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"Climate Change Impacts and Adaptation for Coastal Transport Infrastructure in Caribbean SIDS"

SAINT LUCIA: A Case study

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UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT
PROSPERITY FOR ALL

Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS)

SAINT LUCIA: A Case study

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Synopsis

1. Introduction
   - 1.1 SIDS vulnerability to CV & C
   - 1.2 CV & C impacts on transport/tourism
2. St Lucia country overview
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3. Transport infrastructure: Criticality
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6. Conclusions

Scope of the study

- SIDS are sea-locked and rely on the transport sector (especially airports & seaports).
- Transport infrastructure is vulnerable to CV & C, especially in Caribbean SIDS.

The scope of the present study is the assessment of the criticality of the major transportation assets of Saint Lucia and their potential vulnerabilities to Climate Variability and Change.

SIDS vulnerability to CV & C

- Limited physical size, which eliminates some adaptation options to CV & C
- Generally high population densities
- Remoteness, the great distance to major markets, affects competitiveness in trade
- Limited natural resources
- Extreme openness and high sensitivity to external shocks
- High susceptibility to frequent and more intense catastrophic events
- Insufficient financial, technical and institutional capacities
- Concentration of population, socio-economic activities, and infrastructure along the coastal zone
- Inadequate infrastructure in most sectors

CV & C impacts on transport

Climate change hazards can have specific deleterious impacts on the transport system, leading to direct and indirect damages and system disruptions. The most significant impacts include:

- Direct damage in infrastructure
- Reduced functionality and efficiency of the ports
- Damage/ upgrading of coastal hard defenses
- Trade disruption
- Increased transport costs
- Disruption of traffic flows on road network / isolation of communities
- Impact on the connectivity of the major gateways
- Airport shutdowns
- Indirect impacts on other sectors (agriculture, fisheries, tourism)

As a result, <u>most economic operations will be impeded</u>

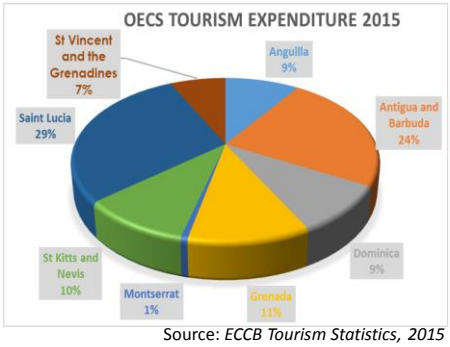
Island transport is mostly tourism - driven

Tourism and transport are interdependent, particularly in islands (and SIDS)

Thus, CV & C impacts on transport will affect tourism, and vice versa

International visitors fly to Caribbean for the 'Sun, Sea and Sand' (3S tourism)

The ("3S") tourism model contributes significantly to the Caribbean economy and is a key source of export earnings for all Caribbean SID



Source: *ECCB Tourism Statistics, 2015*

CV & C impacts on tourism

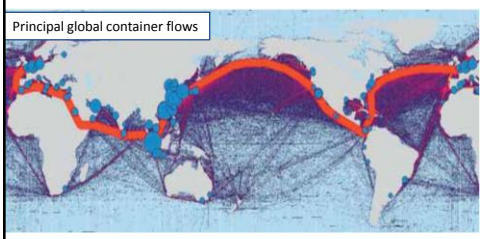
Tourism is a weather and climate-sensitive sector

- Tourism could be disrupted by the loss of beaches, coastal inundation, degradation of ecosystems (coral reefs, seagrasses), saline intrusion, damage to critical infrastructure.
- The above coupled with the projected milder winters in N. America and Europe, might impact on the tourism industry of SIDS
- The tourism industry may also suffer from climate change mitigation measures (e.g. levies on aviation emissions which would increase the cost of air travel).

Why address transport infrastructure's vulnerability?

- ✓ Maritime transport accounts for more than 80 % of world trade while air transport is responsible for carrying about 30-40 % of the value of freight goods
- ✓ Insularity increases SIDS dependency on maritime and air transport (access, trade and mobility)
- ✓ SIDS are highly dependent on transport-intensive imports for much of their consumption needs

Principal global container flows



Shipping services calling at ports in the Caribbean SIDS

Source: UNCTAD, 2015

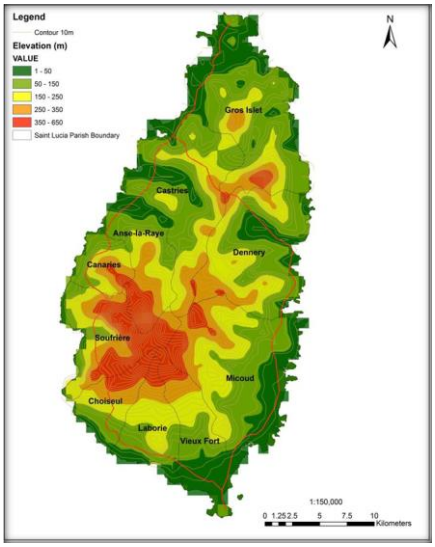
Why address transport infrastructure's vulnerability?

