



Caribbean Center for Rising Seas

Affiliated with:



A program of:



Puerto Rico
Science, Technology
& Research Trust

Climate Impacts on Puerto Rico

2023 Ocean Surface Topography Science Team Meeting

Fernando Pabón, AIA, CAAPPR

Director, Caribbean Center for Rising Seas

Puerto Rico Science, Technology & Research Trust



Caribbean Center
for Rising Seas

Affiliated with: **RISING
SEAS
INSTITUTE**
SMART SOLUTIONS FOR RISING SEAS

A program of:



Puerto Rico
Science, Technology
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**VISUALIZING
GOALS**



**CONTINUOUS
ENVIRONMENTAL
SCANNING**

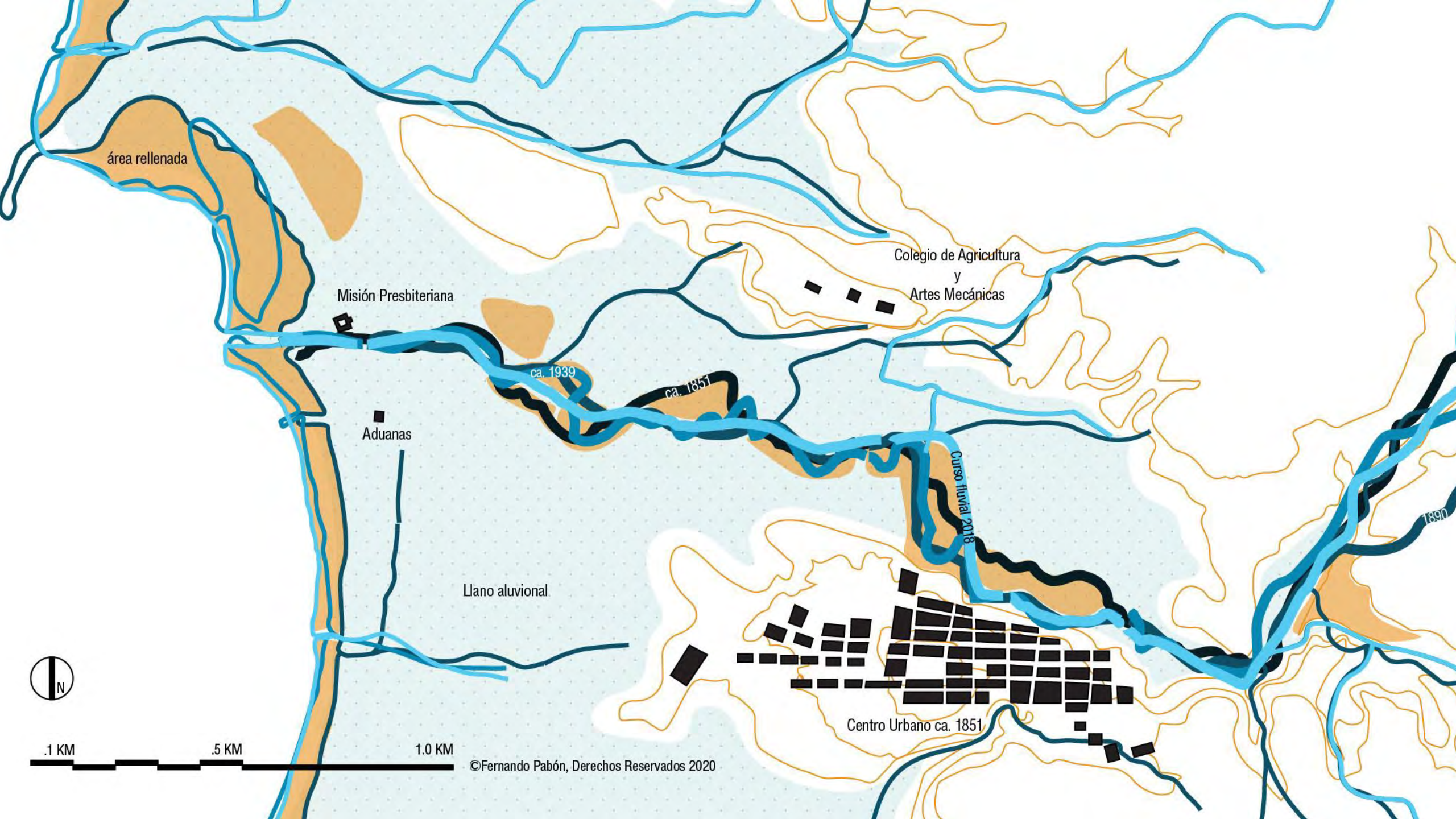


**ACTIVATING
ADAPTATION**



**QUESTIONING &
REFRAMING
POLICY**

The Case of Puerto Rico



An economically urgent task...

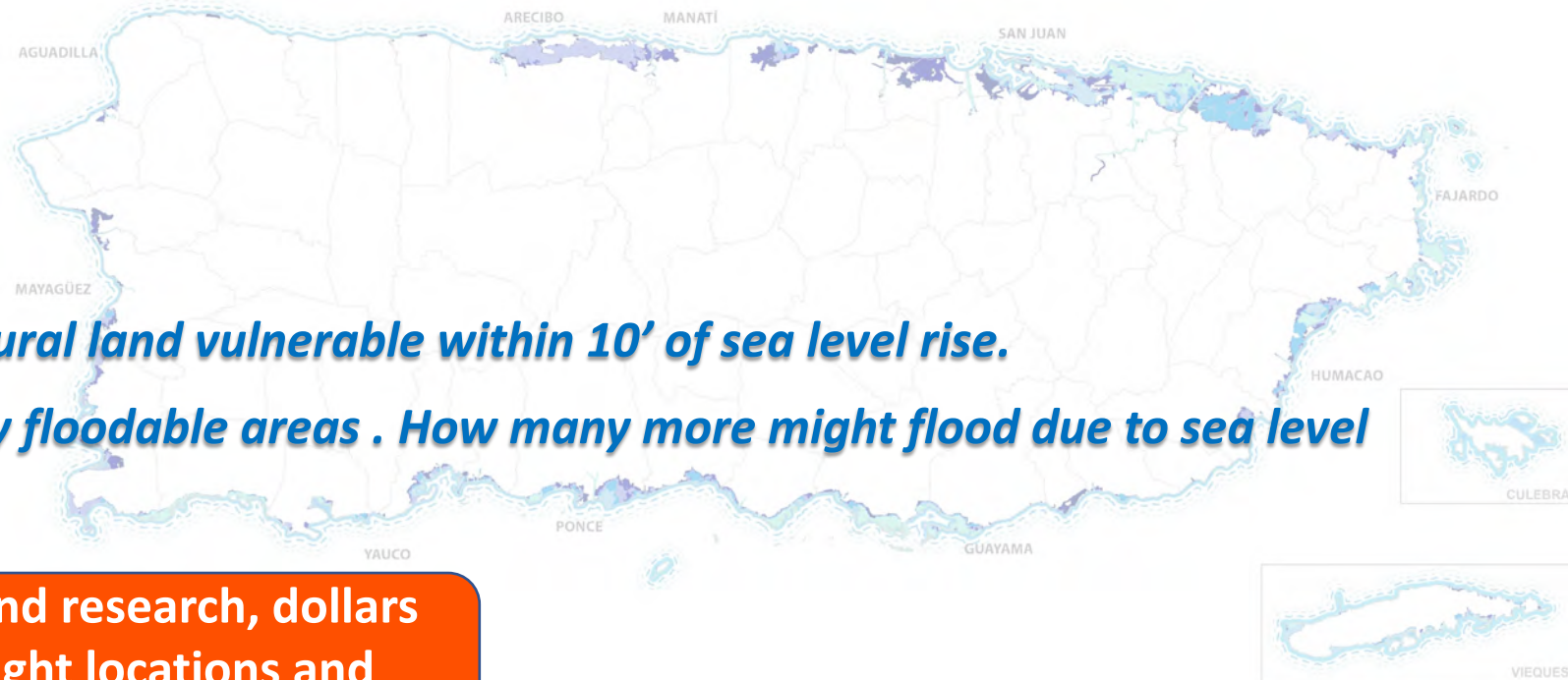
- ❖ **\$70,186.9 million USD** (PR's 2020 GNP), **\$103, 138.3 million USD** (PR's 2020 GDP)
- ❖ **\$2.5 billion in tourism activity per year**, mostly dependent on the shore...
- ❖ **Over 16 Billion USD in CDBG-DR program reconstruction efforts after hurricane María.**
- ❖ **\$1.575 Billion USD in slated USACE storm surge protection projects.**
- ❖ **\$139 Billion USD in estimated costs for recovery after hurricanes Irma & María.**

Unguided, these investments and economic activities are perilously limited to short term recovery and could become long term liabilities.

