic comfort and the thermal perceptions and preferences of beach tourists'	Journal article	Barbados, Saint Lucia and Tobago	GIVRAPD	Provides insight into perceptions of outdoor microclimatic conditions in a coastal environment and identifies important psychological factors that differentiate tourists from everyday users of urban spaces	<i>International Journal of Biometeorology</i> 59: 37–45
'Thermal range of coastal tourism resort microclimates'	Journal article	Barbados and Tobago	GIVRAPD	Examines the adaptive range of microclimatic conditions available in two coastal resort settings in Barbados and Tobago, with a focus on thermo-physiologically relevant climatic parameters	<i>Tourism Geographies</i> 16(3): 346–363
Analysing vulnerability of the Belize coastal tourism sector	Report	Belize	Research call: Identifying opportunities for climate compatible tourism development in Belize	Assesses the vulnerability of the tourism industry in Belize	http://cdkn.org/resource/report-analyzing-vulnerability-belize-coastal-tourism-sector
Community-based vulnerability assessment of agriculture, fisheries and tourism in Soufriere, Saint Lucia	Working paper	Saint Lucia	GIVRAPD	Summarises the results of a community-based vulnerability assessment of the tourism, fishery and agriculture sectors in Soufriere Quarter, Saint Lucia	http://cdkn.org/resource/working-paper-community-based-vulnerability-assessment-agriculture-fisheries-tourism-soufriere-st-lucia

Resource	Type	Country	Project	Details	Source
Adaptation options – tourism					
Identification of climate compatible tourism adaptation options for Belize	Technical report	Belize	Research call: Identifying opportunities for climate compatible tourism development in Belize	Identifies options for adaptation of the tourist industry in Belize	http://cdkn.org/resource/report-identification-climate-compatible-tourism-adaptation-options-belize
'Potential climate compatible tourism adaptation strategies for Belize'	Presentation	Belize	Research call: Identifying opportunities for climate compatible tourism development in Belize	Summarises the potential adaptation strategies for the tourism sector in Belize	http://cdkn.org/wp-content/uploads/2014/04/Bze-potential-climate-adaptation-options.pdf
Adaptation options: identification and appraisal					
Caribbean Climate Online Risk and Adaptation Tool (CCORAL)	Web tool	Regional	CCORAL	A decision-support tool specifically designed for decision-makers working on laws, policies, strategies, plans, programmes, projects or budgets that might be affected by climate change. These decision-makers can use the tool to see whether their work is vulnerable to climate impacts and, if so, what steps they can take to increase resilience.	http://ccoral.caribbeanclimate.bz/
No and low regrets investment options for climate resilience	Information brief	Regional	CCORAL	Describes no and low regret options for resilience investments in the water sector; useful for policy-makers to understand how to make decisions in the face of uncertainty	http://cdkn.org/resource/information-brief-no-low-regrets-investment-options-climate-resilience



Endnotes

References to CDKN-funded work are in bold type.

