Ad Hoc Expert Meeting on

# Climate Change Impacts and Adaptation: A Challenge for Global Ports

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# The Vulnerability of Caribbean Ports to the Impacts of Climate Change: What are the Risks?

Presentation by

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# "The Vulnerability of Caribbean Ports to the Impacts of Climate Change: What are the Risks?"

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# Potential Economic Losses Without Action to Reduce the Impact of Climate Change

Potential economic costs as a percentage of GDP to Caribbean SIDS if no action is taken at the international level to reduce the impacts of climate change:

- By 2025 the average cost to the region will be 14 percent of its GDP
- By 2050 the average cost to the region will be 39 percent of its GDP
- By 2075 - 45 percent of GDP
- By 2100 - 63 per cent of GDP

# Importance of Caribbean Ports

- The open economies of the Caribbean are completely dependent on functioning ports:
- Importation of food, manufactured goods, petroleum products, transportation: CARICOM's current food import bill is approx. US $3.5 billion; petroleum products - approx. US $14 billion in 2008.
- Ports critical to the tourism product – cruise ships, coastal cruisers, yachts.
- Fisheries and related activities
- Berthing & airport landing fees - significant contribution to foreign exchange earnings.

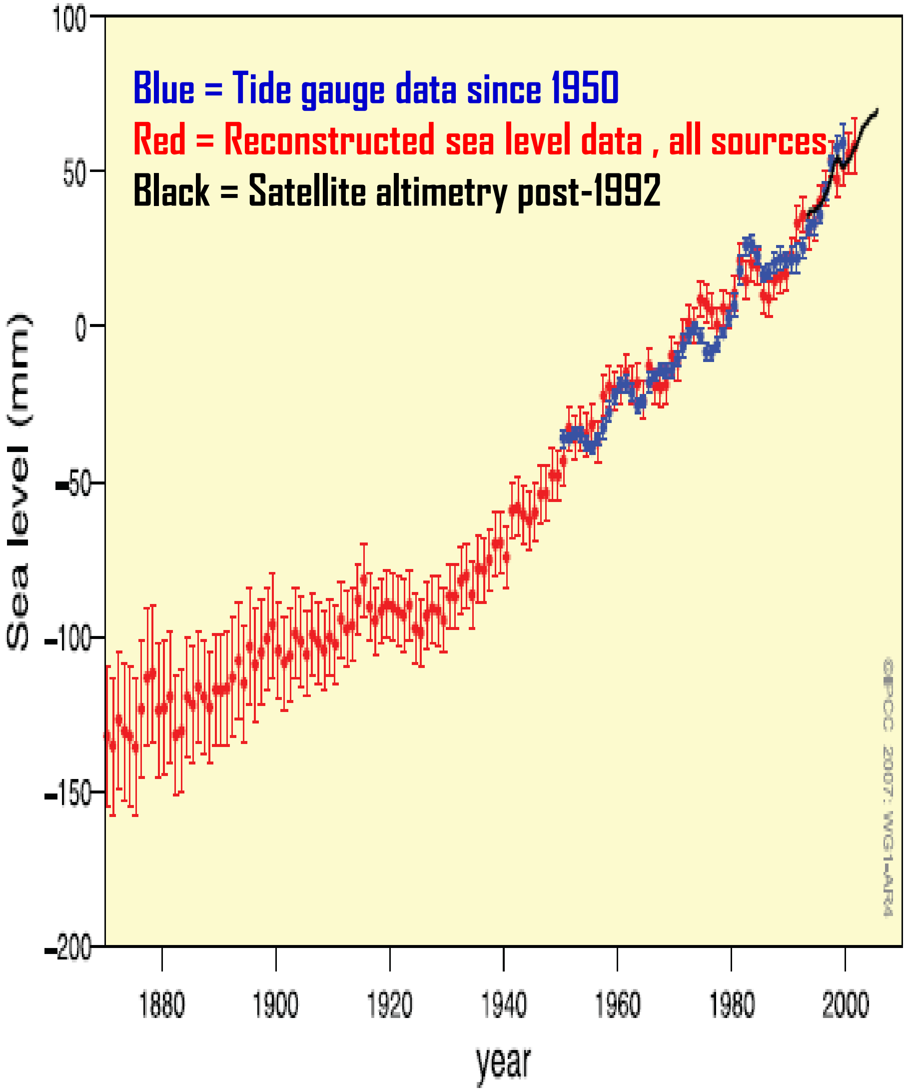
# Caribbean Risk Profile Consistent With Global and Hemispheric Reality

- GCMs project a consistent increase in surface air $^0$T for region, in coming decades, as shown in table.
- Both the observational records & model runs suggest a drying trend for many parts of region.
- Projections for increased wave energy due to due to stronger surface winds.