A geographically urgent task...

- ❖ **44 coastal municipalities,**
- ❖ **≈155 shore side barrios,**
- ❖ **≈799 miles of shoreline,**
- ❖ **Over 90 sq. Km of prime agricultural land vulnerable within 10' of sea level rise.**
- ❖ **Ca. 253,000 buildings in currently floodable areas . How many more might flood due to sea level rise?**

Without adequate study and sound research, dollars might not be delivered to the right locations and projects.



Tipo de riesgo: Aumento en el nivel del mar

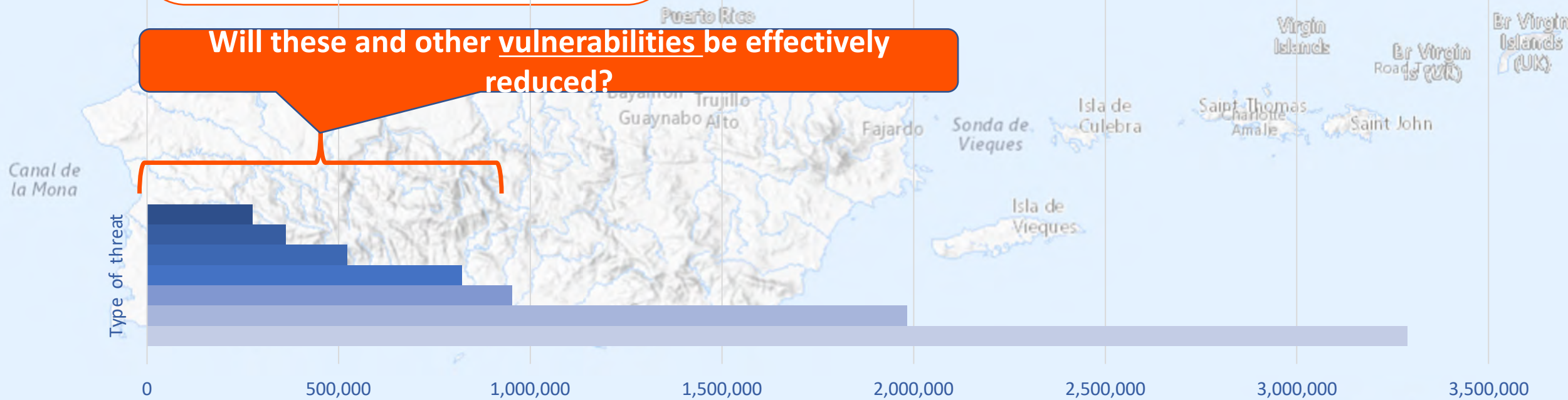


Population Vulnerabilities

- Vulnerable to Coastal Erosion
- Exposed to other types of coastal flooding
- Have experienced storm surge flooding
- Believe they are exposed to river based flooding
- Have experienced overflowing storm sewer flooding
- Inhabitants of Coastal Municipalities
- Total Population

A socially urgent task...

Will these and other vulnerabilities be effectively reduced?



A region at risk...

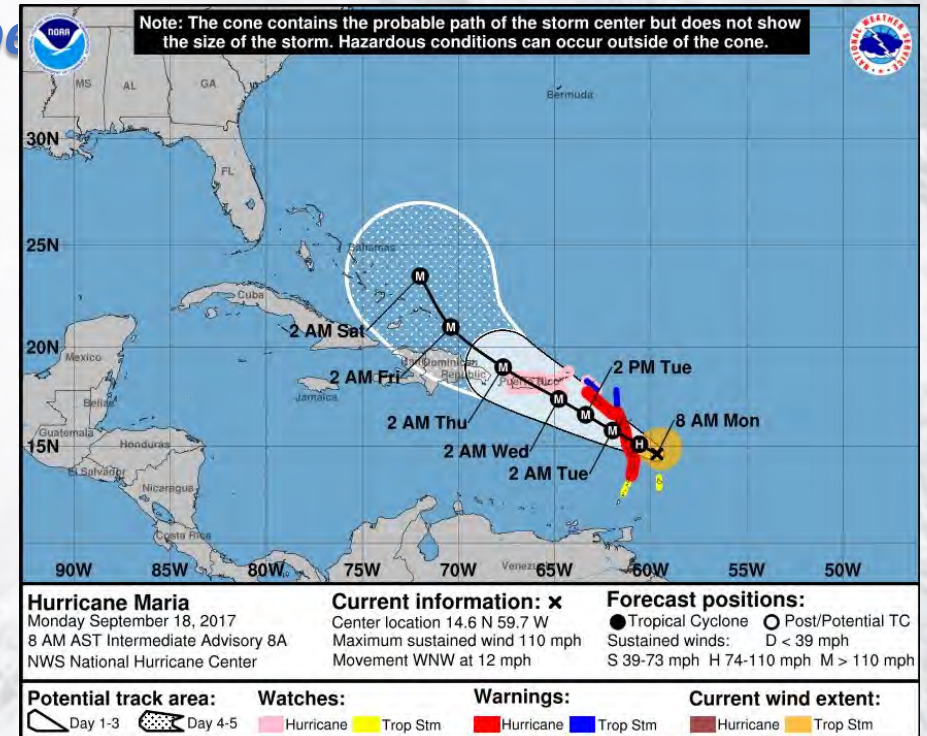
Hurricane Season - Early June through late November

Persistent Drought,

Aged, Fragile, Increasingly Outdated Infrastructure,

Prevalent Poverty,

Complex Politics...



A unique place...

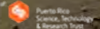


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for Rising Seas

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a program of



Our Mission



Help prepare Puerto Rico and the Caribbean to **adapt and thrive** in the new era of increasing flood risk from storms, tides, and sea level rise.



We facilitate, build capacity, and invest creating and promoting best practices for buildings, infrastructure, and communities.



We encourage **Resiliency** + **Adaptation** with a 100-year perspective among key stakeholders.