- 1 Bynoe, M., Cain, D. and Peralta, A. (2014) *The use of benefit cost analysis to assess adaptation and mitigation interventions in the Caribbean: case studies*. Belmopan, Belize: Caribbean Community Climate Change Centre.
- 2 **Yearwood, S. (2013) *Developing micro-insurance as a climate adaptation strategy for small island coastal communities: comparing the needs, viability, and feasibility for micro-insurance in Mauritius, Seychelles, Saint Lucia and Jamaica*. CDKN Global.** <http://cdkn.org/resource/working-paper-developing-micro-insurance-climate-adaptation-strategy-small-coastal-communities-comparing-needs-viability-feasibility-micro-insurance-mauritius-seychelles-sa>
- 3 Commonwealth Secretariat (2014) *Improving access to climate finance for small and vulnerable states: a report of the Commonwealth Expert Group on Climate Finance to the Commonwealth Heads of Government Meeting 2013*. London: Commonwealth Secretariat. <http://thecommonwealth.org/sites/default/files/news-items/documents/Report%20of%20the%20Commonwealth%20Expert%20Group%20on%20Climate%20Finance.pdf>
- 4 Caribbean Weather Impacts Group (2012–2015) 'The CARIWIG Portal'. caribbeanclimate.bz
- 5 **CDKN (2014a) 'Global Islands' Vulnerability Research, Adaptation Policy and Development (GIVRAPD) St Lucia**. London: Climate and Development Knowledge Network. <http://givrapd.org/sites/st-lucia>
- 6 **CDKN (2014b) 'Global Islands' Vulnerability Research, Adaptation Policy and Development (GIVRAPD) Jamaica**. London: Climate and Development Knowledge Network. <http://givrapd.org/sites/jamaica>
- 7 **CDKN (2014c) 'Caribbean Research Call'**. London: Climate and Development Knowledge Network. <http://cdkn.org/project/caribbean-research-call>
- 8 CCCCC (2009) *Climate Change and the Caribbean: a regional framework for achieving development resilient to climate change (2009–2015)*. Belmopan, Belize: Caribbean Community Climate Change Centre. www.caribbeanclimate.bz/ongoing-projects/2009-2021-regional-planning-for-climate-compatible-development-in-the-region.html
- 9 *Jamaica Observer* (2010) 'IDB: Natural disasters could cripple Caribbean economies'. *Jamaica Observer* 8 October. www.jamaicaobserver.com/business/IDB--Natural-disasters-could-cripple-Caribbean-economies_8034328
- 10 UN-OHRLS (2011) *Small Island Developing States: small islands big(ger) stakes*. New York: United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States, pp. 2–3. <http://unohrlls.org/custom-content/uploads/2013/08/SIDS-Small-Islands-Bigger-Stakes.pdf>
- 11 Bynoe et al. (2014) Op. cit.
- 12 Yearwood (2013) Op. cit.
- 13 Ibid.
- 14 Government of Saint Lucia (2013) *Economic & social review 2012*. Ministry of Finance, Economic Affairs, Planning and Social Security. www.finance.gov.lc/resources/index/25
- 15 Vergara, W., Rios, A.R., Trapido, P., Malarin, H. (2014) *Agriculture and future climate in Latin America and the Caribbean: systemic impacts and potential responses*. Discussion Paper IDB-DP-329. Washington, DC: Inter-American Development Bank. www.unclearn.org/sites/default/files/inventory/idb40.pdf
- 16 CIA (2016a) 'The World Fact Book: Guyana'. Washington, DC: Central Intelligence Agency. www.cia.gov/library/publications/resources/the-world-factbook/geos/gu.html
- 17 CIA (2016b) 'The World Fact Book: Trinidad and Tobago'. Washington, DC: Central Intelligence Agency. www.cia.gov/library/publications/resources/the-world-factbook/geos/td.html
- 18 Vergara et al. (2014) Op. cit.
- 19 ECLAC (2011) *Caribbean Development Report Volume III: The economics of climate change in the Caribbean*. Santiago de Chile: United Nations Economic Commission for Latin America and the Caribbean. www.cepal.org/publicaciones/xml/2/45412/LCARL.346.pdf
- 20 **Rivero, R. Jr, Rivero, R. and Rivero, Z. (n.d.) *Assessment of climate change impacts on agriculture on Cayo District, Belize***. CARIWIG Case Study Report 5. Caribbean Weather Impacts Group. <http://cdkn.org/resource/assessment-climate-change-impacts-agriculture-cayo-district-belize>
- 21 CDKN (2014d) *The IPCC's Fifth Assessment Report: What's in it for Small Island Developing States?* London: Climate and Development Knowledge Network. http://cdkn.org/wp-content/uploads/2014/08/CDKN_IPCC_Whats_in_it_for_SIDS.pdf
- 22 **Centella, A., Bezanilla, A., Vichot, A. and Joslyn, O. (2014) *Drought and agricultural-related forest fires in Belize***. CARIWIG Case Study Report 2. Caribbean Weather Impacts Group. <http://cdkn.org/resource/case-study-drought-agricultural-related-forest-fires-belize/>
- 23 Rivero et al. (n.d.) Op. cit.
- 24 **Boelee, L. and Counsell, C. (2014) *Effect of climate change on water availability in the Font D'Or catchment, Saint Lucia***. CARIWIG Case Study Report 11. Caribbean Weather Impacts Group. <http://cdkn.org/resource/effect-climate-change-water-availability-font-dor-catchment-saint-lucia/>
- 25 **Eitzinger, A., Rhiney, K., Farrell, A., Carmona, S., van Loosen, I. and Taylor M. (2015a) *Jamaica: Assessing the impact of climate change on cocoa and tomato***. Policy Brief 28. Cali, Colombia: Centro Internacional de Agricultura Tropical. <http://cdkn.org/resource/policy-brief-jamaica-assessing-impact-climate-change-cocoa-tomato/>
- 26 **Rankine, D., Taylor, M. and Stephenson, T. (2014) *The impact of future climate change on sweet potato production***. CARIWIG Case Study Report 6. Caribbean Weather Impacts Group. <http://cdkn.org/resource/case-study-impact-future-climate-change-sweet-potato-production/>