- ✓ Transport facilities and infrastructure enable tourism, which is the largest employer and earner of foreign exchange for most Caribbean destinations
- ✓ Transportation supports resident livelihoods, health, and well-being

Therefore, seaports and airports in SIDS—and their intermodal connections—are vital lifelines for movement of goods and tourism; any damage of this infrastructure can disrupt transport services and affect significantly small island economies

St Lucia: country profile

- ✓ Second largest of the Windward Islands
- ✓ Volcanic origin: mountainous/rugged topography, with steep slopes cut by fast-flowing rivers
- ✓ Has a relatively high biological and ecosystem diversity
- ✓ The majority of urban settlements and tourism development are located in the narrow coastal zone
- ✓ Land area of 616 km^2
- ✓ All of the above facts, have led to increased risks with regard to CV & C



(Source: ESL, 2015)

St Lucia: country profile

Population: **184,999**

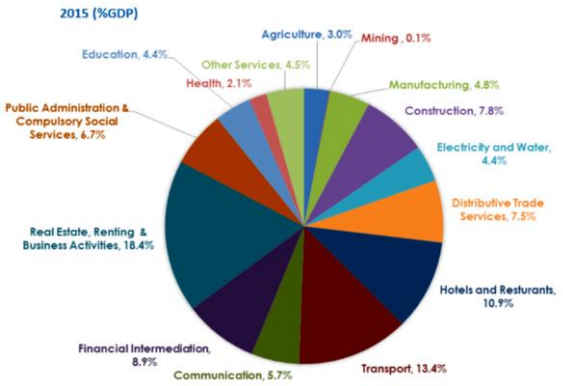
Unemployment: **24.1 %**

Current GDP : **1.43 $ US billion**

Real GDP growth: **2.4 %**

Public debt: **75.4 % of GDP**

Inflation rate: **-1 %**



(Source: SLTB, 2016)

- ✓ The main service sectors account for 60% of GDP
- ✓ Wholesale and retail trade and accommodation and food service activities account for 53% of enterprises in the economy

St Lucia: Climate projections (1)

SIDS are highly exposed and vulnerable to natural disasters, which are expected to increase in frequency and severity.

1. **Increase in average atmospheric temperature**: The country is projected to be warmer by up to 1^{o}C by the 2020s, 2^{o}C by the 2050s and 3^{o} C by the 2080s

2. Reduced average annual rainfall: GCMs show a median decrease of up to 22%

3. Increased Sea Surface Temperatures (SST) by 0.8˚C - 3.0˚C by 2080s

4. **Potential increase in the intensity of tropical storms** but not necessarily hurricane frequency

St Lucia: Climate projections (2)

5. **Storm surges:** projections suggest small/moderate increases in storm surge levels

6. **Waves**: Recent studies project decreases in the wave power of the extreme storms (the 100-year event) as well as insignificant changes in extreme wave direction

7. **Accelerating rate of sea level rise**: Caribbean Sea levels are projected to rise by up to 0.5 – 0.6 m by the end of 21st century

UNDP stated that 1m SLR in CARICOM would cause severe disruption of transportation networks, and the reconstruction costs of lost roads would be about US$ 4,178 million

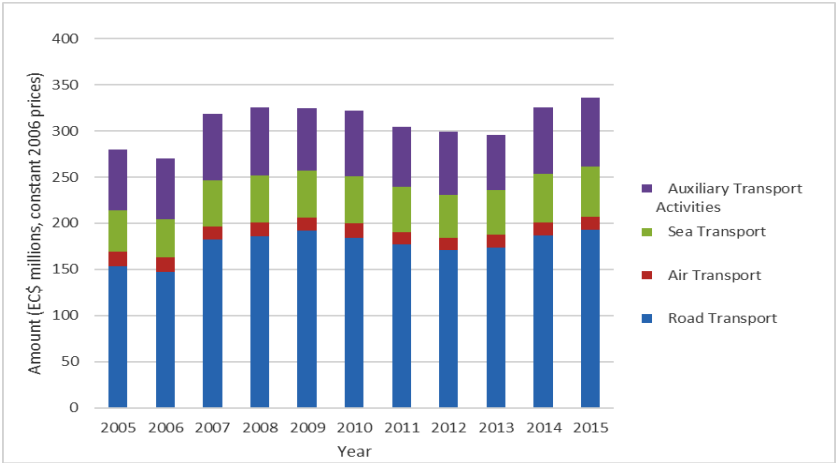
Impacts of a 1m sea lever rise in St Lucia (UNCTAD, 2014)

	Land Area	Population	Urban Area	Wetland Area	Agricultural Land	Crop and Plantation	Major Tourism Resorts	Airports	Road Network	Protected Areas	Sea Turtle Nests	Power Plants	Ports
St. Lucia	1%	1%	<1%	*	1%	1%	7%	50%	0%	0%	6%	0%	100%

Significance of transport to the economy

✓ In 2015, the direct contribution of transportation to St Lucia's economy was 13.45 %

GDP Official Levels: EC$ 336 millions, Rate of growth: 3.21 %



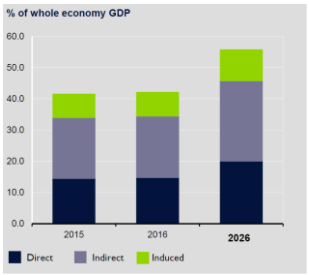
Significance of international tourism to the economy

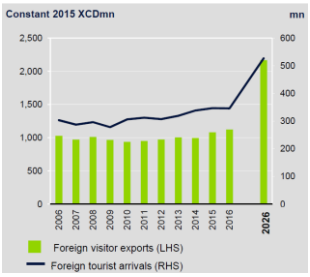
Tourism is a crucial contributor to:

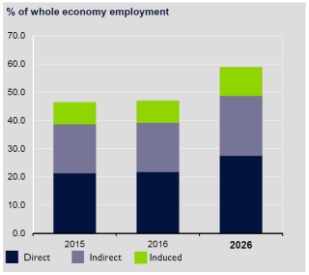
national economy, → 41.5% of GDP

foreign exchange inflows, → XCD 1,079.5mn in visitor exports

and employment → 46.3% of total employment



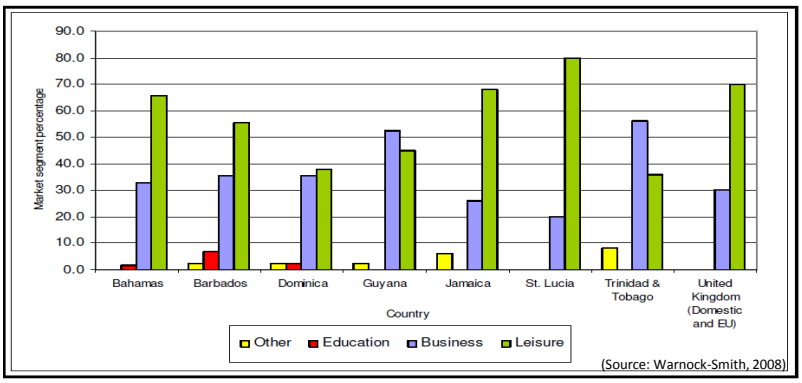




Source: WTTO, 2015

Significance of international tourism to the economy

- ✓ St Lucia is dependent on the leisure market
- ✓ 1,073,017 tourists (stayovers and cruise passengers) arrived in 2015
- ✓ Total tourist expenditure increased by an estimated 3.2 % to EC $2.08 billion



(Source: Warnock-Smith, 2008)

Significance of international tourism to the economy

Trade

✓ Air and sea transport enable the island's economy to participate in world trade and maintain its vital trade links with other countries

(Source: Review of the Economy, 2015)

Criticality of Transport infrastructure: **SEAPORTS**

Entry points to the island

- Dependence on imports

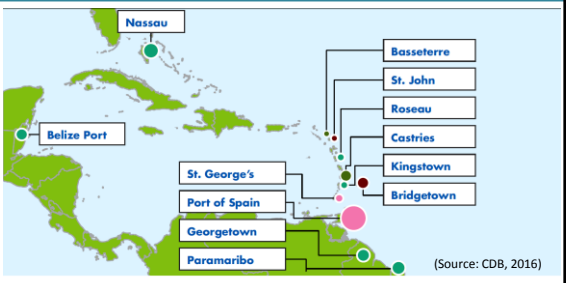
Most imports (mainly fossil fuels & food) are handled primarily through the sea ports

- Critical to tourism industry

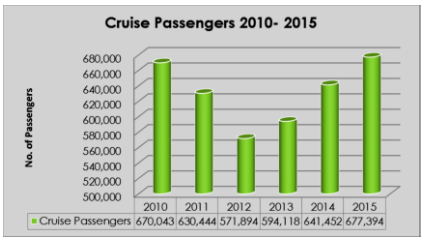
Major destination for cruise ships

- Significant foreign and local revenues

from port-related activities



(Source: CDB, 2016)



(Source: St. Lucia Tourist Board)

Criticality of Transport infrastructure: **AIRPORTS**

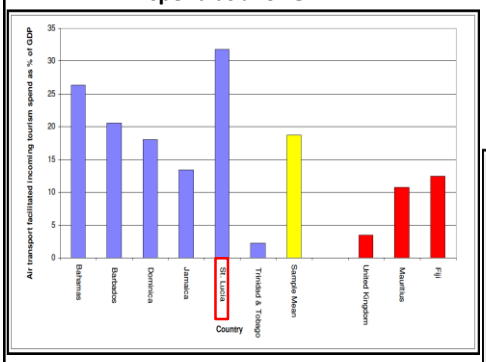
- ✓ Boost accessibility and social expansion
- ✓ Drive tourism development
- ✓ Serve as national and regional economic motors
- ✓ Facilitate the earnings of foreign exchange

In St Lucia, both airports:

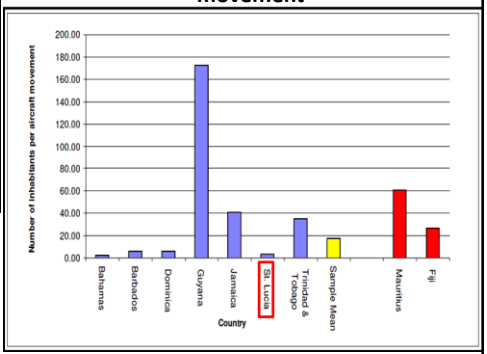
- ✓ Serve the majority of domestic and tourist (stay over) traffic
- ✓ Valuable air-cargo hubs, facilitating domestic and international flow of commerce