Storm Surge



High Tide



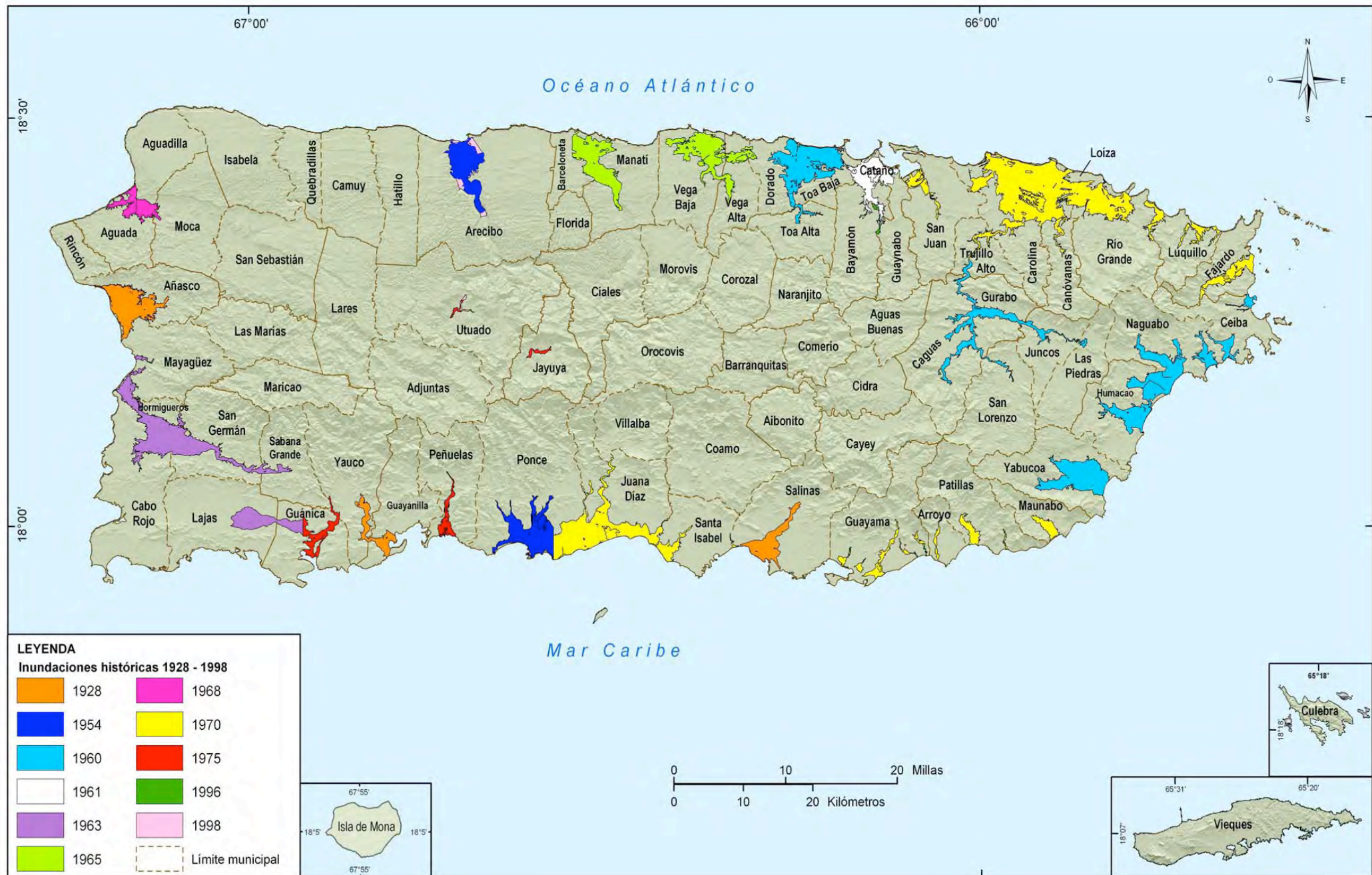
Runoff



Heavy Rain

COMBINATION

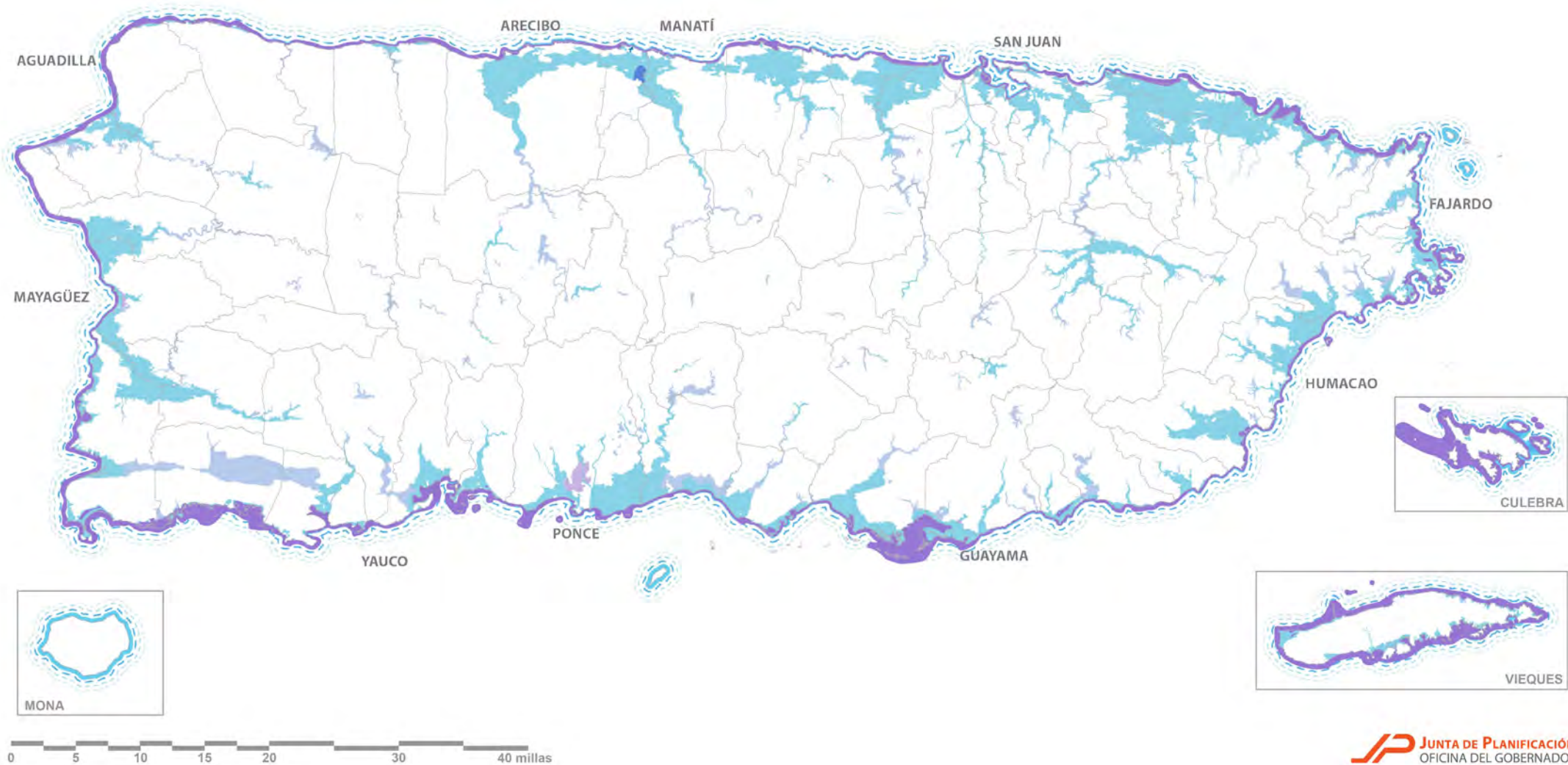




Temporary Flooding from Hurricane Fiona



MAPA 19. RIESGO DE INUNDACIÓN, ZONAS FEMA



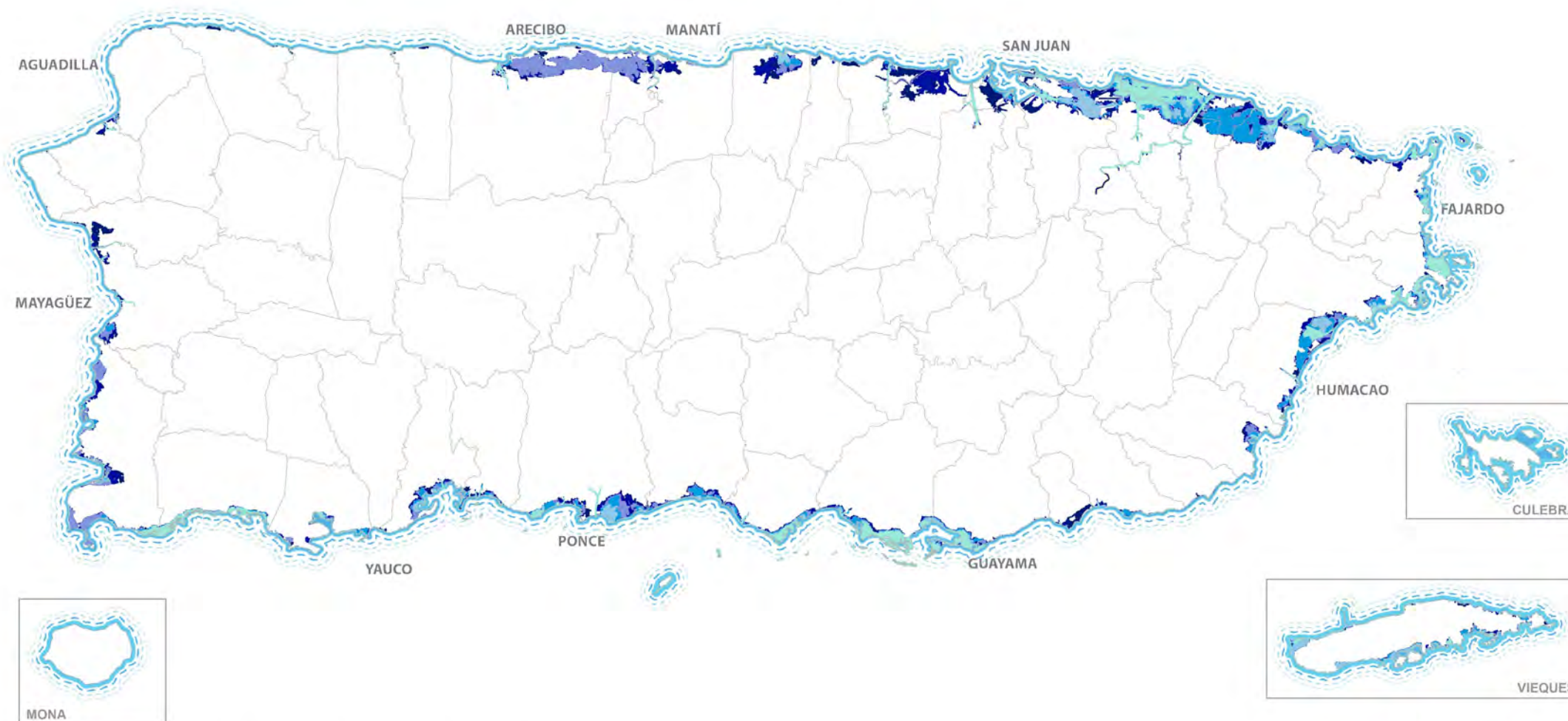
Tipo de riesgo: Inundación Zonas de inundación FEMA

- A – Alto riesgo de inundación. Establecida por métodos aproximados, no se ha determinado la elevación de la inundación base.
- A99 – Áreas a ser protegidas por proyectos de control de inundaciones.