| 2010-2039 ($^0$C) | 2040-2069 ($^0$C) | 2070-2099 ($^0$C) |
|---|---|---|
| 0.5 – 1.0 | 0.80 – 2.5 | 0.94 – 4.8 |

# Why Are Caribbean Ports Vulnerable?

- IPCC SLR projections for the Caribbean → 0.13-0.56 m by 2090s relative to 1980-99.
- Studies since IPCC 4th Assessment → acceleration in rate of SLR – projections as high as 1.5m by the 2090s (e.g. Rahmstorf 2007, Rignot et al, 2008 Rohling et al, 2008)

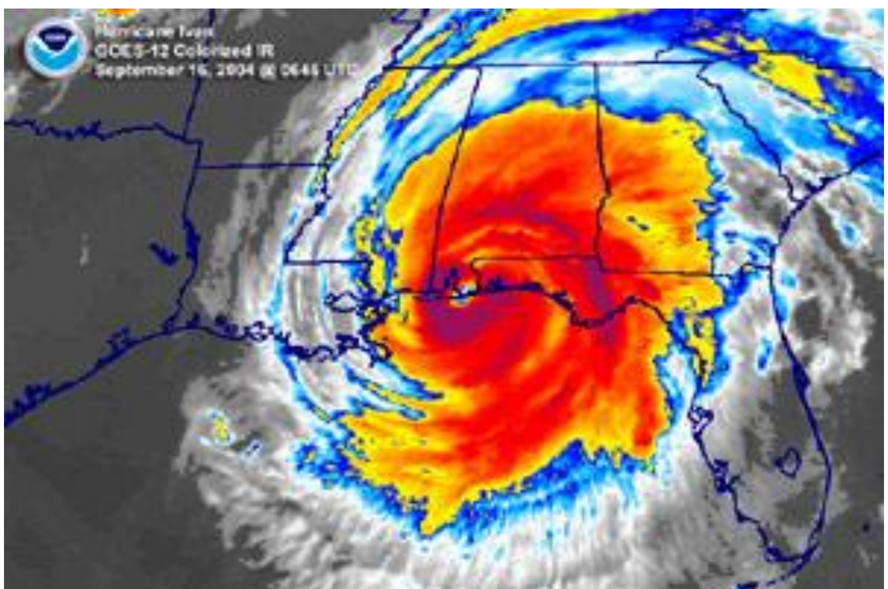


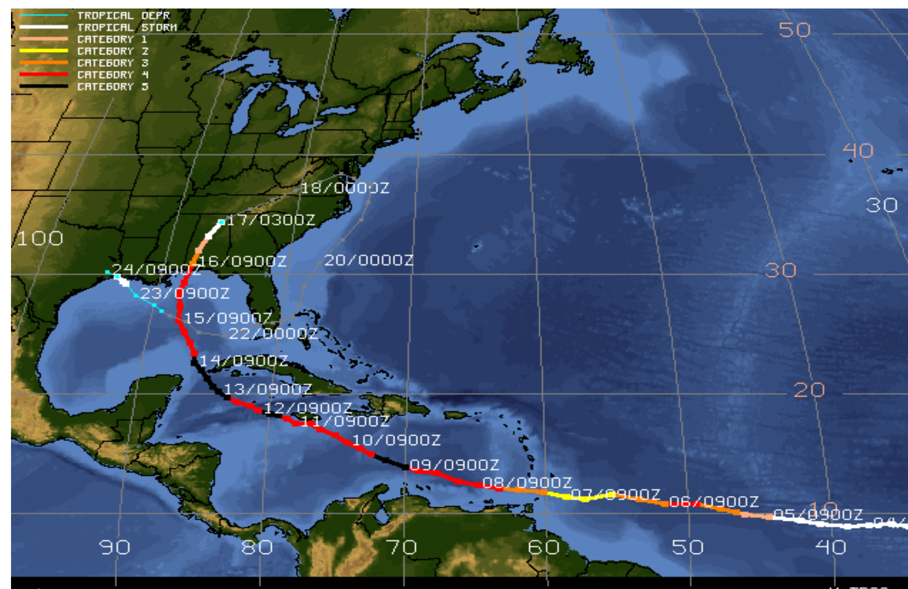
## Water Level Changes and Coastal Infrastructure

- Coastal structures very sensitive to changes in $H_2O$ level → key components are:
  - Astronomical Tide
  - Wave set up - increase in mean water level shoreward of the breaker zone, caused by flux of $H_2O$ at the shore
  - Sea level Rise
  - Sea Level Anomaly - measure of the difference between short- and long-term MSL → *negative* and *positive* anomalies