Criticality of Transport infrastructure : **AIRPORTS**

Air transport facilitated incoming tourism spend as % of GDP

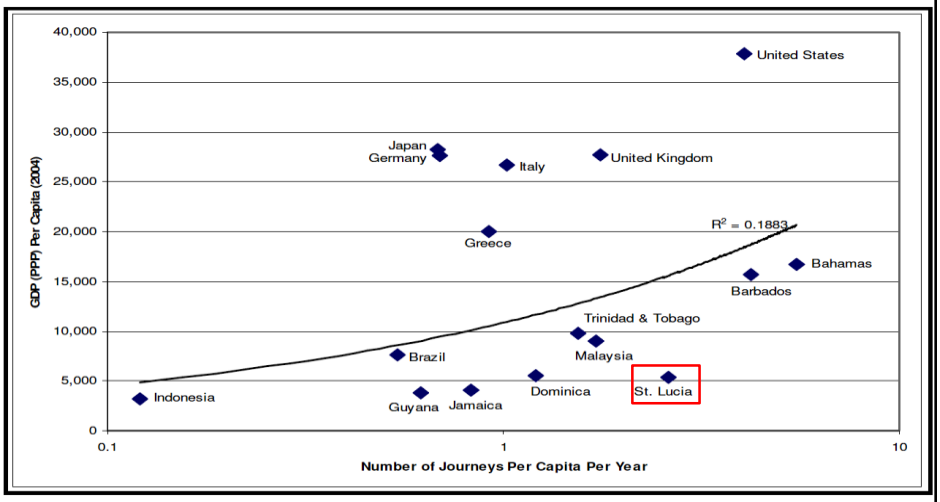


Number of inhabitants per aircraft movement



(Source: Warnock-Smith, 2008)

Criticality of Transport infrastructure: **AIRPORTS**



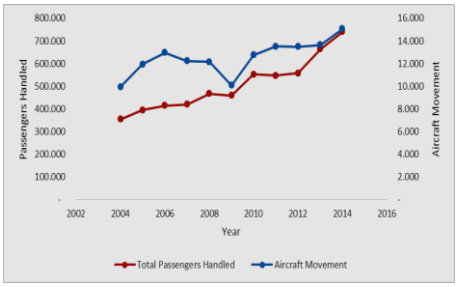
(Source: Warnock-Smith, 2008)

Description of major assets

Hewanorra International Airport

Major facilitator of Saint Lucia's tourism

Serves as the gateway to the international long-haul airlines, connecting Saint Lucia to the US, Canada, Europe and the rest of the world



In 2016:

- 16,157 domestic and international aircraft movements
- 644,837 arriving and departing passengers
- 2,138 tonnes of cargo

Description of major assets

George F L Charles Airport

Small-scale facility that primarily serves regional flights to/from Caribbean and is also a valuable air cargo hub

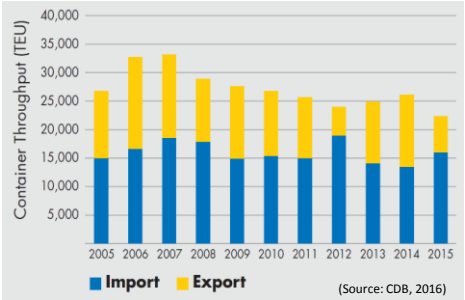
In 2016:

- 17,569 aircraft movements
- 195,859 passengers
- 1,079,303 kg of cargo

Description of major assets

Port Castries

Main port of entry; it handles most of the gateway cargo and the majority of cruise activities



In 2015:

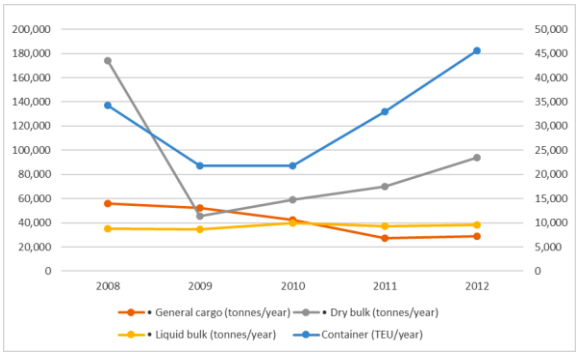
- 388 cruise calls and 677,394 passengers.
- Container traffic : 32,085 TEUs
- Total cargo handled (containerized and bulk): 480,770 tonnes

Description of major assets

Port Vieux Fort

Handles:

- ✓ 46,000 TEU per year, equivalent to 30% of the total OECS traffic
- ✓ most of the country's transhipment cargo (85% of throughput)

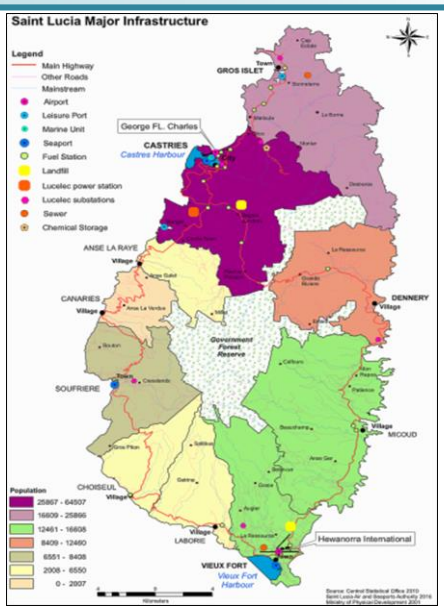


Description of major assets

Road Network

A two-lane (mainly coastal) highway :

- ✓ represents a major artery for the flow of goods and services
- ✓ connects the 2 airports and 2 sea ports
- ✓ Connects also the major assets to the tourist destinations (hotels, beaches)