- AE – Riesgo moderado a alto de inundación de 3 pies o más de profundidad. Determinada por métodos específicos. Se indican las elevaciones de la inundación base.
- AH – Riesgo moderado a alto de inundación de entre 1 a 3 pies de profundidad (por lo general áreas de estancamiento). Define la profundidad de la inundación base.

- AO – Riesgo moderado a alto de inundación de entre 1 a 3 pies de profundidad (por lo general flujo laminar en terreno inclinado). Define la profundidad de la inundación base.
- VE – Área costanera de alto peligro a inundación, con riesgos adicionales asociados con olas de tormentas. Se indican las elevaciones de la inundación base.

MAPA 21. RIESGO POR AUMENTO EN EL NIVEL DEL MAR



Tipo de riesgo: Aumento en el nivel del mar



Salt Water Intrusion is Advancing Inland



The Problem

Greater frequency and severity of floods threatens long term recovery and prosperity.

Sea level rise will keep increasing public welfare costs.

Public policy does not promote the coexistence of property, infrastructure, environment...

Coastal communities and businesses are already in jeopardy.

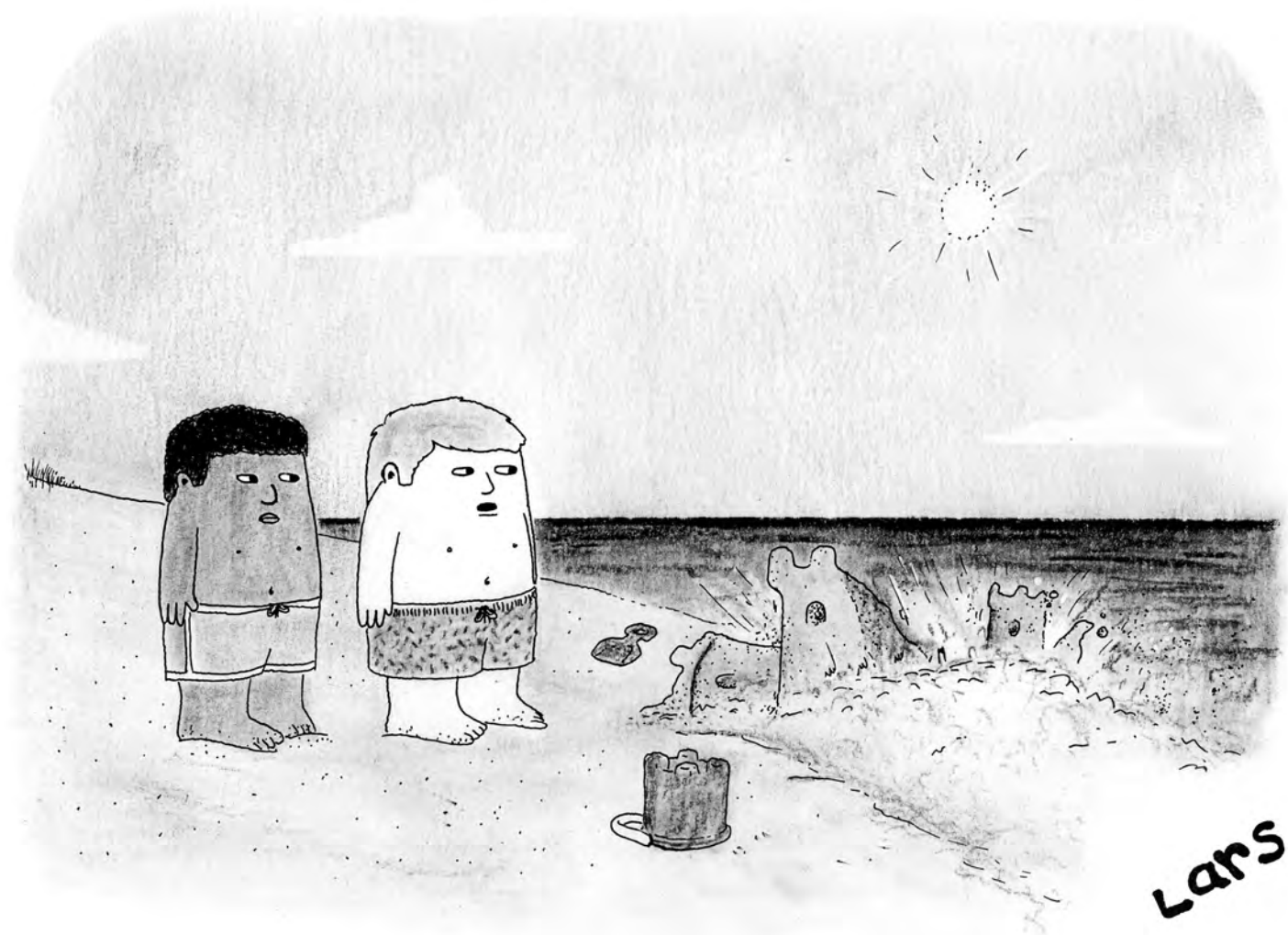
A limited awareness and understanding of this challenge.

A great opportunity for workforce and economic development and employing Resiliency + Adaptation to address unmet needs.



Caribbean Center
for Rising Seas

Partners: RISING SEAS, Caribbean Center for Rising Seas, Caribbean Center for Rising Seas, Caribbean Center for Rising Seas



*"It was inevitable, given how the kingdom ignored the warnings
of its climate scientists."*

Source: Lars Kenseth / The New Yorker Collection/The Cartoon Bank

Our Solution



Change urban development practices.

Update building codes, zoning and land use regulations.

Redefine professional knowledge and understanding of sea level rise and flooding.

Who does the project impact?



Policy is Evolving in Real Time

GOBIERNO

El gobernador Pedro Pierluisi declara una emergencia por la erosión costera

Para financiar los trabajos relacionados a la orden ejecutiva, el gobernador asignó \$5 millones de fondos ARPA y otros \$100 millones del "Programa de Mitigación en la Infraestructura" para sufragar el costo de las medidas recomendadas



This calls for a *Policy Reference and Resource Center* for smart building codes, zoning, and land use regulations



GOBIERNO DE PUERTO RICO
LA FORTALEZA
SAN JUAN, PUERTO RICO

Boletín Administrativo Núm. OE-2023-009

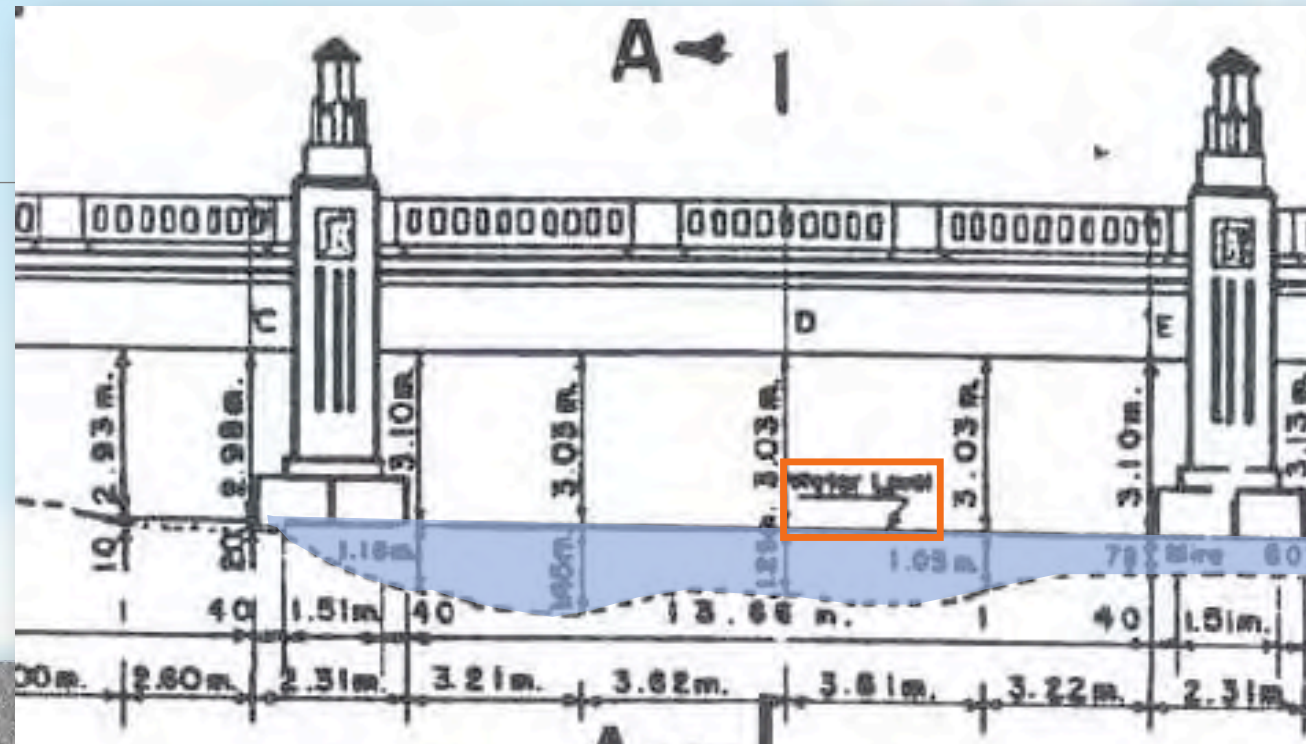
ORDEN EJECUTIVA DEL GOBERNADOR DE PUERTO RICO, HON. PEDRO R. PIERLUISI, PARA DECLARAR UNA EMERGENCIA COMO CONSECUENCIA DE LOS EFECTOS DE LA EROSIÓN COSTERA EN LA ISLA E IMPLEMENTAR MEDIDAS DE PREVENCIÓN, MITIGACIÓN, ADAPTACIÓN Y RESILIENCIA; Y OTROS ASUNTOS RELACIONADOS