# Hurricane M*aximum Wind Intensity* Projected to Increase by at least 5-10 % by the 2050s

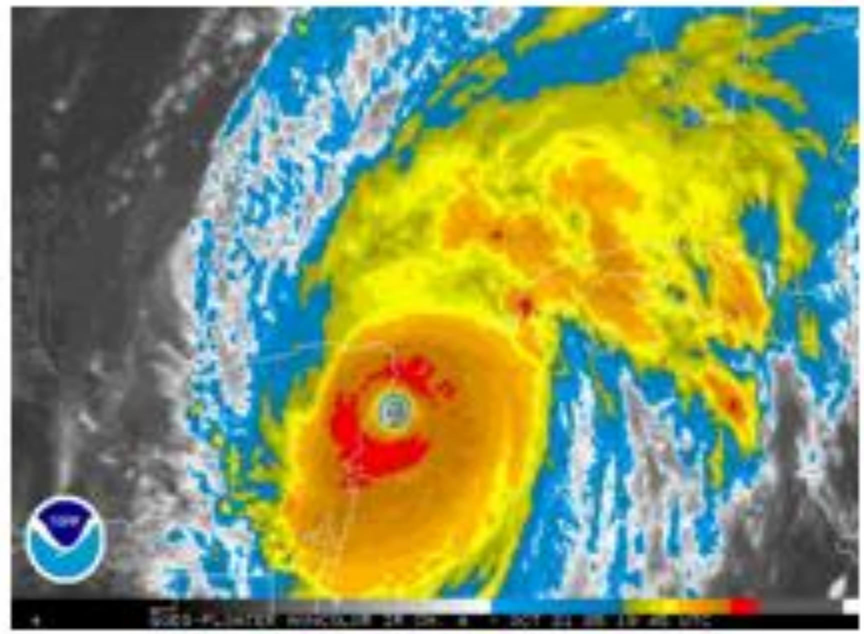
- Four major hurricanes impacted the Caribbean basin in 2004, causing more than US$ 5.0 billion.
- 27 named storms in 2005, 15 of which became hurricanes. An unprecedented 4 hurricanes reached category 5 status.
- Decade 2000 to 2009 experienced more category 5 systems than any other → Isabel (2003); Ivan (2004); Emily, Katrina, Rita, Wilma ( 2005); Dean and Felix (2007).



# Hurricanes developing at lower latitudes and becoming more intense in shorter times

Ivan developed near 8ºN latitude



Wilma developed from a tropical depression to the most intense category 5 hurricane in less than 24 hrs

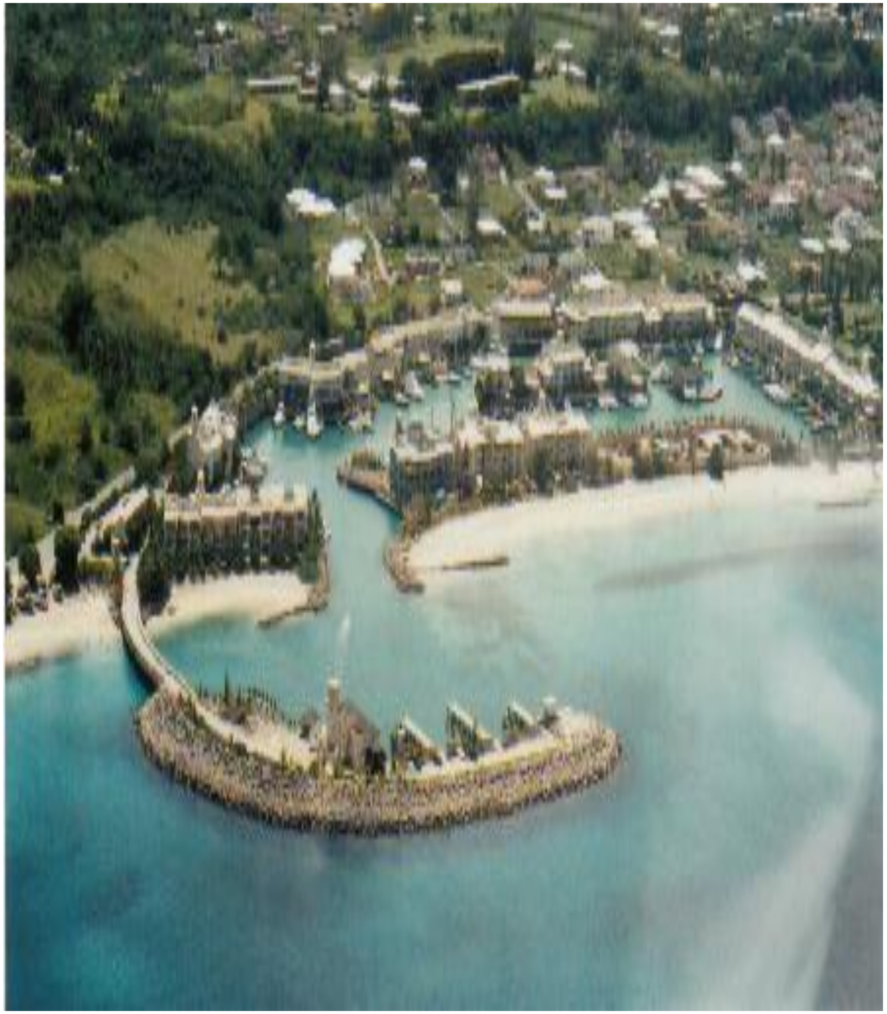
# Additional Risk Factors That Increase Vulnerability