Climate Variability and Change Impacts

Historical impacts/disruptions: **Hewanorra International Airport**

Event	Impacts
1994 Tropical Storm Debbie	Winds of 105 km/h Heavy rains covered HIA with ~51 mm of silt No record of damages/losses
2010 Hurricane Thomas	Winds of 148 km/h to 160 km/h Runway covered with mud and run-off water Shutdown for 4 days Indirect impacts: Significantly lower load factors (consequent economic impacts due to losses from air shuttle passenger fees between the north and the south; passenger taxes and aircraft landing fees)
2013 Christmas Eve Trough	Swelling of La Tourney River; water flooded the runway A Virgin Atlantic A300 airbus had its landing gear damaged and undercarriage ripped apart Total damage costs sustained was about US$ 800,000
2016 Hurricane Matthew	319.19 mm of rain (24-hour period) Shutdown No damages reported

Climate Variability and Change Impacts

Historical impacts/disruptions: **George F L Charles Airport**

Event	Impacts
2007 Hurricane Dean	Maximum gust 67 mph Storm surge washed sand onto the adjacent road and into the airport Eroding sea defenses compromised the west end of the runway Repair cost to the rock armouring was estimated as EC$100,000
2010 Hurricane Tomas	Shutdown for 3 days, reopened for limited access and emergency operations Indirect impacts: Significantly lower load factors (consequent economic impacts due to losses from air shuttle passenger fees between the north and the south; passenger taxes and aircraft landing fees)
2013 - Christmas Eve Trough	Flooding, airport operations suspended for a few hours for cleanup No damages to the facility
2016 - Hurricane Matthew	9.21 inches recorded (12-hour period) Shutdown No significant damages were reported

Climate Variability and Change Impacts

Historical impacts/disruptions: **Port Castries**

Event	Impacts
2007 Hurricane Dean	Damage on the constructed breakwater Boulders from the breakwater were shifted by wave action onto the roadway The south side of the harbor was eroded by wave action and the road in the Faux a Chaux area was undermined Cost of damages: $1,000,000 XCD Some damage was observed to the rock armour at Pointe Seraphine and to an area west of the Port and at the Ganters Bay; cost estimated at 150,000 XCD Clean-up activities to remove sand on the pier
2010 Hurricane Thomas	Waves approximating the 1 in 15 year event No measurable damage
2013 - Christmas Eve Trough	Minimal damage

Climate Variability and Change Impacts

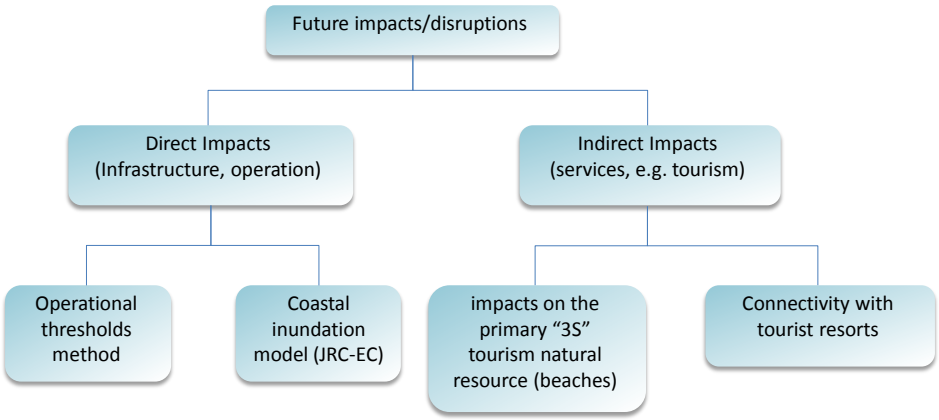
Historical impacts/disruptions: **Port Vieux Fort**

The docks were built to withstand storm surges/waves

Although exposed, no records of historical disruptions, even prior to the 1999/2000 upgrades

Climate Variability and Change Impacts

Future disruptions - Methodology



Climate Variability and Change Impacts

Future disruptions - Direct impacts

Operational thresholds method

Identifying the operational thresholds

i. Employee ability to work safely outdoors and heat index (a function of temperature and relative humidity)
ii. Take off length Requirement of aircrafts and Temperature
iii. Energy cost and Temperature
iv. Other Generic thresholds (wind speed and the precipitation)

Collection of Climate data

i. Raw climate model data (for temperature and precipitation projections) from the database of the Caribbean Community Climate Change Centre (CCCCC)

Estimation of days of disruption

Trough the comparison of the operational thresholds with the climate data, the days that these thresholds would be exceeded were estimated

Climate Variability and Change Impacts

Future disruptions - Direct impacts

Operational thresholds method: *Days of disruptions for the airports*

Airports					
			Disruptions (average days/year)		
Climate Stressor	**Sensitivity**	**Threshold**	**2000-2019**	**2040- 2059**	**2080 - 2099**
Extreme Heat	Aircraft maximum take-off operational temperature	47.7°C (118°F)	0	0	0
	Employee ability to work safely outdoors	Heat Index* over 30.8 °C (87.5 °F) with relative humidity 80% is "high" risk	2.05 (41 days)	13.2 (264 days)	53.7 (1073 days)
		Heat Index* over 32.9 °C (90.7 °F) with relative humidity 80% is "very high" risk	0	1.05 (21 days)	11.8 (236 days)
	Aircraft take-off length requirements	Boeing 737-600 aircraft would not be able to take off from HIA if the temperature exceeds 34.2°C without reducing aircraft loads	0	0	2.2 (44 days)
		Boeing 737-800/-800W/BBJ2 aircraft would not be able to take off from HIA if the temperature exceeds 33°C without reducing aircraft loads	0	0.7 (14 days)	12.2 (244 days)
		Boeing 737-500 aircraft would not be able to take off from HIA if the temperature exceeds 31.2°C without reducing aircraft loads	1.1 (22 days)	12.1 (242 days)	67.5 (1350 days)
		Boeing 737-400 aircraft would not be able to take off from HIA if the temperature exceeds 31°C without reducing aircraft loads	1.7 (34 days)	12.25 (245 days)	67.9 (1357 days)
Wind Speeds	Inability of aircraft to land or take off	Commercial airports: sustained winds of 20 m/s	0	0	0
		General Aviation airports: 11.2 m/s	0.2 (4 days)	0.1 (2 days)	0.05 (1 days)

