Climate Change Vulnerability Assessment and Adaptation Strategies

Ernesto L. Díaz, M.S., EEM
Marine Scientist - Director

2012
OVERVIEW

1. Puerto Rico Coastal Zone Management Program.
2. Climate variability and change in Puerto Rico.
4. Vulnerability Assessment
5. Future Scenarios and Adaptation Strategies.
The Puerto Rico Coastal Zone Management Program\textsuperscript{1} is a partnership led by the Department of Natural and Environmental Resources to promote the protection, conservation and sustainable development of coastal and marine areas and resources.

1. Adopted by Government of Puerto Rico and NOAA in 1978
Goals and objectives:

- Guide public and private development in the coastal zone
- Conduct active management of coastal and marine resources.
- Foster scientific research, environmental education and public participation as key elements of sustainable development.
ÁMBITO DE APlicación del PROGRAMA de MANEJO de la Zona Costanera de Puerto Rico
**RELEVANT STATISTICS**

Ernesto L. Díaz  
2012

**Emerged land area:** 3,508 mi² (9,497 km²)  
**Territorial waters:** 9 mn (10.35 mi)  
**Population:** ~3.8 millones (26th U.S.)  
**Coastal Population:** 2.73 millones (70%)  
**Urban areas at CZ:** 40%  
**Urban/coastline ratio:** 24%

**GDP:** ~$ 95.7 billion/yr

**Economy (2009):**

- **Manufacture:** 45.5%  
- **Finances, Insurance and Real Estate:** 19%  
- **Services:** 12.8% (Turismo: 7%)  
- **Government:** 9.7%  
- **Comerce:** 7.8%  
- **Transportation and Services:** 3.2%  
- **Construccion:** 1.9%  
- **Agriculture:** 0.7

*PRPB 2010*
Critical Infrastructure (CZ jurisdiction: 1 Km)

- Eight ports
- Eight airports
- Six Power Plants
- 1,080 miles of sanitary infrastructure
- 81 industrial parks
- 114 miles of primary roads
Population density

24% urban / coastline ratio
Climate Variability and Change in Puerto Rico

BACKGROUND:

- Scientific studies (Oceanography, Forestry, Wildlife biology, Marine biology, etc.)
- Greenhouse Gas Inventory (pre-Kyoto)
- Sea Grant roundtable
- Climate Change law and Executive Order creating a high level Advisory Commission.
- UPR- Carolina: Climate Change Summits
- Puerto Rico Climate Change Council
Climate Change Adaptation Project

Submitted by PRCZMP approved by NOAA-CSC (2010)

2010-2011: Vulnerability Assessment for three key sectors: coastal communities, critical infrastructure and coastal biodiversity.

2012: Adaptation Strategies (Recommendations, draft bills and proposed amendments to building codes and regulations)
Four Working Groups for the Puerto Rico Climate Change Council (PRCCC)
WG1: Historical trends and projections:

1. Atmospheric temperature
2. Precipitation
3. Extreme events (downpours)
4. Hurricanes
5. Sea surface temperature
6. Winter swells
7. Sea level rise
8. Ocean acidification
WG 2: Ecology and Biodiversity

1. Wetlands
2. Mangroves
3. Coral reefs
4. Beach systems
5. Submerged aquatic vegetation/sea-grasses (SAV)
6. Coastal lagoons
7. Estuaries
8. Keys and islets
9. Bioluminescent bays
10. Sea turtles
11. Fisheries
12. Marine mammals
13. Reptiles
14. Amphibians
15. Forests
16. Wildlife
WG 3: Economy and Society

1. Economic development
2. Energy
3. Tourism
4. Industry
5. Agriculture
6. Infrastructure
7. Coastal communities resiliency
8. Water resources
9. Historical and cultural resources
10. Emergency management
11. Health
WG 4

Communicating climate change and coastal hazards
Air Temperature

• On average, the temperature increased island-wide annually 0.014°C from 1970-1995.

• 12 stations out of 16 that covered throughout the island expressed positive trends from ~1948 to 2007.

• There is evidence of heat islands within Puerto Rico as well. Velazquez-Lozada et al. (2006) mention that the temperature of City of San Juan has grown at a rate of 0.06 °C over the past 40 years.