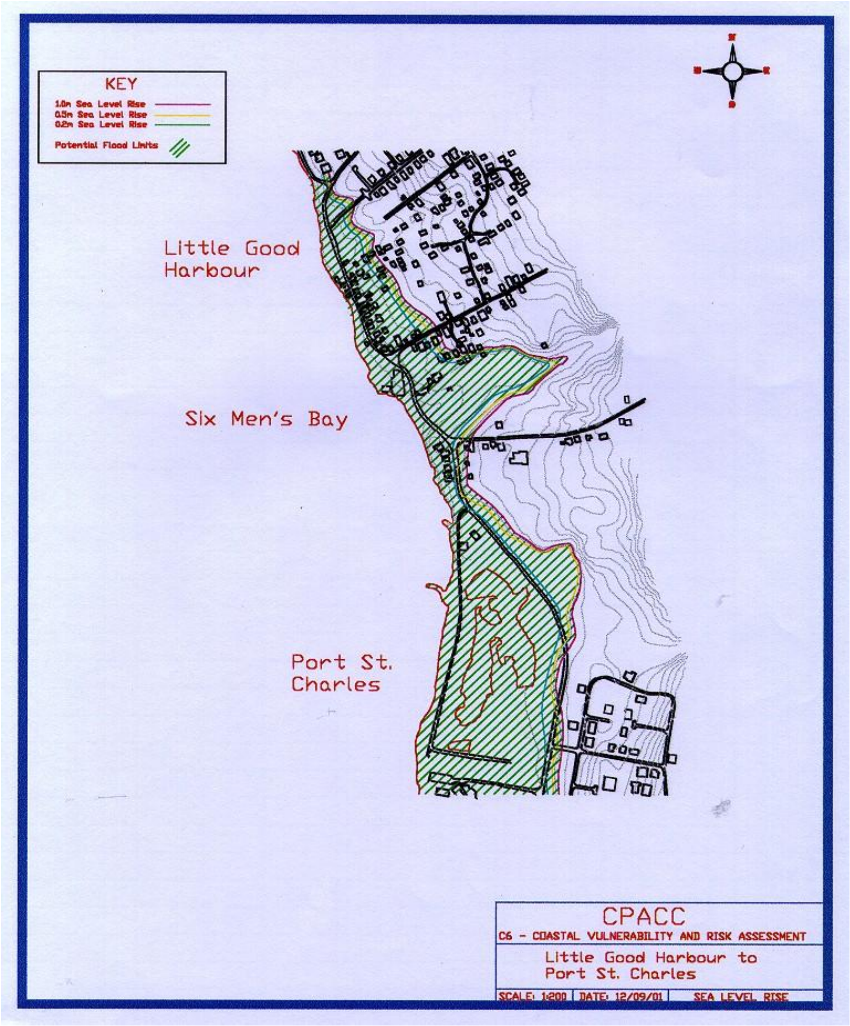
- Various non-climate factors also serve to exacerbate the impacts of climate change and climate variability in the Caribbean.
  - Land subsidence enhances the effect of sea level rise along coastal areas → increases the risks to coastal installations, including transport infrastructure – e.g. highways, air and seaports.
  - Subsidence is occurring at varying rates in a number of locations, e.g. parts of Georgetown, Guyana → 1.8 m (6 ft) below MSL.