Climate Variability and Change Impacts

Future disruptions – Direct impacts

Operational thresholds method: *Days of disruptions for the sea ports*

Ports					
			Disruptions (average days/year)		
Climate Stressor	**Sensitivity**	**Threshold**	**2000-2019**	**2040- 2059**	**2080 - 2099**
Extreme Heat	Energy costs	1°C warming = 5% increase in energy costs if temperature exceeds 27.8°C (mean temperature for the period 1986-2005: 26.8 °C)	N/A	221 (4419 days)	351.5 (7029 days)
		3°C warming = 15% increase in energy costs if temperature exceeds 29.8°C (mean temperature for the period 1986-2005: 26.8 °C)	N/A	47.6 (951 days)	179 (3581 days)
		6°C warming = 30% increase in energy costs if temperature exceeds 32.8°C (mean temperature for the period 1986-2005: 26.8 °C)	N/A	1 (20 days)	15.4 (308 days)
Precipitation	Low visibility inhibits crane operation	Intense rainfall (e.g., > 20 mm/day)	43.5 (870 days)	45.5 (910 days)	46.7 (934 days)
		Very heavy rainfall (e.g. >50 mm/day)	0.9 (18 days)	0.8 (16 days)	0.8 (16 days)
Wind Speed	Ability to berth ships (due to waves)	Winds ≥18 m/s (40.3 mph, 35 knots) force operational shutdown	0	0	0
		With winds of 12.8-18 m/s (28.8-40.3 mph, 25-35 knots), discretion is applied	0	0.05 (1 days)	0

Climate Variability and Change Impacts

Future disruptions – Direct impacts

Coastal inundation model (JRC-EC)

Estimation of future exposure to coastal flooding/inundation

Estimation of extreme sea levels

in order to assess the impacts of a Caribbean hurricane, the effect of a hurricane with the characteristics of Thomas on coastal sea levels is superimposed on the previous projections. Food/inundation assessment is being carried out , using dynamic simulations using the open-access model LISFLOOD-ACC

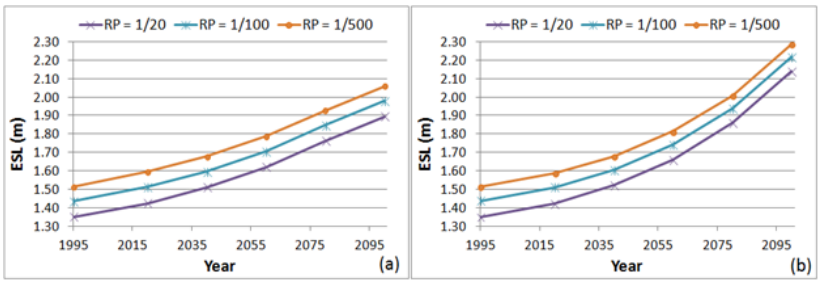
Climate Variability and Change Impacts

Future disruptions - Direct impacts

Coastal inundation model (JRC-EC)

Extreme Sea Level projections

Episodic ESL (due to combined effect of storm surges and wave set up and a hurricane (Thomas)) for 1970-2100 and for 10 return periods for the RCPs 4.5 and 8.5



Time evolution of ESLs for 3 return periods (RP) and according with the RCP scenarios (a) 4.5 and (b) 8.5. (ESLs: MSL+ storm surge + tide +wave set up). (From ECJRC, Michalis Vousdoukas)

Climate Variability and Change Impacts

Future disruptions – Direct impacts

Coastal flooding

Inundation maps for a Caribbean hurricane (Thomas) superimposed on a 100-year ESL (RCP 4.5, 2050). (From ECJRC, Michalis Vousdoukas)

Climate Variability and Change Impacts

Future disruptions – Direct impacts

Coastal flooding

Inundation maps for a Caribbean hurricane (Thomas) superimposed on a 100-year ESL (RCP 8.5, 2100). (From ECJRC, Michalis Vousdoukas)

Climate Variability and Change Impacts

Future disruptions – Direct impacts

Coastal flooding

Hewanorra airport
will be affected only at its eastern side of the runway, which is projected to be inundated by:

- 70 under the 100-year ESL of RCP 4.5 by 2050
- 160 m under the 100-year ESL of RCP 8.5 by 2100

GFL Charles airports
A Caribbean hurricane (Thomas) superimposed on a 100-year ESL (RCP 8.5, 2100) will inundate the entire stretch of the Vigie beach. The inundation of the beach will make the airport very vulnerable to the incident waves.