• Therefore, Puerto Rico is getting a little warmer which is consistent with regional (Caribbean) and global trends.
• Analysis dates (roughly 1948 to 2007):
• Preliminary trend analysis shows that no clear trends can be established for the total annual rainfall at the island, since many stations show increased (14 stations), others show a decrease (12 stations), and some do not show trends.
• Even though a single standard for the whole island cannot be determined, slight changes in spatial distribution can be observed.
• Southern region expressed positive trends in annual rainfall.
• Western region expressed negative trends in annual rainfall.
• North-central regions and eastern region of the island – no clear pattern.
• There are observed seasonal trends. Summer rainfall has expressed negative trends in almost 25 out of 36 stations (70%) with no significant change in autumn and spring.
The mean sea level trend is 1.35 millimeters/year with a 95% confidence interval of +/- 0.37 mm/yr based on monthly mean sea level data from 1955 to 2006 which is equivalent to a change of 0.44 feet in 100 years.
The mean sea level trend is 1.65 millimeters/year with a 95% confidence interval of +/- 0.52 mm/yr based on monthly mean sea level data from 1962 to 2006 which is equivalent to a change of 0.54 feet in 100 years.
San Juan Monthly Mean Sea Level 1962-2010

\[ y = 0.001x - 3.156 \]

0.414 m (2100)
Sea Surface Temperatures (SSTs) - CariCOOS

SST data from CaTS. The trend of SST trend between 1993 and 2007 was linearly estimated at 0.026 (+/- 0.01) degrees Celsius per year.

SST anomaly data from OI.v2 SST product for the CaTS region (Northeastern Caribbean) from 1982 to 2011. A linear fitting of the data yields a slope of 0.023 degrees (+/- 0.002) Celsius per year.
Coastal Inundation

SLR

Increased salt water intrusion to ground water aquifers

Impacts to water supply – water insecurity
Damage to roads
Impacts to port and airport operations
Temporary or permanent interruption of operations

High replacement cost of infrastructure or permanent loss of infrastructure
Erosion

Beach loss

Damage/potential loss of beach front properties, hotels, etc.

Loss or revenue from Tourism and Real Estate

SLR
## Effects of relative sea level rise: climate and non-climate factors (from Nicholls, 2002).

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<th>Other relevant factors</th>
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<td>Wave and storm climate, morphological changes, sediment supply</td>
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<td>Rainfall</td>
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<tr>
<td>Rising water tables/impeded drainage</td>
<td>Rainfall</td>
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</table>
Coastal Features and Ecosystems Update

Ecotone Identification Sampling Points

Lidar Coastal Profiling

National Wetland Inventory Review
Currently, not enough is being done to manage and protect our coastal resources.

"(7) Global warming results from the accumulation of man-made gases, released into the atmosphere from such activities as the burning of fossil fuels, deforestation, and the production of chlorofluorocarbons, which trap solar heat in the atmosphere and raise temperatures worldwide.

Global warming could result in significant global sea level rise by 2050 resulting from ocean expansion, the melting of snow and ice, and the gradual melting of the polar ice cap.

Sea level rise will result in the loss of natural resources such as beaches, dunes, estuaries, and wetlands, and will contribute to the salinization of drinking water supplies.

Sea level rise will also result in damage to properties, infrastructures, and public works.
Percepción pública:

- UMET: 1997
- PMZC: 2009 (8 municipios)
- Caribbean Business-WOSO-Gaither: 2011
- Yale-G.Mason: 2011
Highest Belief in Global Warming
Most Concerned, Most Motivated

Proportion represented by size
Source: Yale Project on Climate Change Communication

CARIBBEAN BUSINESS
Knowledge is Profit.
Puerto Rico is at risk from:

- Continuing development in high hazard areas
- Elimination of dunes, reefs, mangroves and other naturally protective features
- Poor maintenance of existing shoreline stabilization structures
- Poor maintenance and dredging of rivers, canals, and reservoirs
- Poor maintenance of storm-water management systems
- Poor soil management practices on land and coastal watersheds.
Natural ecosystems at risk from sea-level rise are undervalued or ignored in traditional economic analyses (i.e., wetlands, dune loss or beach changes) - Improved methods for future studies are needed.

Local governments should conduct detailed studies to better understand the potential impacts of sea-level rise in their communities.

Future development should be limited in areas that are at risk from rising seas.

Current efforts to build, maintain, or modify structures in coastal areas at risk of sea-level rise should be based on estimates of SLR.

Climate change knowledge and projections must be integrated into the design of all coastal structures.
MODELING ASSETS (NOWCASTS AND FORECAST),

• CaRA and UPRM have jointly established the Alliance for Numerical Modeling and Coastal Forecast. DNER-PRCZMP has contracted the Alliance to perform Coastal Zone inundation modeling using ADCIRC, SWAN and COULWAVE.
• Coastal winds, WRF -CaRA/UPRM, S. Strippling NWS-SJ)
• Coastal waves, SWAN (CaRA-UPRM, – UniNorte)
• Storm surge-inundation ADCIRC (CaRA-UPRM); UPRM, Renaissance Institute and DNER-PRCZMP.
How have we gotten here?  
...and next steps!