**Georgetown, Guyana: Coastal Inundation: although not at risk from storm surge, the risks from SLR are considerable as Georgetown and its port are approx 1.0 m below MSL.**

**Since 1950 – *relative sea level rise approx. 10 mm* yr$^{-1}$.**

# Port St. Charles, Barbados





# Wind Damage

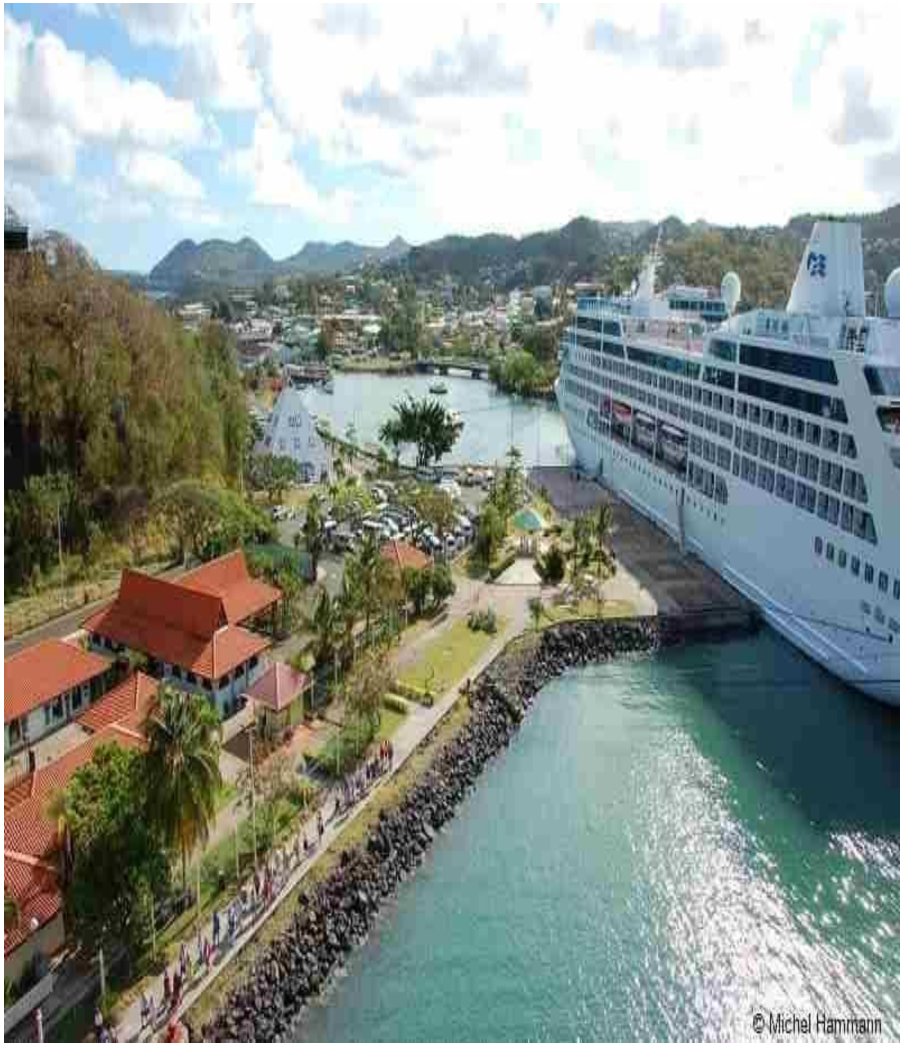
- In addition to SLR, storm surge and flooding, *wind* is also a critical risk factor.
  - During hurricanes → increased exposure of critical infrastructure, e.g. cranes, ro-ro equipment, storage/warehouses, incineration facilities, navigation equipment, anchorage, etc.
  - In 2004, Hurricane Ivan → great disruption to air and seaport installations in Grenada, restricting most operations to daylight hours. Ivan was a relatively '*dry*' hurricane → most damage caused by strong category 3 winds between 178-209km/hr (111-130 mph).

# Port of Nassau, Bahamas

- The Bahamas is highly vulnerable to SLR – 80% of country within 1.5 m (5 ft) of MSL.
- High exposure to Atlantic storms and hurricanes - can expect at *least one event every year*.