POR CUANTO: El cambio climático es un fenómeno que se encuentra manifestándose de diversas formas en nuestra Isla y a nivel mundial. Entre sus efectos se encuentran periodos de sequía prolongados, incendios forestales más frecuentes, pérdida de flora y fauna, aumento del nivel del mar y la erosión costera, entre otros. Debido a la condición geológica de Puerto Rico, estos últimos dos efectos representan uno de los riesgos más inminentes a la Isla, por lo que deben atenderse con mayor prontitud.

POR CUANTO: El aumento del nivel del mar se define como un incremento en el nivel promedio del mar, el cual es ocasionado principalmente por la expansión térmica del agua al incrementar la temperatura en los océanos y mares. También es causado al derretirse capas de hielo que se encuentran sobre tierra y las concentradas en los cascos polares, así como por factores locales como erosión costera, subsidencia del terreno y marejadas ciclónicas. Como consecuencia de este aumento se han generado y continuarán generando daños que afectan la seguridad, propiedad y vida de todos los habitantes de Puerto Rico.

POR CUANTO: La erosión costera es la pérdida o desplazamiento de materiales de la corteza terrestre a lo largo de la costa debido a la acción del mar, por efecto del viento, escorrenia o infiltración subterránea, por factores naturales o causas antropogénicas. Como resultado de la erosión costera, Puerto Rico y sus habitantes actualmente sufren y continuarán sufriendo pérdidas económicas y patrimoniales incalculables, pues se afectarán obras de infraestructura, comunidades en su totalidad, flora y fauna, negocios pequeños, hogares, parques, facilidades recreativas, facilidades turísticas, zonas portuarias, zonas industriales, escuelas, estructuras naturales que sirven como barreras costeras y su recurso natural máspreciado, sus playas.

Research Observatory

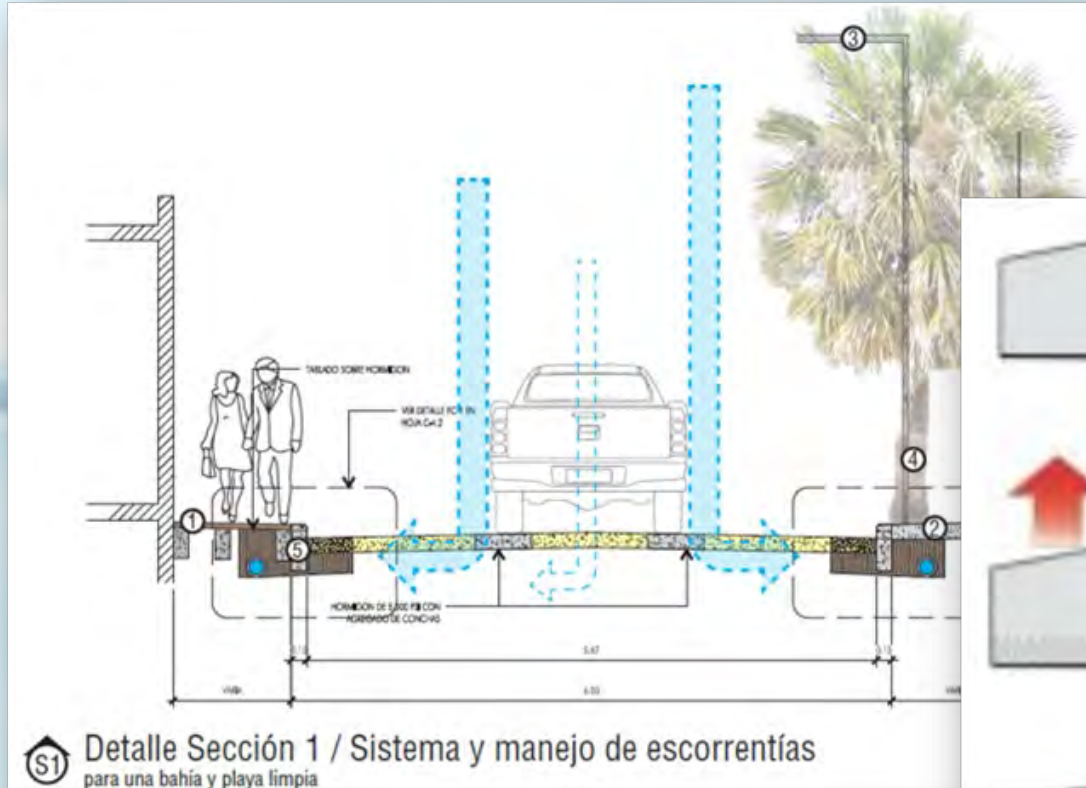


Are we still planning for the realities of 50 years ago? We should question if we are using the adequate premises in our planning efforts for the next 50 to 100 years.

Research on Best Practices



Case studies already exist of pioneering resiliency techniques and guidelines.



Research on Decision Support Tools

Benchmarks

Guide to Planning Height with Safety Margin per life expectancy of buildings and infrastructures

Risk Sensitivity	30 Years	50 Years	100 Years
LOW	1'	2'	7'
MEDIUM	2'	4'	
HIGH	3'	7'	

Reference year for this projection is 2020. The first column is approximated to 2050.

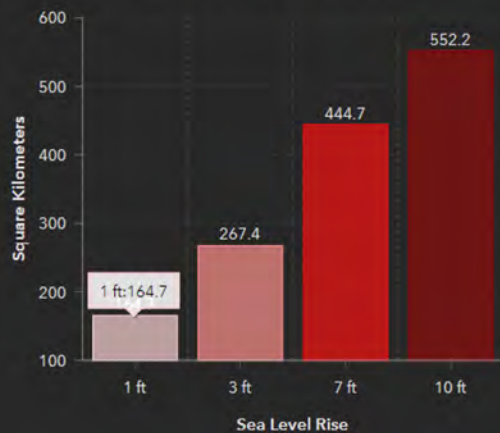
Source: John Englander



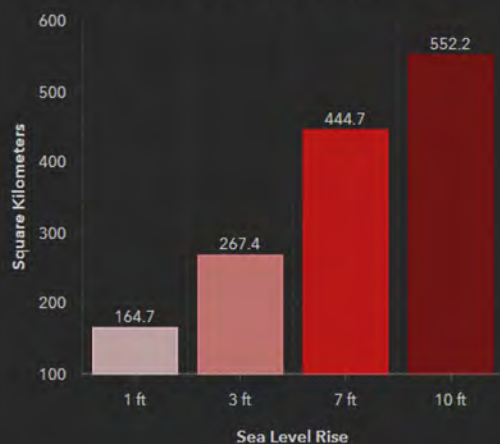
This might yield a methodology for creating Safe Advanced Flood Estimates (SAFE).