Port Castries
All studied scenarios show severe impacts. A Caribbean hurricane (Thomas) superimposed on a 100-year ESL (RCP 8.5, 2100) will impact the docks, inundate berths and cause flooding in areas of the city adjacent to the docks, in the Cargo Sheds and equipment, and cruise ship facilities

Port Vieux Fort
All studied scenarios show severe impacts on Port Vieux Fort (flooding of the docks and berths and surrounding areas)
Breakwaters will be also impacted

Climate Variability and Change Impacts

Future disruptions – Direct impacts

Coastal flooding

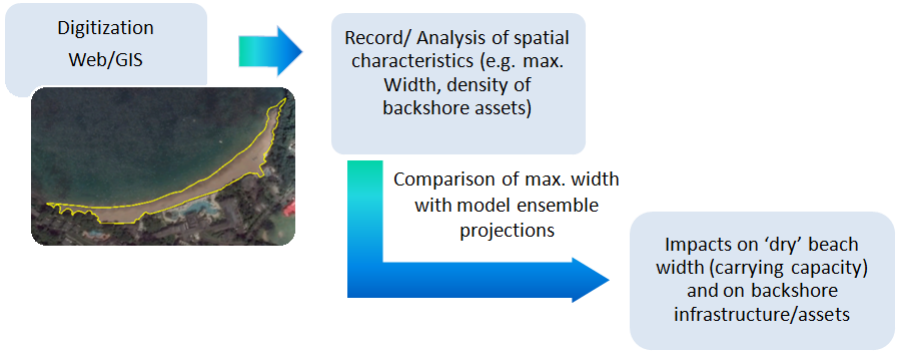
Table summarizing the impacts to major transportation assets due to coastal flooding. 0: no impacts, 1: Low impact, 2: medium impact, 3: high impact.

Scenarios	ESL plus Hurricane (m)	Graded impacts to the Major Assets			
		HIA	GFL IA	Port Vieux Fort	Port Castries
RCP 4.5 – 2050 (RP=1/10)	1.53	1	0	3	3
RCP 4.5 – 2050 (RP=1/50)	1.62	1	0	3	3
RCP 4.5 – 2050 (RP=1/100)	1.66	1	1	3	3
RCP 8.5 – 2050 (RP=1/10)	1.56	1	0	3	3
RCP 8.5 – 2050 (RP=1/50)	1.65	1	1	3	3
RCP 8.5 – 2050 (RP=1/100)	1.68	1	1	3	3
RCP 4.5 – 2100 (RP=1/10)	1.87	1	1	3	3
RCP 4.5 – 2100 (RP=1/50)	1.96	2	2	3	3
RCP 4.5 – 2100 (RP=1/100)	1.99	2	2	3	3
RCP 8.5 – 2100 (RP=1/10)	2.12	2	2	3	3
RCP 8.5 – 2100 (RP=1/50)	2.20	3	2	3	3
RCP 8.5 – 2100 (RP=1/100)	2.23	3	2	3	3

Climate Variability and Change Impacts

Future disruptions – Indirect impacts

Impacts on the primary "3S" tourism natural resource (beaches)



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(i) Seven cross-shore (1-D) morphodynamic models used to create 2 ensembles:
- A long-term, consisting of 3 analytical models (Edelman, Bruun, Dean) and
- A short-term (storm surge), consisting of 4 numerical models (Leont'yev, SBEACH, Xbeach and Boussinesq)

(ii) All models were applied using linear profiles. Experiments were carried out for:
- different profile slopes (1/10-1/30)
- for varying offshore wave conditions (H=1 – 4 m, T=4 – 8 sec)
- sediment texture (d_{50}=0.2 -5 mm)

For each set of environmental conditions 12 SLR scenarios (up to 2 m) were tested (Totally 5500 experiments).

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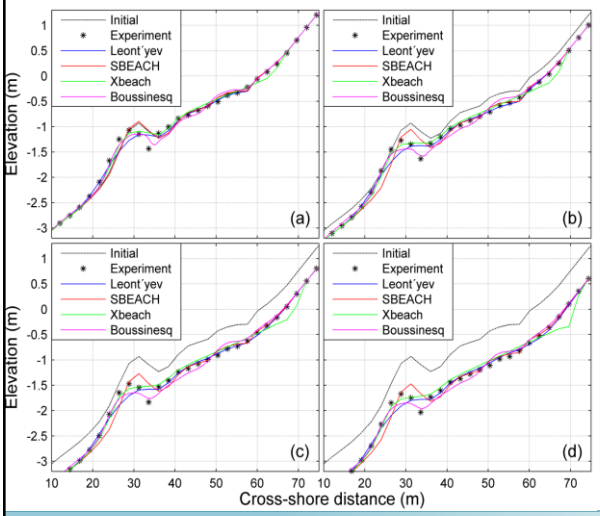

Validation of the models

Profiles by numerical models plotted against results from physical experiments at the GWK wave flume (Hanover): (a) initial/present water level; (b) water level rise of 0.2 m; (c) rise of 0.4 m; and (d) rise of 0.6 m. Both numerical and physical experiments were set up for the same initial (non-linear) profile. (Monioudi et al., 2017, NHESS)