# Storm Surge Estimates - Castries, St. Lucia

- **1:25-yr - 0.3 m**
- **1:50-yr - 0.4 m**
- **1:100-yr - 0.6 m**

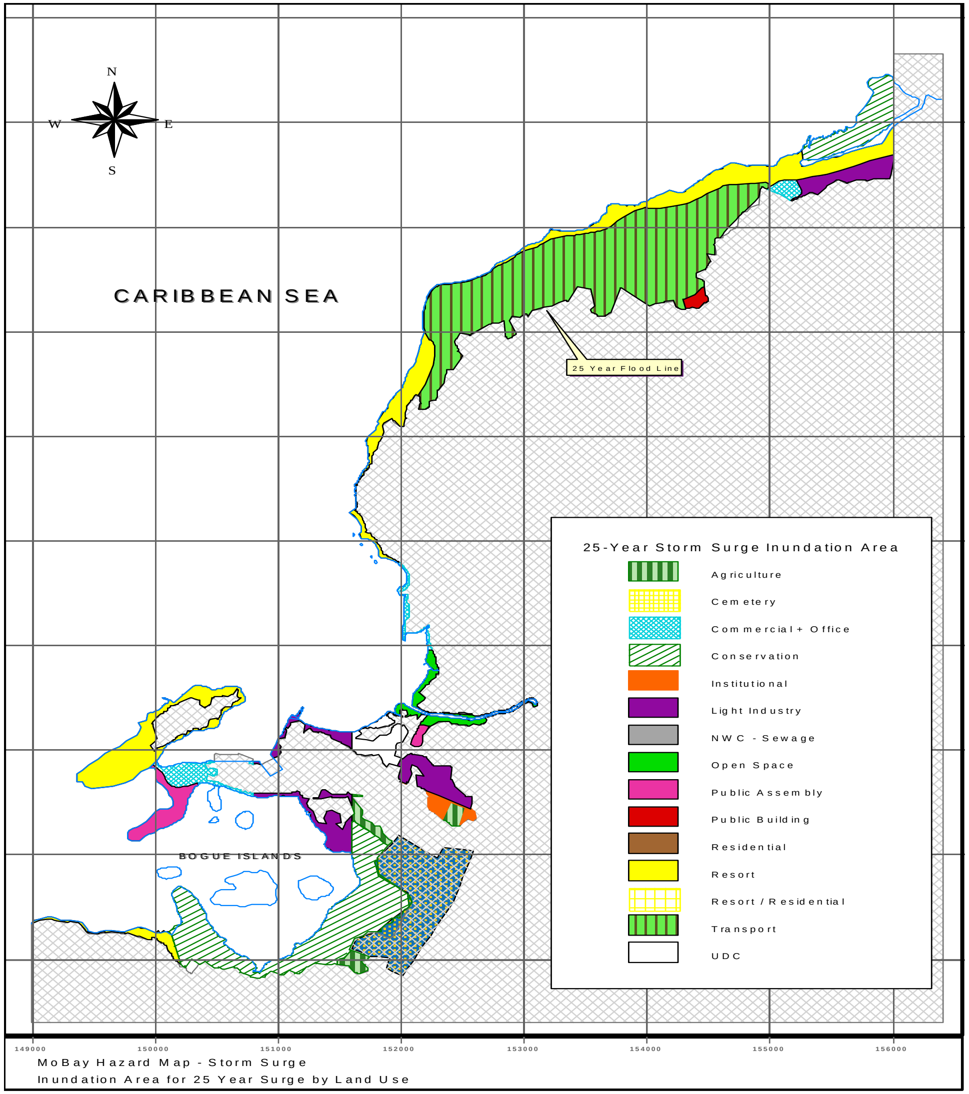


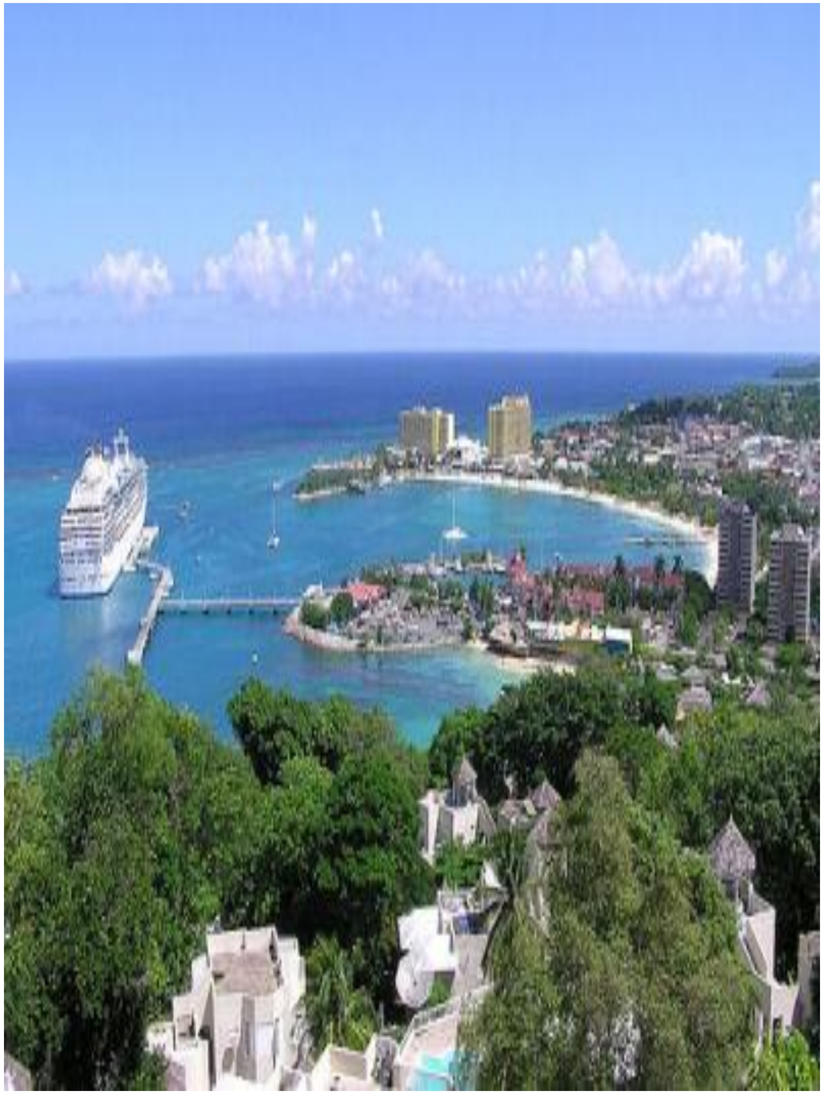

# Port Zante, St. Kitts

- The cruise ship pier was destroyed by Hurricane Georges in 1998. It was rebuilt in 1999 and destroyed by Hurricane Lenny in 1999.
- Now redesigned with massive revetment at eastern & western end to protect the bulkhead.