- 27 Rivero et al. (n.d.) Op. cit.
- 28 Boelee and Counsell (2014) Op. cit.
- 29 Rivero et al. (n.d.) Op. cit.
- 30 Eitzinger et al. (2015a) Op. cit.
- 31 Ibid.
- 32 **Eitzinger, A., Rhiney, K., Farrell, A., Carmona, S., van Loosen, I. and Taylor M. (2015b) *Trinidad & Tobago: Assessing the impact of climate change on cocoa and tomato***. Policy Brief 27. Cali, Colombia: Centro Internacional de Agricultura Tropical. <http://cdkn.org/resource/trinidad-tobago-assessing-impact-climate-change-cocoa-tomato>
- 33 Ibid.
- 34 Centella et al. (2014) Op. cit.
- 35 Ibid.
- 36 Yearwood (2013) Op. cit.
- 37 **Wandel, J. and Cowing, Z. (2014) *Community-based vulnerability assessment of agriculture, fisheries and tourism in Soufriere, Saint Lucia***. Global Islands' Vulnerability Research, Adaptation Policy and Development (GIVRAPD) Project. <http://cdkn.org/resource/working-paper-community-based-vulnerability-assessment-agriculture-fisheries-tourism-soufriere-st-lucia>
- 38 Wandel and Cowing (2014) Op. cit.
- 39 Lobell, D.B., Baldos, U.L.C. and Hertel, T.W. (2013) 'Climate adaptation as mitigation: the case of agricultural investments'. *Environmental Research Letters* 8(1): 015012. <http://iopscience.iop.org/article/10.1088/1748-9326/8/1/015012;jsessionid=1F8FD1E6739A78B078C8360B51C16D17.c1.iopscience.cld.iop.org>
- 40 Lobell et al. (2013) Op. cit.
- 41 Yearwood (2013) Op. cit.
- 42 **CARIBSAVE (2015) 'Saving for a rainy day': micro-insurance as climate change adaptation strategies for SIDS**. GIVRAPD Policy Brief 3. Global Islands' Vulnerability Research, Adaptation Policy and Development. <http://cdkn.org/resource/policy-brief-saving-rainy-day-micro-insurance-climate-change-adaptation-strategies-sids>
- 43 WTTC (2014) *Travel & tourism. Economic impact 2015: Caribbean*. London: World Travel & Tourism Council. www.wttc.org/-/media/files/reports/economic%20impact%20research/regional%202015/caribbean2015.pdf
- 44 Wandel and Cowing (2014) Op. cit.
- 45 **CARIBSAVE et al. (2014a) *Analysing vulnerability of the Belize coastal tourism sector***. London: Climate and Development Knowledge Network. <http://cdkn.org/resource/report-analyzing-vulnerability-belize-coastal-tourism-sector>
- 46 **Mumby, P. et al. (2014) *Towards reef resilience and sustainable livelihoods: a handbook for Caribbean coral reef managers***. Exeter, UK: University of Exeter. www.marinespatialecologylab.org/force/Climate%20Change%20p.%2052-63.pdf
- 47 Wandel and Cowing (2014) Op. cit.
- 48 Boelee and Counsell (2014) Op. cit.
- 49 Wandel and Cowing (2014) Op. cit.; Ibid.
- 50 **Rutty, M. and Scott, D. (2013) 'Differential climate preferences of international beach tourists.'** *Climate Research* 57: 259–269.
- 51 **Rutty, M. and Scott, D. (2015) 'Bioclimatic comfort and the thermal perceptions and preferences of beach tourists.'** *International Journal of Biometeorology* 59: 37–45.
- 52 Ibid.
- 53 **CARIBSAVE et al. (2014b) *Identification of climate compatible tourism adaptation options for Belize***. London: Climate and Development Knowledge Network. <http://cdkn.org/resource/report-identification-climate-compatible-tourism-adaptation-options-belize>
- 54 Estimated annual cost 2010–2050 using the gross aggregation method, which sets negative costs in any sector in a country to zero before costs are aggregated for the country and for all developing countries. World Bank (2010) *The economics of adaptation to climate change: a synthesis report*. Washington, DC: World Bank. http://siteresources.worldbank.org/EXTCC/Resources/EACC_FinalSynthesisReport0803_2010.pdf
- 55 UNEP (2016) *The adaptation finance gap report 2016*. Nairobi: United Nations Environment Programme. <http://drustage.unep.org/adaptationgapreport/sites/unep.org/adaptationgapreport/files/documents/agr2016.pdf>
- 56 CCCCC (2014) 'CCORAL: Caribbean Climate Online Risk and Adaptation Tool'. Belmopan, Belize: Caribbean Community Climate Change Centre. <http://ccoral.caribbeanclimate.bz>
- 57 **GWP-C and CCCCC (2014) *No and low regrets investment options for climate resilience***. Global Water Partnership Caribbean and Caribbean Community Climate Change Centre. <http://cdkn.org/resource/information-brief-no-low-regrets-investment-options-climate-resilience>
- 58 CARIBSAVE et al. (2014b) Op. cit. p. 11
- 59 **Pittman, J., Armitage, D., Alexander, S., Campbell, D. and Alleyne, M. (2014) *Reflecting on climate change and governance in a coastal-marine context: the case of St. Lucia***. GIVRAPD Working Paper Series. Global Islands' Vulnerability Research, Adaptation Policy and Development. <http://cdkn.org/resource/working-paper-reflecting-climate-change-governance-coastal-marine-context-case-st-lucia>
- 60 GWP-C and CCCCC (2014) Op. cit.
- 61 Pittman et al. (2014) Op. cit.

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