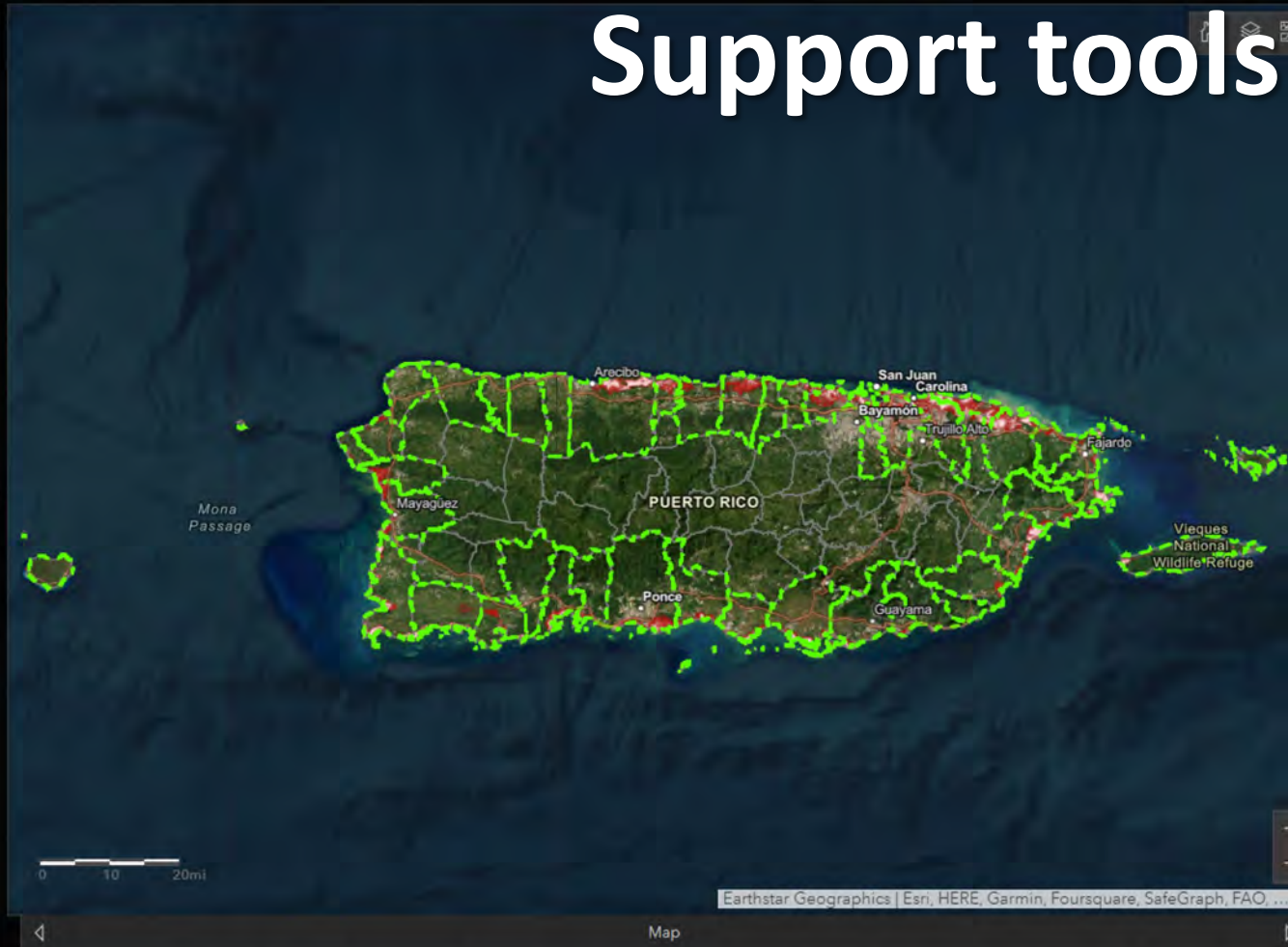
Land Loss in Puerto Rico Due to Sea-Level Rise



Land Loss in the Selected City Due to Sea-Level Rise



Support tools



Map Legend

Coastal Municipal Boundaries

Municipal Boundaries

SLR 1 ft

1 Feet=0.31 Meters

SLR 3 ft

3 Feet=0.91 Meters

SLR 7 ft

7 Feet=2.13 Meters

SLR 10 ft

10 Feet=3.04 Meters

Land Loss in Selected City: Acres (@10ft SLR)

≈136,439.3 🌊

Land Loss in Selected City: Sq Km (@10ft SLR)

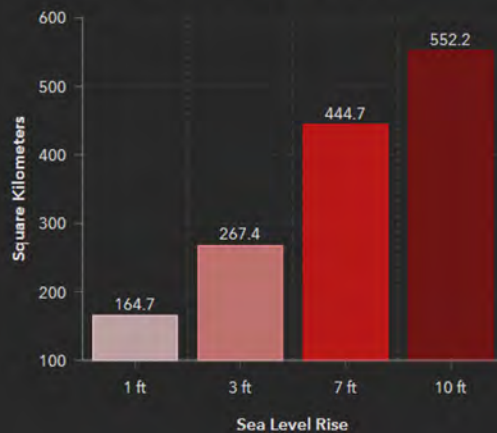
≈552.2 🌊

MAPA DE CLASIFICACIÓN DEL TERRITORIO

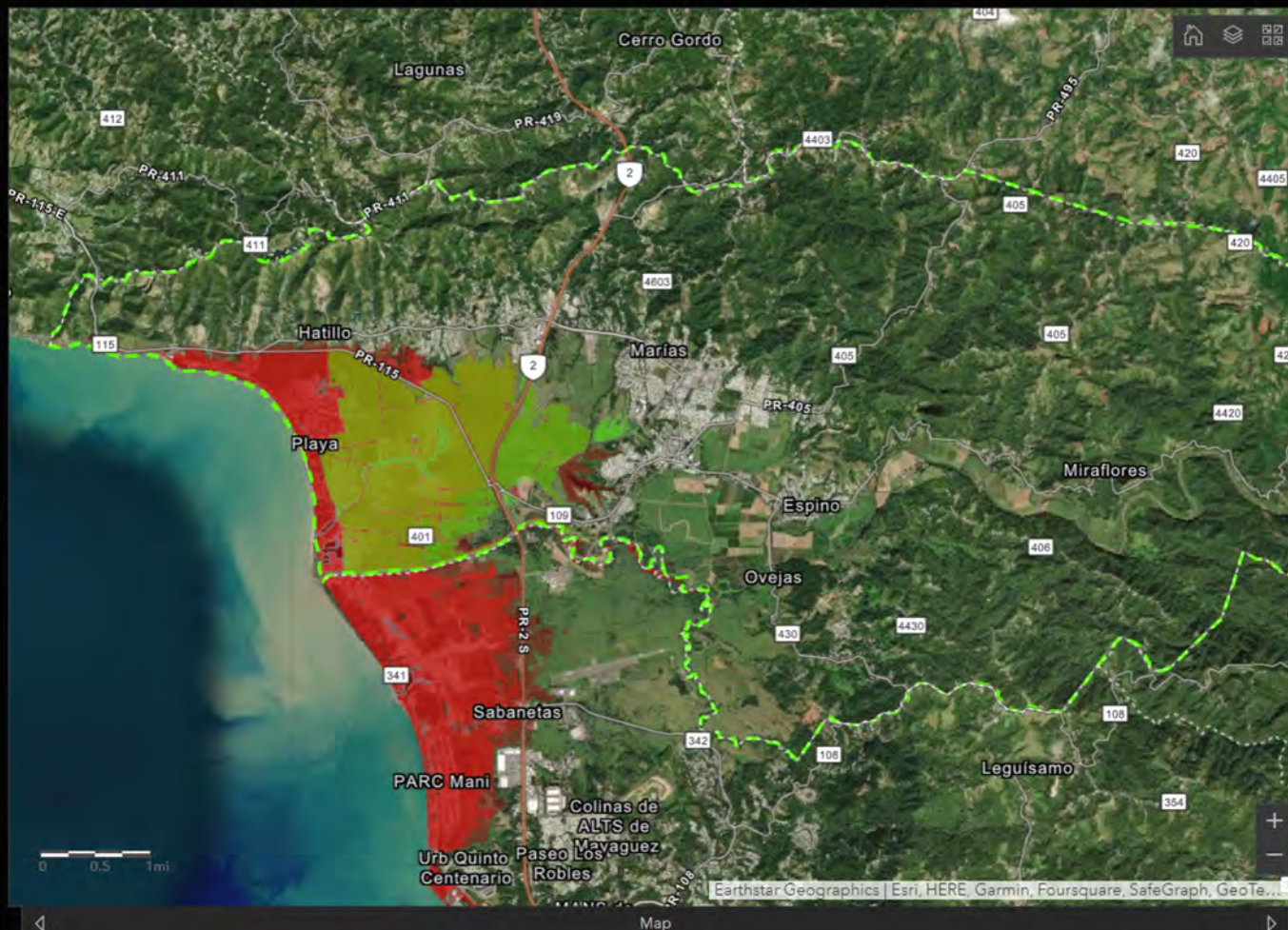
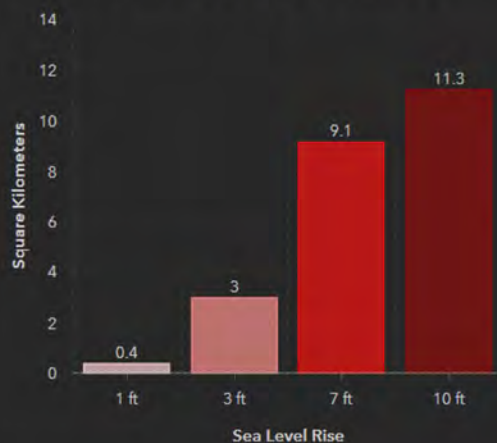