**Port of Kingston & Causeway, Jamaica – 26 $km^2$ of navigable $H_2O$; depth 18.0 m; elevation approx. 4.0 m amsl; Projected SLR 18 cm by 2025, 30-34 cm by 2050, 58-84 by 2100. Storm surge modeling - category 4/5 hurricanes → $H_2O$ levels 3-4 m.**

# Port of Montego Bay, Jamaica: Inundation Area For 1:25 Year Storm Surge



# Storm Surge Scenario - Barbados

Assumptions

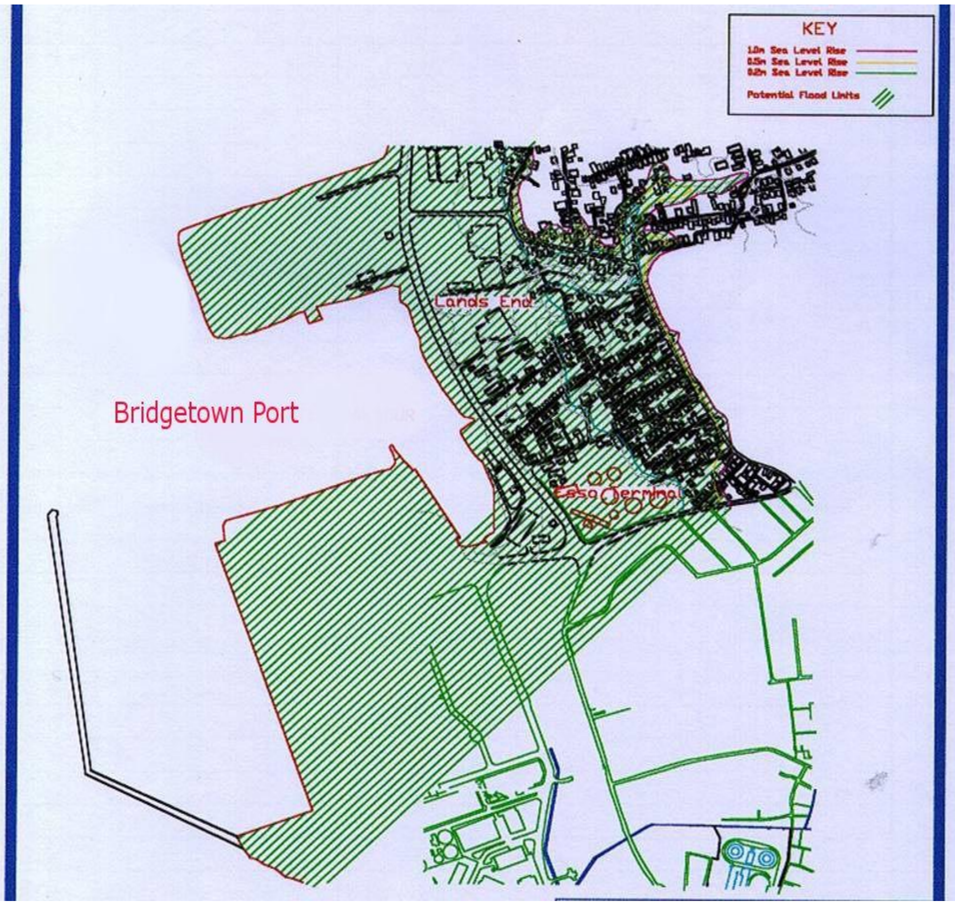
- 1: 100-yr event, i.e. a category 3 hurricane.
- Passage coincides with astronomical high tide.
- SLR of  0.5m (50 cm) relative to 1992 MSL.