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Coordination Techniques of the Puerto Rico Climate Change Council

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Puerto Rico Cambios Climáticos/Climate Chang Listserv (PR-CC-L)

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Discussions 9 of 20 messages view all

- Agenda and Documents for tomorrow's meeting
  By Kasey Jacobs - 11:18am - 1 author - 0 replies
- First document for April 8th Meeting
  By Kasey Jacobs - Mar 25 - 1 author - 0 replies
- Save the Date - April 6 - Puerto Rico Climate Change Meeting
  By Kasey Jacobs - Mar 23 - 2 authors - 1 reply
- A Growing Role for Social Sciences in Climate Change Dialog
  By Kasey Jacobs - Feb 22 - 1 author - 0 replies
- Free Webinar by FWS-OUT8041: Intro to Communicating Climate Change - A Webinar Series for Communicators
  By lilibeth_serr...@fws.gov - Feb 14 - 1 author - 0 replies
  By kjec...@dnr.gov - Feb 9 - 1 author - 0 replies
- RealClimate Blog by Climate Scientists
  By Kasey Jacobs - Feb 1 - 1 author - 0 replies
- Video Talk on Climate Change and Ocean Ecosystems by Ove Hoegh-Guldberg for NCSE
  By Kasey Jacobs - Jan 27 - 1 author - 0 replies
- New PR Coral and Global Warming article in Ecosphere
  By Kasey Jacobs - Jan 25 - 1 author - 0 replies

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VCAPS diagrams: Building blocks
Start with the management concern and the climate stressor
Add outcomes

There are many **outcomes** associated with *heavy precipitation*
- What happens to the socio-ecological system?
- Ask, “Why does the town care about heavy precipitation?”
- If we simply drew a diagram that went from *precipitation* to *flooding*, we’d be ignoring opportunities to manage causes of flooding or erosion (e.g., run-off).
The more detailed the causal chain, the easier it will be to identify and envision possible management actions.
Continue by adding consequences

- **Consequences** are implications of the **outcomes** that affect things that people care about. They exert some sort of loss or cost to things that people value.
  - individuals, communities, institutions, or ecosystems.
- Sometimes the distinction between outcomes and consequences is fuzzy. That’s OK!
Start asking:

- What about this place makes the town more or less vulnerable to these outcomes and consequences?
- What makes this (climate stressor, outcome, or consequence) better, worse, stronger, larger...?
WG 2 Coral Meeting
TALLERES PARA LA EVALUACIÓN DE RIESGOS ACTUALES Y FUTUROS EN LA ZONA COSTANERA

- Erosión
- Tormentas y marejadas
- Inundaciones fluviales y costeras
- Lluvias y sequías más intensas
- Efectos del cambio climático
- Estrategias de adaptación

6 de marzo de 2012
(Municipios costeros del norte)
Embassy Suites, Dorado

8 de marzo de 2012
(Municipios costeros del sur)
Ponce Hilton, Ponce

Ambos talleres serán de 8 a.m. a 4 p.m.

RSVP: 787-999-2200 x.2729 / 2730
### Examples of Outputs from Stakeholder/Expert Workshops

Table 4. *Risk assessment results from the infrastructure risk assessment workshop.*

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<th>Planning Area</th>
<th>Feature</th>
<th>Average Likelihood</th>
<th>Average Magnitude</th>
<th>Most Often Risk Category Answer</th>
<th>Average Risk Score</th>
<th>Climate Driver</th>
<th>Most Often Given Time Answer</th>
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<td>Habitat</td>
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ENCUESTA DE RIESGOS COSTEROS DE PUERTO RICO

* Required

**Nombre de su municipio** *

[ ]

**Población de su municipio** *

[ ]

**Actividades económicas de su municipio** *

[ ]
Communicating Climate Change and Coastal Hazards
PRCCC Working Group 4 Meeting

Friday, December 16th, 2011
9:00AM – 12:00PM
National Weather Service Office, Carolina, PR

RSVP by December 8th to kjacobs@drna.gobierno.pr

Come to discuss, learn, and decide on important issues for the Puerto Rico Climate Change Council

Special Guest Speaker: Andrew Revkin, The New York Times and Dot Earth Blog author will be video conferencing with us to offer advice and take questions on communicating climate change to decision makers and the public. Andy is one of the most respected and influential journalists covering climate change and other global environmental issues in the world.
Purpose:

To develop the communication’s plan for Puerto Rico’s climate change vulnerability assessment and decide on the next steps of Working Group 4.
Desired Outcomes: By the end of this meeting, we will have:

- Agreed upon main message, audience, and frame of a communication’s plan
- A collective understanding of where Puerto Rico needs to go in terms of communicating climate change and hazards
- Agreed upon types of information and graphics to be included in the final reports of the PRCCC
- Next steps of Working Group 4 to be conducted in 2012
Andrew Revkin
Conexión Natural - Parte 2

http://vimeo.com/27002734