- | | | |
|-------------|---|--|
| Vial | SU - Suelo urbano | SREP - Suelo rústico especialmente protegido |
| Hidrografía | SURP - Suelo urbanizable programado | SREP - Hídrico |
| | SURNP - Suelo urbanizable no programado | SREP - Paisaje |
| | SRC - Suelo rústico común | SREP - Agrícola |
| | | SREP - Ecológico |
| | | SREP - Ecológico / agrícola |
| | | SREP - Ecológico / paisaje |
| | | SREP - Ecológico / hídrico |
| | | SREP - Agrícola / ecológico |
| | | SREP - Agrícola / paisaje |
| | | SREP - Agrícola / hídrico |

Land Loss in Puerto Rico Due to Sea-Level Rise



Land Loss in the Selected City Due to Sea-Level Rise



Map Legend

Coastal Municipal Boundaries

Municipal Boundaries

Infraestructura (polígonos)

Suelo Rústico Especialmente Protegido Agrícola

SLR 1 ft

1 Feet=0.31 Meters

SLR 3 ft

3 Feet=0.91 Meters

SLR 7 ft

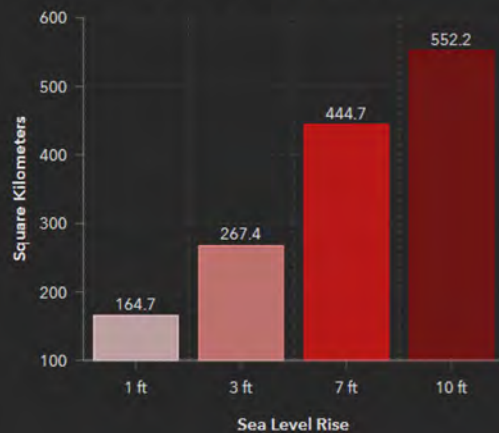
Land Loss in Selected City: Acres (@10ft SLR)

≈2,780.6

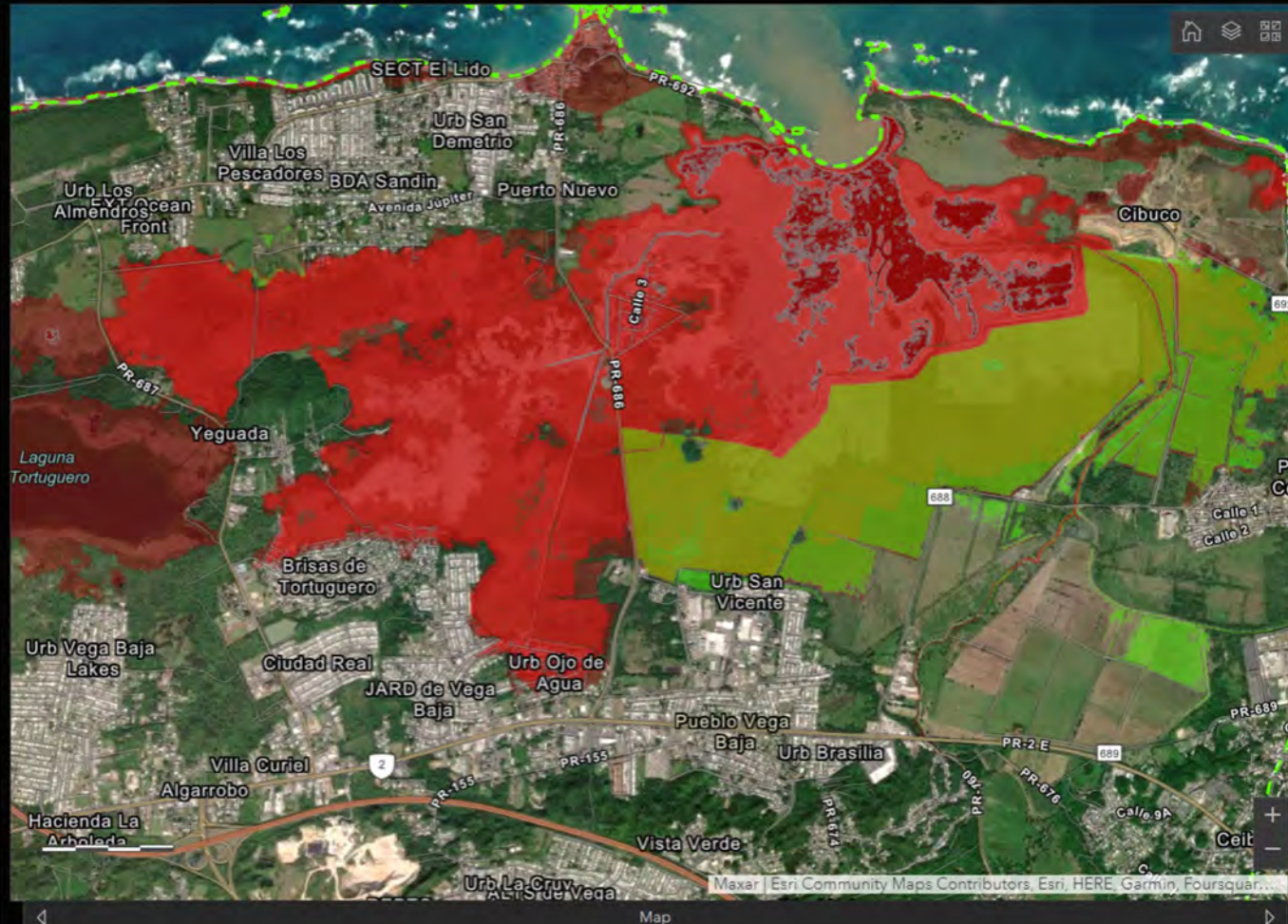
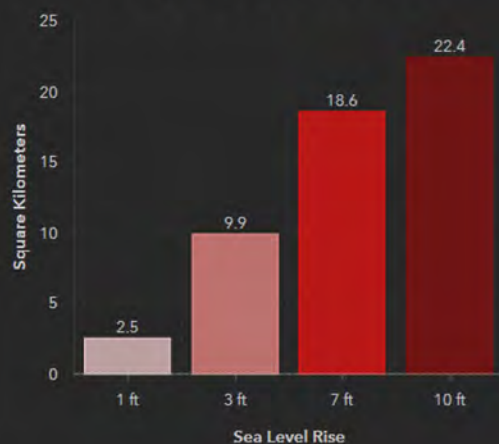
Land Loss in Selected City: Sq Km (@10ft SLR)

≈11.3

Land Loss in Puerto Rico Due to Sea-Level Rise



Land Loss in the Selected City Due to Sea-Level Rise



Map Legend

Coastal Municipal Boundaries

Municipal Boundaries

Infraestructura (polígonos)

Suelo Rústico Especialmente Protegido Agrícola

SLR 1 ft

1 Feet=0.31 Meters

SLR 3 ft

3 Feet=0.91 Meters

SLR 7 ft

Land Loss in Selected City: Acres (@10ft SLR)