Result

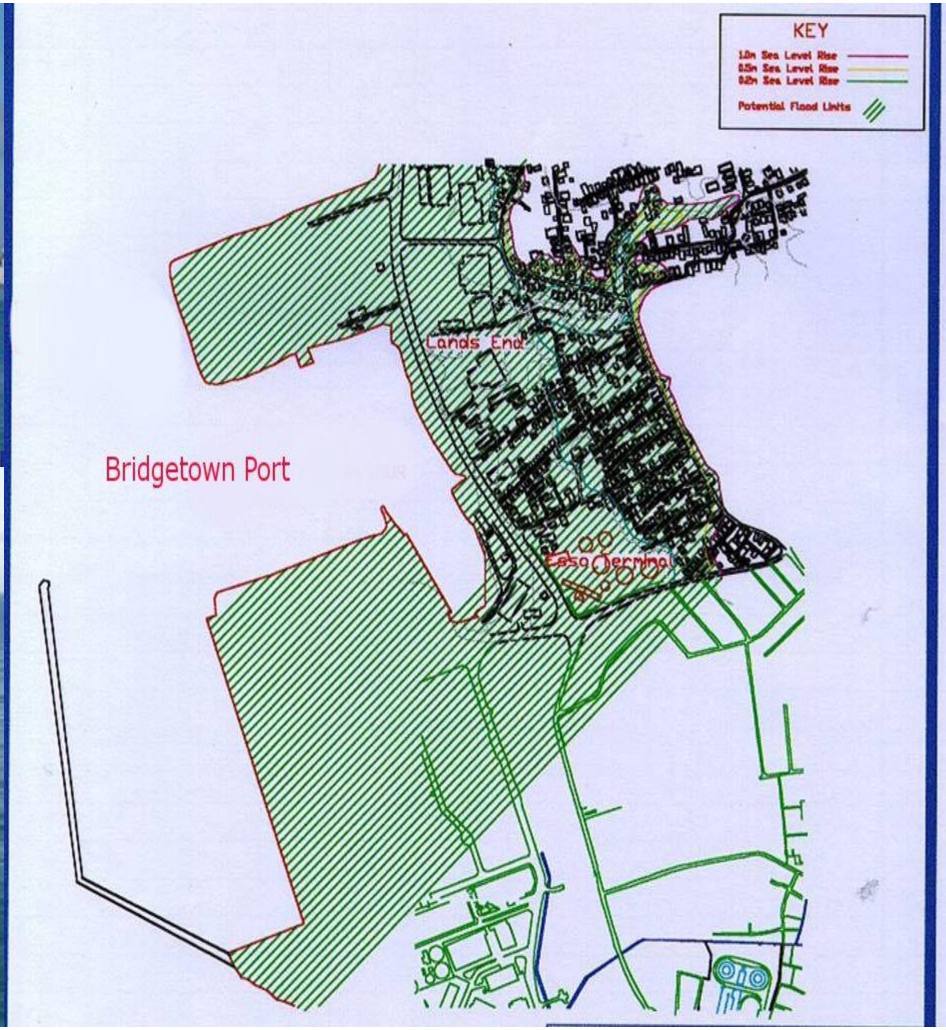
- Under the above scenario, storm surge inundation would extend150-300 m inland.


Barbados Inundation Zone

# Bridgetown Port, Barbados – High Vulnerability to vul




Bridgetown Port, Barbados. Right panel shows area within the precincts of the port that that would be inundated by a category 3 hurricane making landfall at astronomical high tide



# Possible Adaptive Responses for Reducing Climate-Related Risks to Port Infrastructure in the Caribbean

- *Infrastructural* → Improved protection of existing installations; re-design of at risk facilities, where feasible; build *flexibility* into design, so that adjustments can be made as more reliable data (and resources) become available.
- *Managerial & Operational: altered habits and choices* → e.g. reduced wastage of water & electricity in all aspects of port operations; some ports and ships already using desalination; some using solar photovoltaic panels to augment fossil-fuel based energy.
- *Government Policy* → Planning regulations; building codes, including coastal engineering design standards, e.g. minimum ground floor elevations for buildings/warehouses; incentives for use of renewable energy, as need for cooling & refrigeration increases with higher $^0$Ts; effective early warning and evacuation systems.