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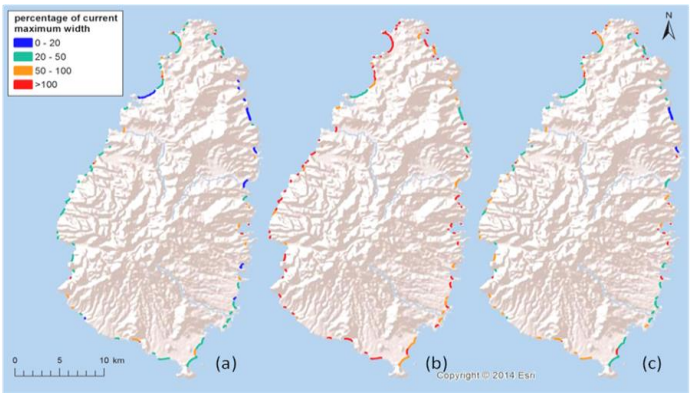


Projections of (a) and (b) minimum and maximum beach retreat under a combined SLR of 1.19 m (for the year 2040) and (c) minimum beach retreat under a combined SLR of 1.76 m (for the year 2100), showing beaches projected to retreat by distances equal to different percentages of their initial maximum widths

Climate Variability and Change Impacts

Future disruptions – Indirect impacts

Connectivity with tourist resorts

An estimation of connectivity impacts on the basis of the number of potential landslides has been carried along the connecting road network between the 2 international airports and the 30 tourist beaches identified along the island coastline through

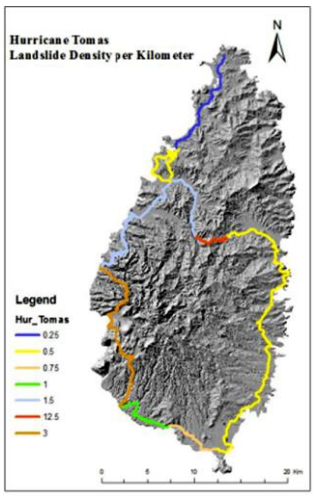
(i) digitization of the major road network using the Google Earth Application and

(ii) the landslide density per kilometer recorded during the Hurricane Thomas

Climate Variability and Change Impacts

Future disruptions – Indirect impacts

Connectivity issues : airports with tourist resorts



Landslides along the road network		
Major touristic destinations	**From HIA (km)**	**From GFL Charles IA (km)**
Cas en Bas	45.9	2.8
Anse Petience	9.5	33.5
Coconut Bay	0.4	42.6
Anse de Sable_1	0.4	43.0
Anse de Sable_2	0.9	44.3
Sugar Beach	46.6	83.9
Malgretoute	53.2	77.4
Soufriere	60.2	70.4
Anse Chastanet	65.9	64.7
Canaries	98.0	38.3
Anse Cochon	111.3	25.0
Anse Galet	114.6	21.6
Anse La Raye	116.7	19.6
Roseau	124.4	11.9
Marigot	126.5	9.8
Grande Cul DeSac	40.6	3.3
La Toc	42.2	1.4
Vigie	43.0	0.0
Choc	43.5	0.5
Almond Morgan	43.8	0.8
St. James	43.9	0.8
Labrelotte_1	44.2	1.1
Labrelotte_2	44.2	1.2
Trouya	44.3	1.3
Reduit	44.9	1.8
Rodney_1	45.4	2.4
Rodney_2	45.6	2.5
Pigeon Island	45.7	2.6
Smugglers Cove	45.9	2.8
Le Sport	46.2	3.1

Conclusions

Hewanorra International Airport (HIA)

i. No impacts are expected in the future due to the effect of storm surges/waves alone
ii. The combined effect of MSLR, episodic extremes and hurricanes may cause the eastern edge of the runway to flood; a 50-year ESL by the year 2100 under RCP 8.5 will inundate a length of about 160 m of the runway
iii. Projected increase in extreme heat days may have significant effects on the airport operations and energy costs

GFL Charles airport

i. Storm surge/waves at the Vigie Beach have resulted only in sand being swept across the road and onto the perimeter of the runway
ii. Under a 50-year ESL by 2100 (under RCP 8.5) superimposed by a hurricane the entire stretch of the Vigie beach is likely to be inundated

Conclusions

Port Castries

i. No damages have been reported by past storm events and ESLs, although floating debris reaching the port from the land have presented problems to berthing vessels
ii. The effects of a hurricane superimposed on the projected ESLs were studied and the results confirmed that the water level may rise above the elevation of the port, causing significant damages/flooding to the facilities

Port Vieux Fort

i. Resilient to storm surges and there have been no known incidents of flooding
ii. A Caribbean hurricane with the Thomas characteristics superimposed on projected ESLs will result to a SLR 1.2 – 2.4 m, causing damages/flooding to the port facilities and surrounding areas,
iii. CV & C may have significant effects on the energy costs of both ports due to the projected increase in extreme temperatures

Conclusions

- ✓ Modeling results for beach erosion/retreat project significant erosion and flooding under SLR from as early as 2040 under the combined effects of the projected MSLR and storm-induced sea levels
- ✓ By 2100, beach erosion from combined MSLR and storm events is projected to be very substantial with potentially severe impacts on both coastal infrastructure and tourism
- ✓ Under increasing beach erosion/retreat and flooding, the long-term recreational value of the Saint Lucia beaches as well as the value of associated assets may fall considerably
- ✓ Plans to respond effectively to the projected beach erosion risk should be drawn up with different adaptation options analyzed
- ✓ The connectivity of the major gateways of international tourism to the major tourist destinations of the island is under increased risk by the large density of landslides
- ✓ Impacts of an event of Thomas characteristics will disrupt access to major touristic destinations
- ✓ Access from HIA is generally at much greater risk than that from George Charles IA
- ✓ Redundancy : GFL Charles airport necessary to be operational

Acknowledgements

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