≈5,533.4

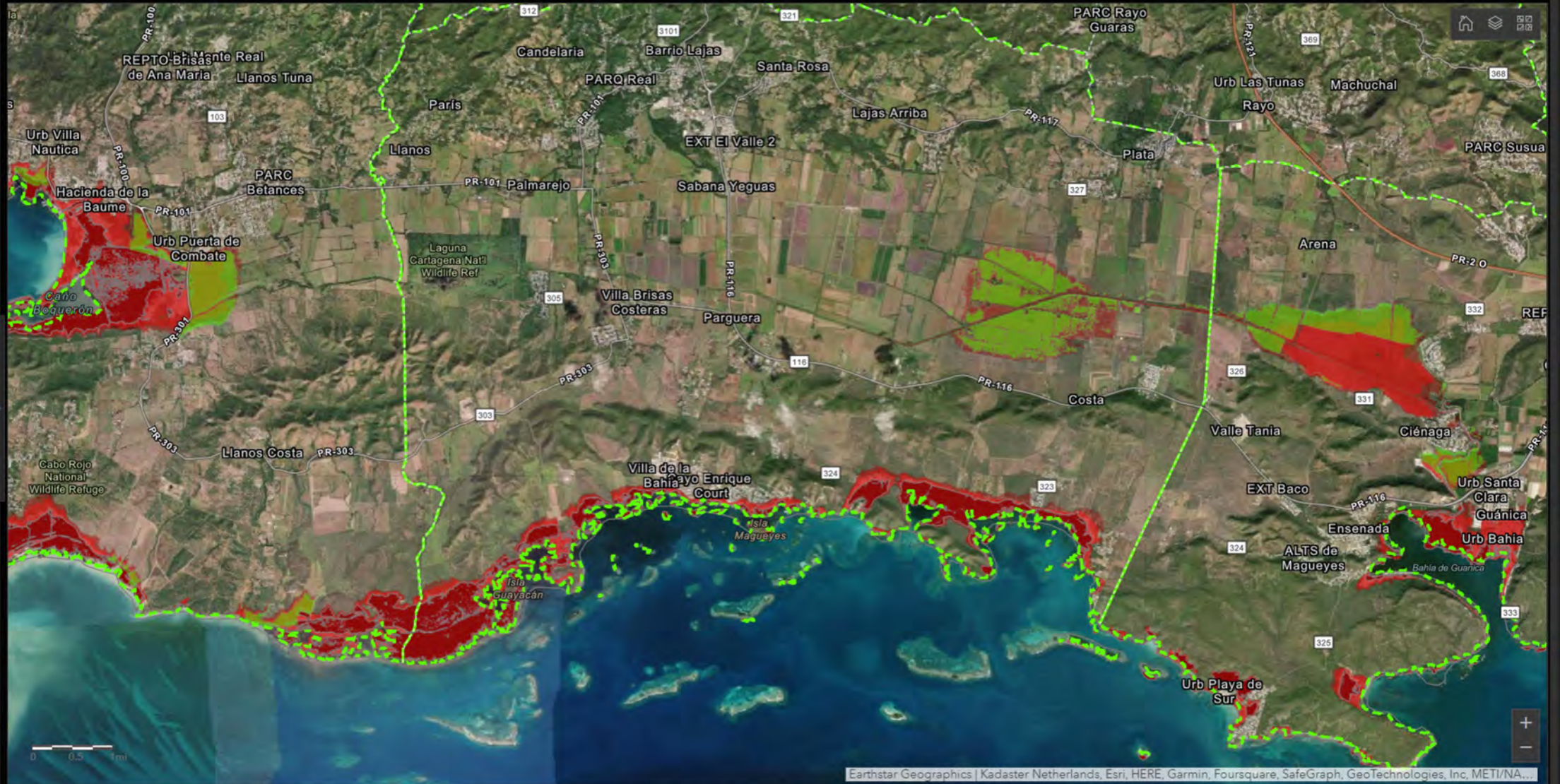
Land Loss in Selected City: Sq Km (@10ft SLR)

≈22.4

Sea Level Rise in Puerto Rico

Selected City None

Water Level 1 ft 3 ft 7 ft 10 ft



Map Impacted Infrastructure (points) Impacted Infrastructure (lines) Impacted Infrastructure (polygons) % of Agricultural Land at Risk % of Structures at Risk

94% of Puerto Rico is 10'+ from sea level



STAGES OF SEA LEVEL RISE

94% of PR is 10' above current sea level



Rethinking Next Steps, Timeframes, & Priorities

means:

Short Term: Increasing Water Storage and Drainage Capacity

- Horizontal Room for Water – Respecting Floodplains, Designing floodable areas
- Vertical Room for Water – Sponge-like landscape/percolating pavements, bioswales...

Mid Term: Increasing Redundancy and Resilience

- Checking and increasing clearances or Margins of Safety
- Lifting or enabling building Resilience and Adaptation

Long Term: Recognizing Growing Obsolescence of Available Tools

- Updating Building Codes, Zoning Regulations, and Planning Instruments
- Moving Inland, to Higher Ground

**A way to gradually manage change
and avoid disadvantageous
conditions.**

Education + Advocacy



Professionals must fulfill continuous education requirements focused on health, safety and welfare.



SEMINARIO

2 HORAS CONTACTO

Una mirada al calentamiento global desde los mapas de inundaciones

Miércoles, 30 de noviembre
3:00pm a 5:00pm

Teatro Ing. Salvador V. Caro, Colegio de Ingenieros y Agrimensores de Puerto Rico

La Ciencia del Aumento del Nivel del Mar

John Englander

Director Ejecutivo, Centro Caribeño de Aumento del Nivel del Mar
Presidente, Rising Seas Institute

La efectividad de los mapas de inundación ante el Cambio Climático y el Aumento del Nivel del Mar

Hanna Rodríguez Morales, SC

Ingeniera, Moderadora



Félix Aponte Ortiz
Planificador



Ruth Trujillo Rodríguez
Agrimensora



José Rodríguez Maldonado
Ingeniero

REGÍSTRATE



2 HORAS CONTACTO TÉCNICAS PARA INGENIEROS Y AGRIMENSORES

\$60 No Colegiado
\$30 Colegiado
\$15 Estudiante



Separa tu espacio a través de CIAPR: (787) 758-2250



Afiliado a: **RISING SEAS INSTITUTE**

Un programa del: **Fideicomiso para Ciencia, Tecnología e Investigación de Puerto Rico**

44ª ASAMBLEA ANUAL EXPO Y CONVENCION

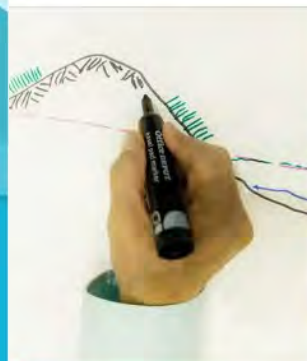
ARQUITECTURA Y EL AUMENTO DEL NIVEL DEL MAR

COLEGIO DE ARQUITECTOS Y ARQUITECTOS PAISAJISTAS DE PUERTO RICO

04 DE JUNIO DE 2022
QUINTADOR, RESORT, FAJARDO PUERTO RICO

Puerto Rico Science Trust
7 de junio · 🌐

Ante la 44ta Asamblea Anual del Colegio de Arquitectos y Arquitectos Paisajistas de Puerto Rico nuestro equipo del Centro Caribeño del Aumento del Nivel del Mar dijo presente 🙌 con la presentación de **John Englander** el cual explica la importancia de planear para un futuro donde el nivel del mar continúe en aumento. También el arquitecto Fernando E. Pabón Rico compartió algunas estrategias y recursos que nos ayudan a construir pensando en el futuro.



Caribbean Center for Rising Seas



El Rector del Recinto Universitario de Mayagüez, Dr. Agustín Rullán Toro, se complace en invitarle a la charla:
UNSTOPPABLE RISING SEA LEVEL:
"The Engineering Challenge of the Century will Change Our Entire Society"



POR: JOHN ENGLANDER

Oceanógrafo experto en el aumento en el nivel del mar, director ejecutivo del Centro Caribeño sobre el Aumento en el Nivel del Mar y presidente del Rising Seas Institute.

Autor de:

-High Tide on Main Street: Rising Sea Level and the Coming Coastal Crisis. The Science Bookshelf, 2012
-Moving to Higher Ground: Rising Sea Level and the Path Forward. The Science Bookshelf, 2021

El evento contará con traducción al español y transcripción del audio

Jueves 16 de septiembre del 2021 10:15 AM (EST) **zoom**

RisingSeasInstitute.org CaribbeanCenterRisingSeas.org



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prscience1

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Practical Application in the Built Environment



Promoting 100-year Flood Safe Communities requires understanding the difference in flooding causes.



Flooded area in Condado, 2022



What are we looking for?

- ❖ Increased Safety: Reducing the risk of structural and psychological damage...
- ❖ Flood Resilience: Avoiding evacuations and disruption during flooding events.
- ❖ Updated Scientific Data: Critical for the smartest decision making.
- ❖ Environmental Protection: Minimizing environmental impacts of flood control.
- ❖ Stability and Community Environmental Justice: encouraging the preservation of neighborhood ties to promote resistance to future disasters and challenges.

Scientific Research & Scientific Communications for...

1. Flood resistant design and construction will **reduce property damage and loss of life.**

2. Help make Puerto Rico **"future ready"** - a model for the Caribbean and the world.

3. Flood resistant designs will **attract more investment and create more jobs.**

4. People will **visit Puerto Rico** to see what we are doing to adapt in advance of future flooding.

5. Creating **a better legacy and inheritance** for future generations .

*Climate change has passed a tipping point...
We must rise with the tide.*



Caribbean Center
for Rising Seas

Aligned with
UN Sustainable
Development
Goal 13

A program of
Purdue Rice
Climate Technology
& Research Trust

iThank you!



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